ISSN 0124-5481

Journal of Science Education

REVISTA DE EDUCACIÓN EN Ciencias

Vol. 14 N° 2, 2013

Translating science education research into science teaching and learning p. 56

Revisiting *The Chemical History of a Candle* p. 60

Investigación • Internet • Computadores

Métodos activos • Innovaciones • Creatividad

Desarrollo de capacidades

ISSN 0124-5481

UNILA

Universidad Autónoma de Colombia

UNIVERSIDAD DE LA AMAZONIA

UAN UNIVERSIDAD ANTONIO NARIÑO

UNIVERSIDAD DEL QUINDÍO

This Journal is indexed and abstracted in:

Scopus (Elsevier) www.info.scopus.com
Qualis (qualis.capes.gov.br/webqualis), Brasil
Chemical Abstracts (CA)
Educational Resources Information Center (ERIC)
Educational Research Abstract Online (ERA) UK, www.tandf.co.uk/era
Contents Pages in Education, UK
Latindex , México

You can access the Journal On Line:

www.accefyn.org.co/rec

Subscribe to the

Journal On Line

ISSN 0124-5481

Página WEB con la Revista Virtual:
http://www.accefyn.org.co/rec

Address of the Journal:

E-mail : oen85@yahoo.com

JOURNAL OF SCIENCE EDUCATION, N° 2, vol 14, 2013

CONTENTS

CHALLENGES IN SCIENCE EDUCATION 55

FROM SER TO STL: TRANSLATING SCIENCE EDUCATION RESEARCH INTO SCIENCE TEACHING AND LEARNING
De la investigación hacia la enseñanza y aprendizaje: transferir la investigación en educación científica a la enseñanza y aprendizaje de ciencias
Childs P. (Ireland) 56

REVISITING *THE CHEMICAL HISTORY OF A CANDLE:* SOME REFLECTIONS FOR CHEMISTRY TEACHERS BASED ON A CASE STUDY
Revisitando *La historia química de una vela*: algunas reflexiones para profesores de química respaldadas por un estudio de caso
Baldinato J., Nagy J., Alves Porto P. (Brazil) 60

E-LEARNING THROUGH THE EYES OF THE CZECH STUDENTS
Aprendizaje electrónico desde el punto de vista de los estudiantes universitarios
Klement M. (Czech Republic) 66

PROBLEM BASED LEARNING ENVIRONMENTAL SCENARIOS: AN ANALYSIS OF SCIENCE STUDENTS AND TEACHERS QUESTIONING
Aprendizaje basado en problemas en escenarios ambientales: un análisis de interrogación de estudiantes de ciencias y profesores
Torres, J., Preto, C., Vasconcelos, C (Portugal) 71

INDÍCIOS DO MODELO INTEGRATIVO NO DESENVOLVIMENTO DO PCK EM LICENCIANDOS EM QUÍMICA DURANTE O ESTÁGIO SUPERVISIONADO
Evidence for integrative model during PCK development in chemistry student teachers during pre-service training
Gomes Elias Mariano Pereira P., Fernandez C. (Brasil) 74

ASSESSMENT OF A VISIT TO AN OPTICS LABORATORY DURING UNIVERSITY SCIENCE WEEK.
Evaluación de la visita a un laboratorio de óptica en la semana de la ciencia
García J.A., Perales F. J., Gómez-Robledo L., Romero J. (Spain) 78

INVESTIGAR LA EXPLICACIÓN DE LOS EDUCANDOS EN CLASES DE CIENCIAS: LAS BASES CULTURALES Y BIOLÓGICAS.
Research the explanation of students in science classes: the biological and cultural basis.
Gomes da Silva H., Infante-Malachias M.E. (Brasil) 82

DISEASE DETECTIVES AT WORK: A LESSON ON DISEASE TRANSMISSION FOR SECONDARY SCHOOL STUDENTS
Detectives de enfermedades en el trabajo: una clase sobre la transmisión de la enfermedad para los estudiantes de escuela secundaria
Dawson M., (USA) 85

DRAWINGS, WORDS AND BUTTERFLIES IN CHILDHOOD EDUCATION: PLAYING WITH IDEAS IN THE PROCESS OF SIGNIFICATION OF LIVING BEINGS
Diseños, palabras y mariposas en la educación infantil: juego con las ideas en el proceso de significados sobre los seres vivos
Rodrigues Chaves Dominguez C., Frateschi Trivelato S.L. (Brazil) 88

DESIGNING A CHEMISTRY EDUCATIONAL GAME AND EXAMINING REFLECTIONS ABOUT IT
El diseño de un juego educacional de química y su análisis
Bayir E., Deniz C. (Turkey) 92

JUEGOS EDUCATIVOS Y APRENDIZAJE DE LA TABLA PERIÓDICA: ESTUDIO DE CASOS
Educational games and learning about the Periodic Table: case studies
Franco Mariscal A.J., Oliva Martínez J.M. (España) 93

INSTRUCTIONAL RELATIONSHIP OF SOCIOSCIENTIFIC ISSUES-BASED INSTRUCTION AND PEER-ASSISTED LEARNING STRATEGY: AN IMPLICATION FOR SCIENCE INSTRUCTION
Relación educativa de asuntos socio-cientificos de ensenanaza y las estrategias asistidas de aprendizaje: las implicaciones para la enseñanza de ciencias
Mikhail Yahaya J., Nurulazam MD Zain A., A/P Karpudewan M.(Malaysia) 98

BOOK REVIEWS 101

2DO FORO MUNDIAL DE DESARROLLO ECONÓMICO LOCAL
II Fórum Mundial de Desenvolvimento Econômico Local........103

Index vol. 14, 2013 104

Editorial

CHALLENGES IN SCIENCE EDUCATION

One of the continuing challenges in science education is not the lack of science education research (SER), or the lack of funding for research and development (which are well supported by the EU in Europe and by the NSF in America), but the lack of impact of the research and development activities on science teaching and learning (STL). We know a lot more today about the problems and issues in the teaching and learning of science than we did 20 or 30 years ago. Much time, effort and money has gone into curriculum development, new courses and textbooks, and a plethora of EU-funded projects (see www.scientix.eu) , mostly in the area of inquiry-based science education (IBSE). We know a lot about the difficulties students face in learning science subjects and we know that the problems are universal. However, we know far more about the problems at second-level than we do at third-level, because most SER is done in primary and post-primary schools, and an interest in third-level SER is relatively recent. We also know more about the students than we do about their teachers and lecturers, as most studies are done on the students. My article in this issue 'From SER to STL' looks at the challenge of translating SER into STL. There are major problems of dissemination and communication to overcome between the research community and the practitioners in the classroom or lecture hall. Teachers are the key to success in education, in any subject and at any level, and in any country, and so we must focus on equipping teachers with the best intellectual and practical tools to do their job well. If we don't do the job properly in initial teacher training (ITT) then the new science teachers entering the profession will usually perpetuate the *status quo*: they will teach as they were taught themselves. But we also need to target serving teachers, who may spend up to 40 years post ITT, by providing relevant and informed continuing professional development (CPD). There is massive inertia in all educational systems and change takes a long time to effect. Unless we tackle all parts of the system then we will not break the vicious cycle, where traditional views and practices outweigh newer, evidence-based approaches. We need to ensure that the curriculum (what is taught), the pedagogy (how it is taught) and the examinations (how it is assessed) are all informed by the findings of SER and best practice. We want to move towards evidence-based science teaching and learning. We still have a long way to go, especially at third level, and the effective translation of SER into STL remains a major challenge for all those involved in science education research and the initial training and CPD of science teachers.

The articles in this issue of JSE remind us that science education is an international activity, which includes many separate science disciplines, and cuts across all levels of education. After we visit the challenge of turning SER into STL we then revisit *Michael Faraday's A Chemical History of a Candle* with Brazilian chemistry teachers, and then look at e-learning through the eyes of Czech students. The next article looks at the assessment of the value of a visit to an optics laboratory in a Spanish university during Science Week, an example of non-formal learning. Turning to biology we look at a lesson on disease transmission for secondary students, and staying in the science classroom, an article from Portugal looks at problem-based learning in environmental science. The next article looks at early science education in Brazil in relation to ideas about living things. A paper from Turkey looks at designing and reflecting upon a chemistry-based educational game, reminding us of the value of games in teaching science. The learning triangle and the relationship between macroscopic and symbolic imagery is explored in the next paper in the context of chemistry demonstrations. Finally from Malaysia we have an article looking at the implications for science instruction of socio-scientific issues-based instruction (SSIBI) and peer-assisted learning, followed by one from Brazil on the development of PCK in student chemistry teachers during their pre-service training. This is a rich smorgasbord of science education papers, both research and practice, and there should be something for everyone in this issue. We wish you happy and fruitful reading!

Peter E. Childs
University of Limerick, Ireland
Peter.childs@ul.ie

From SER to STL: translating science education research into science teaching and learning

De la investigación hacia la enseñanza y aprendizaje: transferir la investigación en educación científica a la enseñanza y aprendizaje de ciencias

Peter E. Childs

Chemistry Education Research Group, Dept. of Chemical & Environmental Sciences and National Centre for Excellence in Mathematics and Science Teaching and Learning, University of Limerick, Limerick, Ireland
peter.childs@ul.ie

Abstract

Despite many decades of Science Education Research (SER) there seems to have been little transfer into the classroom or lecture theatre. This work identifies several factors that contribute to this and suggests ways they might be addressed: the academic rat-race; the shortness of initial teacher training (ITT); the communication gap with teachers; the relevance of much SER; the lack of involvement in SER by teachers.

Key words: *science education research; action research; initial teacher training; pedagogical content knowledge; communicating science education research*

Resumen

A pesar de varias décadas de investigaciones en educación en ciencias (SER) parece hay poca transferencia de estos resultados al aula o sala de conferencias. En este trabajo se identifican varios factores que contribuyen a esta situación y sugiere formas en que podrían abordarse: lucha por la supervivencia académica, la falta de formación inicial del profesorado , la falta de comunicación con los profesores, la relevancia de muchas proyectos de investigación, poca participación de los profesores en estas investigaciones.

Palabras clave*: investigación, educación científica, investigación-acción, formación inicial del profesorado, comunicaciones en la investigación en educación*

INTRODUCTION [1]

Has several decades of science education research (SER) had any effect on the way science is taught and learnt in school and university? The answer would have to be - yes, to some extent, but very little compared to the effort, money and time put into science education research (SER) over many years. SER has become a large enterprise: many research groups around the world, several dedicated journals, large numbers of research publications. In many ways it is a field of academic study that has come of age. However, its impact on science teaching and learning is still in question. Bucat (2004) said: *"Research has not had the impact on science teaching that we would have hoped. Furthermore, science education research seems to be looking for direction. Much of chemical education research has used subject matter simply as a vehicle to develop domain-independent pedagogical theory."* He went on to say: *"The advances have not in general been translated to the classroom, and Chemistry education seems unsure of its direction."*

John Hattie (2008) in his book *Visible Learning* says this: *"How can there be so many published articles, so many reports providing directions. So many professional development sessions advocating this or that method, so many parents and politicians inventing new and better answers, while classrooms are hardly different from 200 years ago? Why does this bounty of research have so little impact?"*

This lack of impact raises the question as to the primary purpose of science education research (SER). Is its goal to understand better the problems of teaching so as to improve things **or** is it an academic pursuit, important for academic careers, and largely divorced from what goes on in the classroom and lecture theatre? We could contrast these two approaches as the pragmatic and applied **versus** the theoretical and pure. There is always a tension between applied and pure research in any subject. The emphasis on pure/theoretical versus applied/pragmatic varies from one country and one research group to another. I am in the applied/pragmatic camp, as I believe that the purpose of SER should be primarily to understand the teaching and learning science, with a view to changing and improving our practice. One could argue that research that does not change teaching in the long run is pointless, both from the point of view of the practitioner and also from the perspective of the paymasters, who both want to see tangible results. However, this does not mean that pure research is not important or may not end up being applied to practice. Likewise applied research must have some theoretical basis even if its main focus is on practice. I have previously discussed this topic in general (Childs, 2007) and in relation to improving chemical education (Childs, 2009).

THE GAP BETWEEN EDUCATIONAL RESEARCH AND PRACTICE

MacIntyre (2005) discussed the different types of knowledge produced by research and that used by teachers and suggested "*that there is a very large gap between the kind of knowledge that good scholarly educational research can at best provide and the kind of knowledge that teachers most use in good classroom teaching.*" Many other people over the last 100 years or so have talked about this gap between research and practice. In 1996 Hargreaves complained that *"teaching is not, at present, a research-based profession. I have no doubt that if it were, teaching would be more effective and more satisfying."* (Hargreaves, 1996)

Greenwood and Abbot (2001) identified four factors responsible for this gap:

- the separateness of the research and practice communities;
- the limited relevance of educational research as perceived by practitioners;
- the failure of researchers to produce usable interventions; and
- the limited opportunities for meaningful professional development by practitioners.

MacIntyre (2005) pointed out the contrast between the type of knowledge research provides and the type of knowledge which teachers use:

- propositional (knowledge that) versus pedagogical knowledge (knowledge how);
- a focus on coherence and truth rather than practicality;
- a focus on the theoretical and general rather than the pragmatic and the local; and
- an impersonal versus a personal view of knowledge.

To summarise, teachers and researchers are divided by the language they speak and the knowledge they value.

In his commentary on '*Making use of evidence. Bridging the gap between research and practice*', Morris (2011) summarises the problem: *"Vital though this connection between research and practice may be, in the field of education it still remains relatively weak – a few references in initial training, occasional links in CPD, perhaps an isolated case of action research. Research may find its way into academic journals and government guidance but rarely into the hands of school and college practitioners."*

More recently John Oversby has dealt with this topic in his RSC Science Education Award lecture, 'Mind the gap' (Oversby, 2012a) and in the *ASE Guide to Research in Science Education* (Oversby, 2012b). The divide between educational research and practice is clearly still a live issue and the gap still remains to be bridged.

The dangers of fads and fashions in education research

The view that educational research is of no use to the teacher is a view with a long pedigree. There has long been a complaint about education that

1 This a shortened version of a plenary lecture given at DIDSCI 2012, Krakow, Poland and the full version was published in the Proceedings.

it is driven by the latest fashion. In an article in *Newsweek* (Begley, 2010), the author attacks the record of educational research and cites research by Cobern *et al*, 2010, who compared direct instruction versus inquiry-based and concluded: *"Some claims for inquiry methods regarding understanding the nature of science are not sufficiently well supported by evidence."* Such studies are salutary lessons that some strategies, which are adopted as the latest educational 'silver bullet', are not in fact always useful. We should always check out the evidence for a particular strategy, before rushing to implement it, or we will be driven here and there by the latest wind of educational fashion (Chaddock, 1998).

The individual teacher usually has no means of evaluating the effectiveness of a particular strategy. Hattie (2009) has evaluated the research on 138 strategies, with over 50,000 individual studies and 800 meta-analyses measuring achievement. He uses the size effect value (SE) to compare studies and those with a SE > 0.4 are in the zone of desired effect. A value of +1.0 (or -1.0) corresponds to 1 SD gain (or loss). His top 20 strategies do *not* include inquiry-based teaching (which has a SE of 0.31 and is 86th out of 138.) The importance of this study is that it provides a measure of the effectiveness of various strategies, independent of their publicity or fan-base, enabling us to choose which strategies to use and which to avoid. This evaluation was not subject-specific i.e. it is about the general use of the various strategies, at various levels of education, and not specifically about science education.

Why does so much SER fail to change STL?

Why the findings of SER, whether pure or applied, often fail to make any impact in the classroom, the places they are meant to illuminate, affect and change? There are many reasons for this and I would like to discuss some of them now.

a) **The academic rat-race:** Most research is done by third-level academics, whose careers and promotion are determined by the number and quality of the papers they produce. What matters most in academia are the Impact Factors of the journals they publish in, rather than the impact in the classroom. Research with no possible application is valued as much as research which actually changes and improves teaching and learning. Also academics at third-level may be far removed from the reality of subject teaching, particularly in education departments: they are thus doubly–distanced from the reality they are researching. There is increasingly a culture of publish or perish in universities, driven by short-term targets, and more concerned with research income than scholarship or application. Even *"Funded projects have been driven mainly by goals of contributing to the accumulation of scholarly knowledge; disseminating this knowledge to practitioners as materials, directives, or rules had been see as a secondary responsibility of the investigators."* (Sabelli and Dede, 2001) The goals and pressures of academics are often very different from those of the harassed teacher in the classroom, where survival is the name of the game.

b) **The shortness of initial teacher training (ITT):** whether ITT for science teachers is based on a concurrent model (teaching subjects, education, pedagogy and teaching practice combined in a 3-4 year bachelor degree) or a consecutive model (education, pedagogy and teaching practice covered in 1-2 years after completing a subject-based bachelor degree), there is relatively little time for SER and relating it to the classroom. In addition to general education, such ITT courses have varying amounts of Pedagogical Content Knowledge (PCK), where SER interfaces with subject matter knowledge (SMK) in relation to the pedagogical knowledge (PK) needed for specific teaching situations. Given little exposure to SER before entering ITT, students are likely only to get a superficial and limited treatment during it. There is always more PCK to be covered than time allows. Trying to fit in all that the trainee science teachers need to know in the time available, is like trying to fit a litre of beer into a half-litre mug, whether they are on concurrent or consecutive courses.

c) **The communication gap with teachers:** There are several aspects to the problem of communicating SER to teachers, which reduce the transfer.

i) The language used in academic papers is often riddled with jargon and statistics, and is impenetrable to non-specialists;

ii) Journals are expensive and often inaccessible to teachers, unless they are open access internet journals like *Chemistry Education Research and Practice* (CERP);

iii) In academic research much of the communication and networking is done in conferences, and teachers do not often attend such conferences;

iv) Conferences for teachers, on the other hand, often focus on practical matters or subject content with less emphasis on SER.

d) **The (ir)relevance of much SER:** Research articles are often unrelated to the situation and problems faced in the classroom and seem irrelevant to practising teachers. Teachers are busy people and their main concern is with their students and what they have to teach. They look for information and materials that can easily be adapted to their own teaching situation. Much SER is not seen to be directly relevant to teaching or requires too much translation or adaptation before use. As a result teachers do not find it useful or worth the effort and time to see whether it is useful. The gap between much academic SER and its application in the classroom is too large for many practitioners to bridge. In fact, they may view much educational research as not worth reading, as it is irrelevant to the real world they work in.

e) **The lack of involvement in SER by teachers:** Most research is done by university-based academics and their postgraduate students, or by teacher educators, and with only a few practising teachers. Researchers and teacher educators are most commonly based in education departments, not science departments (although Germany is an exception) and this weakens their connection with subject teachers and with science. The lack of involvement by teachers in SER means that they have no stake in it and are detached from it. SER is seen as something other people do to them, rather than something they participate in themselves. Research (or scholarship) is seen as research *on* practice rather than research *of* (or *with*) practice. If teachers are the subjects of, rather than participants in, research, then they are less likely to be committed or consider themselves as stakeholders or partners.

f) **The lack of time and expertise by teachers:** Teachers are busy people with full timetables and do not have the energy, the time, the access or the expertise to make themselves familiar with SER and judge what is relevant to the classroom. Their main concern is survival in the classroom and professional development comes second to the pressures of the job. By comparison, academic life is less demanding than school and there is less understanding of the pressures on teachers. Teachers do not have funds to attend science education conferences, often held at times to suit third level academics not school teachers.

g) **The failure to influence policy makers:** The education system in most countries is centrally controlled by the Ministry of Education. Government policy thus determines the curriculum and assessment, as well as monitoring teaching quality. Teachers are required to teach the prescribed curriculum and prepare students for external assessment, and these constraints determine their pedagogy. If the curriculum and the assessment are not research-informed by but subject to other influences e.g. political pressure or the influence of higher education, then they will be deficient. Also teaching materials, such as textbooks, are prepared to fit the curriculum and the assessment and may not reflect the findings of SER. If the science curriculum, assessment and text-books are not research-informed then SER will have no real influence on teaching and learning.

h) **Lack of subject-teaching experience by researchers:** Sometimes researchers may not have had experience actually teaching a science subject, either currently or in the past and may be coming from a general educational background. This lack of first-hand experience of teaching science, necessarily means poor understanding of the problems in teaching the subject. PCK, where pedagogy meets the subject, requires good knowledge of the subject to be effective. Science education researchers who lack experience in teaching a subject will be less equipped to communicate with practising teachers and will lack credibility and that first-hand knowledge necessary to understand the problems of teaching a subject.

Dealing with these issues

In this section I will consider each of the issues raised above and suggest ways they can be dealt with or alleviated.

a) The academic rat-race: publish or perish

Much academic research is done to fulfil research quotas and meet the demands of a 'publish or perish' culture in universities. The research may be irrelevant to the classroom and to the needs of teachers, and most of it will never be read, but it is essential for one's CV and for academic promotion. Writing general articles or even books for teachers is not as valued as research papers. The needs of the teaching profession are thus prostituted on the altar of academic respectability. It is as if the value of a GP were measured by his research output rather the number of patients successfully treated. The balance must be redressed so that science education researchers are encouraged and rewarded for working with and communicating with teachers, rather than just with their academic peers. Academics should be encouraged to write for and speak to teachers directly.

b) The shortness of initial teacher training (ITT):

'No time, no time' might describe most ITT courses, whether they be 1-2 year consecutive courses or 3-4 years concurrent courses. The time available in either type of ITT course for PCK is usually limited, squeezed between education (general pedagogy) and teaching practice, and in concurrent courses also by science courses. Learning how to teach science often takes up very little time in ITT courses, so that students have limited exposure to the wealth of SER that is available and its relevance to the teaching of science. Even if they have heard of a topic, there is usually inadequate time to explore its application to science teaching. Consequently new teachers go back into the school system with an inadequate knowledge of PCK and consequently tend to revert to traditional methods, as in the old maxim – 'teachers teach not how they were taught to teach but how they were taught'. Given the time constraints, the aim of ITT should be to help new teachers become flexible and adaptable and to help them think and improvise, rather than covering everything (Hayes and Childs, 2010) Rather than giving them solutions to today's problems, we should be giving them the tools to solve both today's and tomorrow's problems. If student teachers can see something of the value of SER, if they can find their way around the literature and see a few examples of how SER can be used, then they will be more likely to use it themselves in the future.

A better strategy would be to increase the length of ITT courses by one year, allowing more time to develop PCK and explore SER. However, length alone is not sufficient and a Master's level programme, including research, would provide both the necessary length and depth. The McKinsey Report (Barber and Nourshed, 2007) identified the quality of teachers as the main determinant of the quality of school systems. The top performing systems were very selective in choosing the best trainee teachers, and often educated the teachers to Master's level. Making teaching an all Master's level profession would raise the quality, improve the depth of pre-service training, and also increase the application of SER in STL. *"While initial teacher training provides teachers with the critical skills to succeed in the classroom, a master's degree builds on those by encouraging teachers to follow critical, reflective, inspirational and innovative approaches to education and to take risks."* (Noble-Rogers, J., 2011) The main recommendation of the ETUCE report on *Teacher Education in Europe* was it should be an all Master's level profession.

ETUCE advocates an initial teacher education at Master's level that: Provides in-depth qualifications in all relevant subjects, including in pedagogical practice and in teaching transversal competences

- *Is research-based, has high academic standards and at the same time is rooted in the everyday reality of schools*
- *Includes a significant research component and produces reflective practitioners*
- *Gives teachers the skills needed to exert a high degree of professional autonomy and judgment in order to enable them to adapt their teaching to the needs of the individual group of learners and the individual child or young person*
- *Offers the right combination between theory and pedagogical practice and benefits from partnerships between teacher education institutes and schools*
- *Encourages mobility of teachers within the different levels and sectors of the education system, provided that adequate re-qualification is acquired.* (ETUCE, 2008)

c) The communication gap with teachers:

A major problem is the communication of SER to teachers. An effort needs to be made to digest and translate appropriate SER into a language teachers can easily understand, in journals or websites they have easy access to. The National Centre for Excellence in Mathematics and Science Teaching and Learning at the University of Limerick (www.nce-mstl.ie) is to doing this by publishing 4-page Resource and Research Guides in science and mathematics. The Association for Science Education in the UK has a regular Research Focus feature in its magazine, *Education in Science,* dealing with SER. (http://www.ase.org.uk/journals/education-in-science/) The accessibility of SER is also being addressed by online, free-access journals, such as *Chemistry Education Research and Practice*, published by the RSC (http://pubs.rsc.org/en/journals/journalissues/rp). John Oversby has developed an effective teacher's focus group PALAVA in Reading in the UK, which meets regularly to discuss research and to encourage teachers to apply research and conduct research in their classrooms. (Oversby, 2012a) Similar groups involving local chemistry teachers and university academics working in chemistry didactics have been run for several years from the universities of Dortmund and Bremen in Germany (Eilks & Ralle, 2002).

d) The (ir)relevance of much SER:

Teachers don't want to read about irrelevant research, which does not meet their immediate needs. Teachers are often narrowly focused: does this relate to my subject, is it relevant to my students (age, level, curriculum) and is it likely to be useful? If not, then the teacher is likely to ignore the work. It is thus important for researchers to work with teachers to identify problems and issues of relevance to teaching. Often teachers would like a specific solution to a particular problem e.g. how to teach X better, or how to deal with some classroom problem i.e. they have a very applied, local and pragmatic view of relevance. Researchers must strive to show the relevance of SER to actual practice, even if the original research is theoretical and non-specific.

e) The lack of involvement in SER by teachers:

Often teachers do not feel that they have any ownership of much SER: it is something done to them rather than for them. They may be bombarded by questionnaires or requests for information from outside, without any personal involvement in the aims, design or implementation of the research. No-one likes to be a guinea pig, even with informed consent, and there is a need to change the model so that teachers are involved at all stages of the research. If teachers have a say in what problems are worth studying and how to go about the investigation, then they will be more committed and more involved in both the conduct of the research and in the use of the findings. The welcome shift towards classroom-based Action Research is an example of this approach. This can be started during ITT by having student teachers involved in action research. SER needs to be seen as a partnership between researchers and practitioners, what Sabelli and Dede (2001) have termed 'integrated co-development'. They make the valuable point that the reflective interplay between research and practice must be bi-directional, not uni-directional (from researcher to teacher), as it often is at present. A co-development approach requires cooperation and collaboration between researchers and teachers to identify problems and research strategies, giving practitioners a real stake in the conduct and outcomes of research.

f) The lack of time and expertise by teachers:

Unless teachers are given the time for professional development during their career, or even during the working week, they will be not able to keep up with the latest SER. Time should be allocated for this in the teaching week, as well as in a structured, life-long CPD programme. Teachers need to be equipped with the tools and expertise to use and become involved in SER and this must be done mainly after initial qualification. Resources and time need to be allocated to this aspect of the teacher's professional development.

g) The failure to influence policy makers:
Too often the voice and expertise of the SER community has not been heard or utilised by policy makers. The science teacher training and the science education research communities, which are not always identical, should be represented on policy committees, task forces and syllabus committees dealing with issues of science education, and thus contribute to government policy.

h) Lack of subject-teaching experiences by researchers:
It should be a *sine qua non* that science education researchers have themselves had experience of teaching science, whether at second or third-level, either currently or in the recent past. Ideally they should retain a stake in teaching science as well as researching the teaching and learning of science. There is a lot to be said for the science didactics (or pedagogy) groups to be located in science departments as in many German universities, rather than in education departments, as is the case in the U.K. and Ireland. There can often be a lack of sympathy for the particular problems of teaching a specific subject within an education department, just as there can be a lack of understanding of education in a science department.

CONCLUSION: TEACHING MUST BE RESEARCH-INFORMED

Teaching involves a dynamic interplay between the curriculum (often defined externally by governments), the pedagogy (how teachers teach and the resources they use) and assessment (how the curriculum objectives are assessed). Although this should represent an integrated system, this is not always the case and often assessment is the tail that wags the dog and determines how the curriculum is interpreted and taught. There should be coherence between the learning outcomes defined by the curriculum, the teaching and learning strategies employed to deliver these outcomes, and the design of the assessment instruments. This paper seeks to make the case that each of these dimensions of teaching and learning should be research-informed (Figure 1).

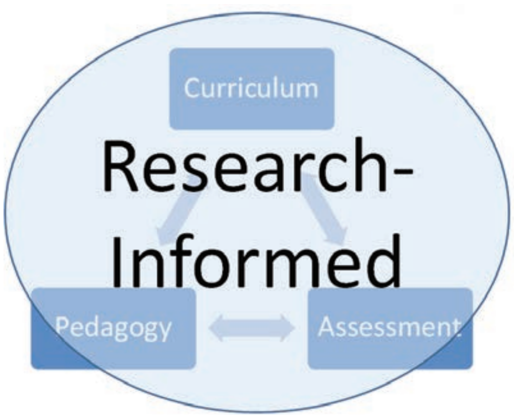


Figure 1 Research-informed teaching and learning

There is strong pressure from the EU following the Rocard Report of 2007, *A Renewed Pedagogy for the Future of Europe* (Rocard, 2007), through its FP-7 Science and Society projects. The International Association of Science Academies (IAP, 2010) and by the All European Academies (ALLEA, 2012) also promote IBSE as the panacea for all science teaching ills. Consequently a plethora of IBSE projects has been launched in Europe, with several similar projects running in the same countries. There seems little effort to assess how these projects relate to each other and how the findings can be disseminated more widely. There is surely a need for a research project to do a meta-analysis of all these projects and come to some assessment of their value. The ALLEA Report, although promoting IBSE, recognises that *it "..seems appropriate to devote some research time on developing methodologies that are better suited to measure and compare the success, or otherwise, of IBSE approaches."* (ALLEA, 2012) It would seem unwise to put all our pedagogical eggs in one IBSE basket, when experience has shown that no single approach works for all pupils in and that a variety of pedagogical strategies should be employed.

The TLRP EBSE Research Network project in the UK identified that the "*Widespread use of research evidence in the classroom seems to depend on at least two factors:*

- *tangible and useful outcomes, such as curriculum materials and teaching approaches, resulting from transformation of research findings into practical strategies;*
- *the presence of a professional culture which encourages both exploration of research and changes to practice."* (Bartholomew *et al*, 2003)

In other words, SER must be clearly seen by teachers to be of practical use in the classroom, and it must be supported by a professional culture which favours the transfer of SER into STL: this must start in the teacher's initial training and continue throughout their career.

If we are to allow SER to inform STL there must be good communication between teachers and researchers, and the formation of a collaborative partnership. There must be an integration of ideas and approaches supported by SER into teacher training and CPD; into curriculum design; into teaching materials and textbooks; in pedagogy and especially in assessment. All these aspects of teacher preparation and practice should be research-informed in order to bring about systemic change in the way science is taught. In almost every country, science teaching is driven by assessment, particularly if this is a high-stakes, terminal state examination. Unless the final assessment is aligned with learning outcomes, which in turn are informed by SER, then the insights from SER will never be fully implemented. The onus is on science education researchers to communicate their findings to teachers, to work closely with teachers and involve teachers in their research. Systemic change takes place from the roots upwards and not by tinkering with the branches. Too much SER to date has been small-scale, short-term and limited in scope and it is doubtful whether this approach is able to bring about real change in STL. It is also not enough to convince science teachers of the value of SER – in the real world, we also have to convince politicians and educational administrators.

Some specific recommendations:

1. Every aspect of science teaching and learning (STL) needs to be informed by science education research (SER) – curriculum, pedagogy and assessment.
2. We need to evaluate the effectiveness of new teaching and learning strategies by reviewing the available research rather than jumping on the latest bandwagon.
3. Science teaching and learning is complex and multidimensional and there is no 'silver bullet' to solve our problems – we need a mix of strategies, tailored by the teacher to suit his/her specific situation.
4. We need to develop partnerships between researchers and teachers in order to transfer SER into STL effectively and bridge the gap.
5. Teaching should become a Master's level profession across Europe.
   Trainee teachers should be exposed more to SER and be involved in research themselves.
   CPD should be life-long and introduce and involve teachers in SER.
6. Science education researchers should have current or past experience in teaching science at either 2nd or 3rd level, in order to understand first-hand the problems of teaching science.

I will leave the last word to Jean Piaget:

The principal goal of education is to create [people] who are capable of doing new things, not simply of repeating what other generations have done—[people] who are creative, inventive, and discovers. The second goal of education is to form minds which can be critical, can verify, and not accept everything they are offered. (Piaget, 1964)

BIBLIOGRAPHY

ALLEA. *A renewal of science education in Europe: Views and Actions of National Academies*, 2012, accessible at http://www.allea.org/Content/ALLEA/WG%20Science%20Education/Helsinki/Report%20ALLEA%202012%20last.pdf, accessed 21/6/12

Barber, M. and Nourshed, M., *'How the world's best performing schools systems come out on top'*, McKinsey & Co., 2007, available at
http://www.mckinsey.com/clientservice/socialsector/resources/pdf/Worlds_School_Systems_Final.pdf

Bartholomew, H., Hames, V., Hind, A., Leach, J., Osborne, J., Millar, R. and Ratcliffe, M., 2003, *Towards Evidence-based Practice in Science Education 4: Users' perceptions* *of research*, available at http://www.tlrp.org/pub/documents/no4_miller.pdf, accessed 24/6/12

Begley, S., Newsweek, May 9, 2010, available at www,thedailybeast.com/newsweek/2010/04/30/second-classscience.print.html accessed 12/6/12

Bucat, B.'Pedagogical Content Knowledge as a way forward: applied research in Chemistry education', *Chemistry Education: Research and Practice*, 5(3), 215-228, 2004.

Chaddock, G.R. 'Resisting education's fads', *Christian Science Monitor*, 90(190), B1, 1998, available at http://www.csmonitor.com/1998/0825/082598.feat.feat.2.html, accessed 24/10/12

Childs, P.E. 'The problems with science education: "The more things change, the more they are the same"', *Interconnections between Mathematics and Science*, SMEC06, Dublin, St Patrick's College, 2007, ISBN: 1-872327-6-13, 6-27 Available at http://main.spd.dcu.ie/main/academic/mathematics/smec2006proceedings.html, accessed 12/6/12

Childs, P. E. 'Improving chemical education: turning research into effective practice', *Chemistry Education Research and Practice*, 10, 189 – 203 , 2009, Available at http://pubs.rsc.org/en/Content/ArticleLanding/2009/RP/b914496j, accessed 12/6/12

Cobern, W.W., Schuster, D., Adams, B., Applegate, B., Skjold, B., Undrieu, A., Loving, C.C., & Gobert, J.D. Experimental comparison of inquiry and direct instruction in science *Research in Science & Technological Education* 28(1) 81-96, 2010, Available at http://www.wmich.edu/way2go/docs/Experimental%20comparison%20of%20inquiry%20and%20direct%20instruction%20in%20.pdf. Accessed 12/6/12

Eilks, I. & Ralle, B. 'Participatory Action Research within chemical education', in B. Ralle & I. Eilks (eds): *Research in chemical education – What does this mean?*, Proceedings of the 16th Symposium on Chemical Education at the University of Dortmund, 87-88, Aachen: Shaker

ETUCE. *Teacher Education in Europe*, 2008, available online at http://etuce.homestead.com/Publications2008/ETUCE_PolicyPaper_en_web.pdf , accessed 19/6/12

Greenwood, C. R., & Abbot, M. 'The research to practice gap in special education', *Teacher Education and Special Education*, 24(4), 276-289, 2001.

Hargreaves, D., 1996, 'Teaching as a research-based profession', Teacher Training Agency Annual Lecture, London.

Hattie, J. *Visible Learning: A synthesis of over 800 meta-analyses relating to achievement*, 2nd. Edition, Routledge, 2009.

Hayes, S. and Childs, P. E. 'Teaching teachers how to teach: implementing research in the science classroom', In Flexible Learning, 34-35, Dublin, Ireland: NAIRTL, 2010, [online] available at: http://www.nairtl.ie/documents/2010%20Flexible%20Learning%20Conference%20Proceedings.pdf , accessed 31/6/12

IAP. *Taking Inquiry-based Science Education (IBSE) into the Secondary Education*, Report of the IAP-International Conference, York, 2010, accessible at http://www.interacademies.net/12238/2951/12250/15174.aspx

MacIntyre, D. 'Bridging the gap between research and practice', *Cambridge Journal of Education*, 35(3), 357–382, 2005.

Morris, A. Making use of evidence. Bridging the gap between research and practice, *CPD Matters* #1 Autumn 2011, 2011, available at http://www.ifl.ac.uk/__data/assets/pdf_file/0008/25937/CPD-Matters-Newsletter-Issue-1-2011-Online-final.pdf, accessed 22/6/12

Nobel-Rogers, J. 'Why teachers must keep on learning', *The Independent*, 24th. March, 2011, available at http://www.independent.co.uk/news/education/schools/why-teachers-need-to-carry-on-learning-2251220.html, accessed 19/6/12

Oversby, J. 'Mind the gap', Proceedings of SMEC 2012, *Teaching at the heart of learning*, 114-116, Dublin City University, Ireland, 2012a.

Oversby, J. 'Science education research: a critical appraisal of its contribution to education', ch. 1 in *ASE Guide to Research in Science Education*, ed. Oversby, J., Hatlied, Association for Science Education, 2012b.

Piaget, J. From remarks at a conference on cognitive development, Cornell University , 1964. Quoted in Philip Hampson Taylor, *New Directions in Curriculum Studies*, 90 , 1979.

Rocard, M, Csermely,P., Jorde, D., Lenzen, D., Walberg-Henriksson,H. & Hemmo, V. *Science Education Now: A Renewed Pedagogy for the Future of Europe*, Brussels: Directorate General for Research, Science, Economy and Society, 2007, available at http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf, accessed 21/6/12

Sabelli, N. and Dede, C. 'Integrating Educational Research and practice: Reconceptualizing Goals and Policies', 2001, Available at http://www.ctl.sri.com/publications/downloads/policy.pdf , accessed on 19/6/12 (see also http://www.virtual.gmu.edu/ss_research/cdpapers/integrating.htm)

Received 17-07- 2012/ Approved 29-04-2013

Revisiting *The Chemical History of a Candle*: some reflections for chemistry teachers based on a case study

Revisitando *La historia química de una vela*: algunas reflexiones para profesores de química respaldadas por un estudio de caso

José Otavio Baldinato, Jennifer A. Z. Nagy, Paulo Alves Porto

Grupo de Pesquisa em História da Ciência e Ensino de Química (GHQ)
Programa de Pós-Graduação Interunidades em Ensino de Ciências / Instituto de Química – Universidade de São Paulo (São Paulo, Brasil).
palporto@iq.usp.br

Abstract

Michael Faraday (1791-1867) was one of the most outstanding scientists of the nineteenth century, and also a popularizer of science. One of his series of lectures was published in book form in 1861, under the title The chemical history of a candle. The aim of this work is to revisit Faraday's text, fostering reflections on relevant aspects of present-day chemistry teaching. We chose a few experiments performed by Faraday and suggest an overview of his course with the intention to make explicit some inherent difficulties related to the chemical knowledge brought up by the speech. Among these features are: the problem of handling invisible agents (such as oxygen being necessary for combustion); the establishment of essential properties which could allow one to positively characterize an unknown substance; recognizing analog results or conditions in chemical processes; and the notions of synthesis and analysis recurrent in the text. We believe a closer examination of these aspects could help teachers to reconsider their own language, as well as their didactic sequences. Though it all may go unnoticed in the context of science popularization, teachers should be aware of learning difficulties related to particular approaches to chemistry.

Key words: *Michael Faraday, candle, popularization, discourse, learning difficulties.*

Resumen

Michael Faraday (1791-1867) fue uno de los científicos más destacados del siglo XIX y también actuó como divulgador de la ciencia. Una de sus series de conferencias se publicó en forma de libro en 1861, y se llamaba La historia química de una vela. El objetivo de este trabajo es revisar el texto de Faraday, fomentando la reflexión sobre aspectos relevantes de la enseñanza de la química. Elegimos algunos experimentos realizados por Faraday y pormenorizamos su discurso con la intención de explicitar algunas dificultades inherentes al conocimiento químico abordado. Entre estas características están: el problema de la manipulación de agentes invisibles (como el oxígeno necesario para la combustión); el establecimiento de las propiedades esenciales que permitirían la caracterización positiva de una sustancia desconocida; el reconocimiento de resultados o condiciones analógicas en los procesos químicos; y las nociones de síntesis y análisis recurrentes en el texto. Creemos que un análisis más detallado de estos aspectos puede ayudar a los profesores a reconsiderar su propio discurso, así como sus actividades didácticas. Aunque todo esto puede pasar desapercibido en el contexto de la popularización de la ciencia, los profesores deben ser conscientes de las dificultades de aprendizaje relacionadas con enfoques específicos a la química.

Palabras clave: *Michael Faraday, vela, divulgación, discurso, dificultades de aprendizaje.*

INTRODUCTION

Michael Faraday (1791-1867) was one of the most outstanding scientists of the nineteenth century, and also a popularizer of science. One of his series of lectures was published in book form in 1861, under the title *The chemical history of a candle*. The aim of this work is to revisit Faraday's text, fostering reflections on relevant aspects of present-day chemistry teaching.

In recent years, the possibilities for introducing the history of science into science education have been discussed by many authors (Höttecke, Silva, 2010; Gooday *et al*., 2008; Wandersee, 2002). We agree with Allchin (2004) when he suggests that science educators should be familiar with historical case studies, instead of resorting to brief vignettes or tangential sidebars, which do not allow a more complete picture of the process of science. Allchin also claims that teachers have to adapt the case study for their students – and we take this as a fundamental point. In this sense, our research group in Brazil has been engaged in developing historical case studies aimed for chemistry teachers (Souza, Porto, 2012; Vidal, Porto, 2011; Viana, Porto, 2010).

Here, we present a case study for teachers' appreciation. How (and if) it may be discussed with a particular group of pupils is a decision to be made by their teacher, considering the characteristics and the context of the group. As Stinner and his group (2003) have shown, there are many ways of working with case studies in science education, but they depend on teachers that "have more than a cursory acquaintance with the history and philosophy of science, and have good content and pedagogical content knowledge in science" (p. 624). So, we believe that the material presented in this work could be used in courses designed for chemistry teaching training, for it motivates reflections both about the nature and the complexity of scientific knowledge itself and about the way chemical ideas are presented for pupils. Moreover, we agree with Abd-El-Khalick and Lederman (2000), when they claim that teachers cannot teach about the nature of science unless they have been adequately prepared to do so. They argue that teacher training must include an explicit approach to history and philosophy of science issues, in order to provide teachers with an updated conceptual framework on these subjects (Abd-El-Khalick, Lederman, 2000; Porto, 2010).

D. Höttecke (2000) presented a suggestion for working with historical experiments, by replicating them. He argued that this kind of activity shows that science is a multi-layered human activity, including intellectual and technical-manipulative skills, and presented the replication of an electrical experiment by Michael Faraday. In the present work, we revisit another set of Faraday's experiments, but our focus is on the intellectual dimension, since we understand that the very selection and organization of experiments made by Faraday for his public may raise challenging questions for present-day chemical educators.

The value of Faraday's ideas to present-day science educators has already been shown, via a quite different approach, by E. Crawford in her analysis of the text of the 1854 lecture entitled "Observations on Mental Education" (Crawford, 1998). A case study designed for physics teachers was recently published in Portuguese, on Faraday's discovery of electromagnetic induction (Dias, Martins, 2004). The study of Faraday's investigations of water patterns produced under vibrations motivated E. Cavicchi to establish an interesting parallel between the experimental process in which Faraday was involved, and the one held by the Swiss psychologist Jean Piaget when studying children's learning. From this parallel, Cavicchi draws implications that help to understand science learning among present-day students (Cavicchi, 2006). These few examples show that the study of Faraday's work is still a rich source of inspiration for educators in science.

The chemical history of a candle is a text that continues to be a favorite among chemistry teachers, and an object of analysis for chemical education researchers. Walker, Gröger and Schlüter (2008) have recently suggested how Faraday's appeal for approaching science from the well-known phenomenon of a burning candle may be used in student-centered, open-teaching activities. The authors suggest that the activities could be adapted for a wide range of students, from primary school to university levels. Although the authors depict a classroom storyline in which the teacher sometimes overestimates experimental results as capable of changing students' ideas, the initiative is particularly interesting for switching the protagonist character from the lecturer to the pupils as well as for presenting a balanced set of questions and demands for the students to express what on Zoller's reference (1993) could be categorized as low-order and high-order cognitive skills. In another paper, we also analyzed some of the didactic strategies used by Faraday in his series of lectures, showing that they comprise features that could be considered sound advices to current-day teachers (for instance, the appeal to everyday facts, the display of fascination towards the subject or the adequacy of the discourse according to the public) (Baldinato, Porto, 2008). The whole text is public domain. Some modern abridged versions to the course may be found and even complete transcriptions are available on the internet.[1]

This work focuses on some of the experiments described in *The chemical history of a* candle. Our choice for the experiments was based on the particular reasoning followed by Faraday throughout the whole course, which takes chemical knowledge as something built by means of materials' synthesis and analysis processes (Baldinato, 2009). Meanwhile several experiments serve the lecturer only for illustrating some physical processes such as capillarity or density relations, there are other experiments which play a more privileged role in formulating conclusions as well as by pointing the next questions to be explored in the course. Inside the narrative, this last type of experiment is often found when the lecturer approaches specific properties of a material (water, air or wax), and also when he mentions their decomposition into simpler bodies (carbon, hydrogen gas, oxygen, etc.) which deserve further investigation aiming at a real understanding of the nature of those starting materials.

We intended to choose a few amongst the experiments performed with great care by Faraday and the selected ones are presented below in the same order as they were in the original text. This was done to retain the sequence of ideas followed by Faraday. Our aim is not just to redo the sequence of experimental demonstration designed by Faraday but, by doing so, we intend to make explicit some inherent difficulties related to the chemical knowledge brought up by the speech. Among these features are included: the problem of handling invisible agents (such as the oxygen necessary for combustion); the establishment of essential properties which could allow one to positively characterize an unknown substance; recognizing analog results or conditions in chemical processes; and the notions of synthesis and analysis recurrent in the text. We believe a closer examination of these aspects that are only implicit in Faraday's lectures could help teachers to reconsider their own speech, as well as their didactic sequences, though it all may go unnoticed in the context of science popularization – putting some obstacles to the real understanding of chemical concepts and methods.

As we have mentioned above, some initiatives for adapting Faraday's lectures in form of didactic units have already been provided by specialists and might be of great help for teachers (Walker *et al*., 2008; Manrique *et al*., 2010). In this sense, it is noteworthy that most of Faraday's experiments involve only simple materials such as candles, matches and glass tubes, and those may be easily adapted to be performed with today's apparatus while some other tests might be incompatible with our modern laboratory safety requirements, such as the use of solid potassium both to decompose carbon dioxide and to characterize water as we'll describe ahead. However, the present work intends only to suggest some reflections on the complexity of chemical reasoning illustrated by Faraday's experiments and these may be raised among teachers just by considering the experiments' description, without actually performing them. We believe the selected features are representative of inherent difficulties associated with chemistry teaching. Moreover, we do not mean that chemistry classes should be like a lecture, with passive students. However, we do believe that the following analysis may help chemistry teachers to reflect on the nature of scientific knowledge, on the way chemical concepts are introduced to students, and on students' difficulties and misconceptions when dealing with chemical ideas.

In the first section we bring a brief contextualization of Faraday's work as a popularizer of science and next we present the selected experiments from the series on the chemical history of a candle pointing out the reflections we would like to suggest for teachers.

1. Faraday and science popularization in the early 19th century

In the nineteenth century chemistry used to interest various spheres of society. Chemists found their way of obtaining social support that facilitated their own development within a broad context that took science both as a source of pleasure for the aristocracy and as a standard for the ideal of industrial and social progress, directly connected to advent of the steam engine and the application of new technologies at work.

Chemistry proved itself capable of contributing to society in several aspects, not only as a means for developing useful knowledge to be applied in the improvement of tools, materials and processes, but also as entertainment. In both these fronts, its participation in the studies of electrical phenomena was noteworthy. Chemistry was the science of the secondary qualities, with colors,

1 Ian Russell performed some of Faraday's experiments with candles in a 2005 edition of the Royal Institution *Friday Evening Discourses* (available on You Tube). Russell's website provides a summary of Faraday's *Chemical History of a Candle* (http://www.interactives.co.uk/candle.htm). The full transcription of Faraday's lectures may be easily found on Google Books (http://books.google.com/) or Project Gutemberg (http://www.gutenberg.org) and there is a free audiobook on LibriVox (http://librivox.org/).

smells and tastes. Its practical and laboratorial approach could be presented in striking performances which guaranteed full audiences in London and Paris, where Humphry Davy and Antoine Fourcroy gave their lectures with explosive experiments and exciting performances. The historian David Knight describes this period with a certain dose of nostalgia, making reference to a time when approaching to chemistry was something vibrant, albeit it happened in a way that may not match our "days of 'health and safety' legislation" (Knight, 2007, p. 125).

Some institutions were highlighted by undertaking popularization as part of their researchers' routine. That was the case of the Royal Institution of London, founded in 1799, which is associated with the establishment of "a milestone on science popularization activities" (Massarani, Moreira, 2004, p. 76). The Institution stated clearly on its foundation records the aims of diffusing the Knowledge, and facilitating the general Introduction, of Useful Mechanical Inventions and Improvements; and for teaching, by Courses of Philosophical Lectures and Experiments, the application of Science to the common Purposes of Life (quoted by James, 2007, p. 141).

The Royal Institution offered several types of courses and lectures to different audiences, and its most notable researchers/lecturers during the nineteenth century were Humphry Davy and Michael Faraday, whose biographies attest completely different personal lifestyles, in contrast with two characteristics they had in common: the skills in research and in science communication.

The chemical history of a candle was one of the two series of lectures to be transcribed and published by contemporaries with Faraday's consent. These sets compose a primary source that brings us a close approximation to the context of chemistry popularization in the nineteenth century.

2. Revisiting the chemical history of a candle

As it was usual, from the last weeks of 1860 to the beginning of the following year, the Royal Institution main auditorium had all of its seats occupied by a very diverse audience. This seems to be despite the small course pamphlets indicate that the cycle of Christmas lectures was specifically tailored for the youth.

The candle was selected by Faraday as a starting point for his lectures primarily because it was a common and extremely well known object (in a time when there was no electric light). Faraday remarked that a candle has interesting properties: it is preserved for a long time even under adverse conditions (as in contact with sea water for years); even if broken, it burns regularly, maintaining its function. The candle, when properly burned, disappears without a trace of dirt on the candlestick, which may seem a very curious circumstance to an observer. More than that, however, Faraday used the candle in his course because he believed that:

There is not a law under which any part of this universe is governed which does not come into play and is touched upon in these phenomena. There is no better, there is no more open door by which you can enter into the study of natural philosophy than by considering the physical phenomena of a candle. (Faraday, 1861, p. 9-10)

The first of Faraday's six lectures is entirely dedicated to general aspects of candles, such as their manufacture, types and shapes. Moreover, he introduces his first explanations about the role of fuel substances and the basic mechanism for a candle's burning.

Experiment 1 – analyzing to investigate

To start the tests with the flame, and proceed with investigations about Nature, Faraday put one end of a glass tube in the middle of the flame, and the other in a bottle. The deposit of a heavy substance could be seen at the bottom of the bottle: it was wax that constituted the candle, turned into vapor and then condensed again inside the bottle. Faraday then proceeded to test this wax. He heated it until liquefaction and burned the vapor then formed by approaching a flame. That vapor was at the center of the candle, and was formed by the heat of the flame. The final test consisted in, once again, installing one end of the tube in the center of the candle flame, where the vapor was formed: the vapor thus captured could then be burned by bringing a flame to the opposite end of the tube (Figure 1).

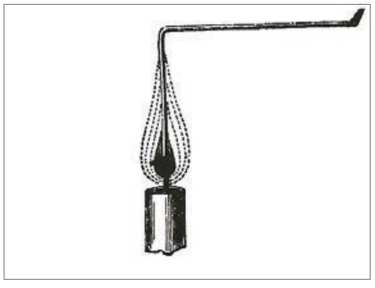


Figure 1 – Faraday's test with wax vapor. (Faraday, 2002, p. 43)

Faraday identifies two fundamental phenomena here: the combustion and the production of wax vapor in the central region of the flame. Combustion occurred only in the external areas of the flame, where the wax vapor reached the air needed for the process.

At this point, Faraday exemplifies a widely used scientific procedure: the analysis of complex phenomena, or – in other words – the division of a complex phenomenon into simpler parts, to get a better understanding of how these parts fit together. By "separating" the wax vapor from the flame, Faraday is trying to demonstrate that it is first necessary to vaporize the wax in order to burn it. By doing so, Faraday contradicts a common misconception, that what burns is the candle wick, while the wax would be just a support. Faraday also introduces the idea that an invisible entity, present in the air, takes part in combustion. This last topic will be further analyzed in the sequel.

Experiment 2 – investigating the invisible

Faraday then discussed the necessity of air for combustion. He covered the burning candle with a glass flask: after a while, the flame began to dim and finally went out. Faraday noted that this did not occur because of the lack of air, for the bottle was still full of it. Another explanation was needed, and he suggested investigating the composition of the candle by analyzing the products of combustion.

The problem was that it was necessary to investigate the role of an invisible entity in the phenomenon. This is very usual for a chemist – but teachers are not always aware of the difficulty that students have to follow their reasoning in this regard. In a short but elucidating paper, Braathen (2000) presents a review on how this specific topic which takes the air as a participant in burning candles has been subject of debate among researchers in chemistry teaching. The issue presents itself connected to a whole series of usual misunderstandings among students and teachers.

In the lecture, Faraday made use of his personal credibility to deviate from the common sense conception that the flame goes out when the air is over. He does it by calling the public's attention to some changes that have occurred in the qualities of the air inside the flask instead of its absence. In fact, the explanation for the phenomenon depends on a number of concepts which may require several experimental demonstrations to illustrate. Again, not all teachers are aware of the web of relationships involved in the explanation of chemical phenomena and that their students may not be able to grasp all of it at once.

Experiment 3 – identity and diversity

By the end of the second lecture, Faraday started inferring what sort of substance could derive from the candle burning. He pointed out some simple experiments that could indicate the formation of a "condensable" substance among these products. Water was such thing and the experimental demonstration of it was used to reestablish the narrative in the third lecture. To do so, Faraday relied on "a very visible action of water", which he used "as a test of the presence of water". Faraday took a small piece of potassium and put it in a basin with water, and observed the potassium "lighting up and floating about, burning with a violet flame" (Faraday, 1861, pp. 65-66).

Then, Faraday applied the same test to the "condensable" part of the combustion products of the candle. He first placed a burning candle under a porcelain bowl containing a mixture of ice and salt, which caused a drop of colorless liquid to condense on the cold bottom of the container (Figure 2). Faraday collected that drop and added a piece of potassium into it. As a result, the potassium inflamed and burned the same way as in the previous test, which was done with water. Faraday said that the same could be observed if the liquid were collected from the combustion of an oil or gas lamp: that is, all these fuels produce water when burned.

Figure 2 – Assembly designed to collect a drop of water produced by the candle's combustion. (Faraday, 2002, p. 66)

Here there is an implicit general methodological question: how to establish the identity (or the diversity) of two similar phenomena or, more specifically, of two substances. Establishing that two phenomena have a common property does not prove that they are similar in nature. One needs to identify the essential aspects of the phenomenon – those which define its nature – and its accidental aspects – those that are only "superimposed" over the unchanging core of the phenomenon, which are variable and subject to external influences (Martins, 1999, p. 833). In this case – about how to identify whether a substance is water – Faraday implicitly admitted that, in this particular context, the characteristic chemical reaction in the presence of potassium is an essential property of water. Furthermore, it is also assumed that no other substance reacts in the same way with potassium under the same conditions – which may not be true. To test this hypothesis could be very complicated but, in logical terms, it could not be ruled out before establishing the identity of the resulting liquid as water. The fact, however, is that there are many other possible tests, which together led Faraday to believe that the produced substance was water. The test with potassium was chosen, probably, because it is simple to make, easy for the public to understand, and has a dramatic visual effect. Compare it, for example, to another test, like measuring the liquid's boiling point: the execution and explanation to the public would be much more difficult and less attractive. Discussion of these kinds of issues may help teachers to reflect that there are many hidden layers of meaning in the discourse of science, which not always are perceived by them.

Experiment 4 – relating science to everyday life

Faraday then turned to the nature of water. He stated: "Water is one individual thing; it never changes… either in a solid, liquid or fluid state", adding that it is "compounded of two substances, one of which we have derived from the candle, and the other we shall find elsewhere." (Faraday, 1861, pp. 67-69.)

Before tackling the question of water composition, Faraday discussed changes of physical states, arguing that this kind of change did not modify water essentially. He took some liquid water in a glass flask and heated it to convert the liquid into steam showing the difference in volume. A watch-glass supported on the mouth of the flask shook "like a valve chattering" (Faraday, 1861, p. 71). This was an indication that the flask was full of steam which tended to escape as the volume increased. Furthermore, Faraday pointed to the fact that the volume of liquid water remaining in the bottom of the flask did not change significantly – that is, there is a huge difference in volume between liquid and vapor. Faraday also demonstrated this in reverse. He quickly closed a tin container filled with water vapor and poured cold water on the outside (Figure 3). As soon as the steam condensed, the container collapsed – according to the lecturer, because there was "a vacuum produced inside by the condensation of the steam." (Faraday, 1861, p. 75.) From these experiments, Faraday concluded that one cubic inch of liquid water could be converted into one cubic foot of steam, and vice versa.

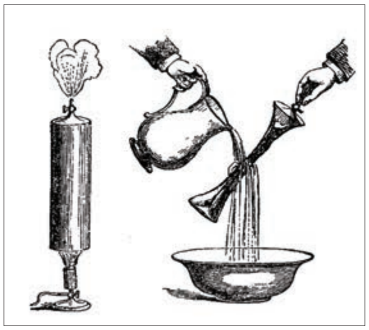


Figure 3 – Test for steam and liquid water properties. (Faraday, 2002, p. 74)

Faraday also aimed at a dramatic effect with the next demonstration. He completely filled a strong thick iron container with water leaving no space for air. Then he cooled the container immersing it in a mixture of ice and salt. After a while (which Faraday used to make other demonstrations) the iron container broke with a loud noise. Faraday stated that the explanation was the same as for the fact that ice floats on water: ice has greater volume than the same mass of water. In this case, Faraday's explanation relates his demonstration with a phenomenon seen in everyday life, familiar to his audience, revealing that both facts have the same cause.

Experiment 5 – following a complex reasoning

Faraday proceeded to show that water is a compound of two simpler substances. He asked: "How shall we get at this? I myself know plenty of ways, but I want *you* to get at it from the association in your own minds of what I have already told you" (Faraday, 1861, p. 77; italics in original).

His speech followed a reasoning involving metals, water and combustion. It is interesting to observe Faraday's declared concern, that he would like his public to discover the explanation. He did not offer a ready answer, but the reasoning presented was also neither "natural" nor "obvious" at all – it demanded a series of previous chemical knowledge as we shall see.

Once again, Faraday showed the action of metallic potassium over water: "you see it burns beautifully, making a floating lamp, using the water in the place of air." (Faraday, 1861, p. 78.) Then, he put some iron filings in water, and noted that they rust and react with water in the same way as potassium – although in a different degree of intensity, according to Faraday. He then placed a small strip of zinc in a flame showing that it also burned, turning into a white residue. Faraday asked his audience to "put these different facts together in your minds." (*idem.*) In this respect he said: "By degrees we have learned how to modify the action of these different substances, and to make them tell us what we want to know." Faraday added a further demonstration, throwing iron scraps into a flame, showing that they burn and remarking that iron filings "burn beautifully in the air." (Faraday, 1861, p. 79.)

Faraday then said that one can understand what happens when iron reacts with water. He reproduced an experiment made by Lavoisier, the first chemist to mention the composition of water in the terms still used today. It consisted in passing water vapor through a metal pipe containing red hot pieces of iron inside and placed over a furnace (Figure 4). Faraday observed that after the steam passed on the heated iron it released a gas on the other end of the pipe, which was collected under water. This gas could not be water vapor since it did not condense when cooled. The following test was done: "if I now apply a light to the mouth of the jar [in which the gas was collected], it ignites with a slight noise. That tells you that it is not steam; steam puts out a fire: it does not burn" (Faraday, 1861, p. 82). Faraday added that this substance could be obtained from any water sample, either produced by a candle flame, or by any other source.

Proceeding with his reasoning he stated that the action of the water vapor on iron changed this metal into "a state very similar to that in which these filings were after they were burnt." (*idem.*) The gas could also be produced by the action of water on other metals. Faraday reported that the contact of water with zinc does not produce an effect as fast as with potassium because zinc has a coating which prevents such action. However, if one dissolved zinc's protecting coat by means of an acid one would observe that the transformation is much faster than in the case of zinc with water alone[2]. Faraday pointed out that this process produced gas in great abundance, which was the same inflammable substance previously obtained from water. Faraday performed several experiments with this gas. But first, he stressed that this substance came from the candle (which consisted of this gas and carbon) since the gas could be separated from the water that condensed from the flame. Faraday stated that the gaseous substance here was hydrogen.

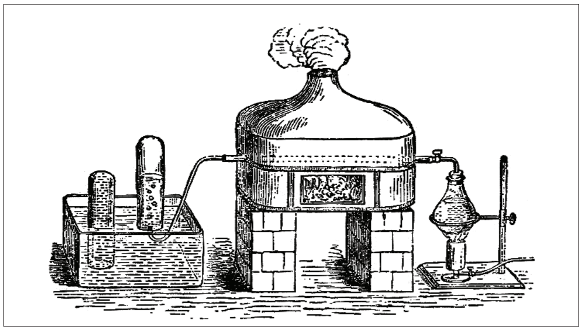


Figure 4 – Lavoisier's experiment presented by Faraday to decompose water. (Faraday, 2002, p. 80)

At this point, one can identify some more features of the scientific reasoning that Faraday is showing his audience. He began reasoning by analogy, showing the public that the actions of water on potassium, iron or zinc are similar, and these three substances belong to the class of metals. The methodological issue already highlighted in the case of Experiment 3 is presented again: the essential phenomenon is the same (the reaction with water) and the differences (the reaction rates) would be merely accidental or superficial. Moreover, there is a much more complex analogy, which relates combustion to the reaction of metals with water. To follow Faraday's reasoning one had to admit that the

2 Current-day chemists would disagree with Faraday's explanation for the behavior of zinc in water and acid solutions. Instead of a protective coat, current chemical knowledge points to the relative oxidation potentials of each metal and that of water at different temperatures to explain different reactivity. As described for the iron filings, hot zinc would react with steam but not with cold water. At room temperature the acid plays an essential part in the production of hydrogen by reacting with the metal.

"burning" of potassium in water is analogous to the burning of iron filings in the air. The reasons to establish such a relationship may become clearer as the demonstrations and explanations succeed, but, again, they are not obvious and we would not necessarily find these analogies useful nowadays. High school students who are starting to learn chemistry, for example, may have problems to reach a significant learning of this sequence of ideas, and their teacher should be aware of that.

Experiment 6 – more analogies

Faraday presented what was formerly called the "philosopher's candle" (Faraday, 1861, p. 86). Pieces of zinc, water and sulfuric acid were put in a flask with a cork and a glass tube passing through it. The hydrogen produced was burned at the end of the tube. Faraday described the flame as "foolish, feeble" (Faraday, 1861, p. 88) but extremely hot. He then proceeded with the condensation of the substance produced by the gas combustion. Placing a wide-mouthed glass bottle over the flame, colorless droplets formed inside the bottle and water started to flow on the inner walls after a while (Figure 5). Faraday noted that the combustion of hydrogen produced water alone, for no other substance condensed. In the sequel, he demonstrated how light hydrogen is. By means of a pipe, the hydrogen generator was connected to a vessel containing water with soap. The soap bubbles flew upwards while Faraday demonstrated that mouth-blown bubbles tend to go down.

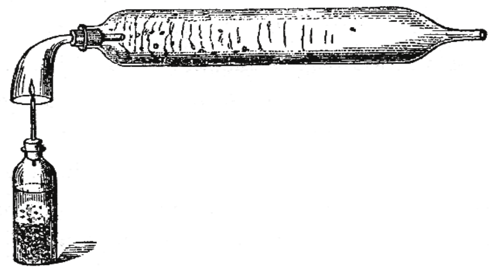


Figure 5 – Water condenses after been formed by the combustion of hydrogen in the "philosophers candle". (Faraday, 2002, p. 89)

Faraday acknowledged that he still needed to identify what else, besides hydrogen, constitutes water. To do this, he presented to his public a voltaic battery, defined as "an arrangement of chemical force, or power, or energy, so adjusted as to convey its power to us in these wires." (Faraday, 1861, p. 94.) Again, Faraday used analogies to explain. "Let us put together, first of all, some substances, knowing what they are, and then see what that instrument does to them." (Faraday, 1861, p. 95.) Faraday put a piece of copper metal into nitric acid remarking that the "beautiful red vapour" (*idem*) produced would be discarded through the chimney. He waited until the solution became blue and much of the metal had dissolved (could no longer be viewed). Platinum plates attached to the voltaic battery were immersed in the resulting mixture. After a while, Faraday pointed out to a copper deposit on one of the platinum plates. He concluded that the same copper that was dissolved was again changed into metal by the voltaic battery.

After demonstrating the power of the voltaic battery, Faraday was to show its effect upon water. Two electrodes connected to the voltaic battery were placed within a container full of water (to which a little acid was added), and the gaseous products were altogether collected elsewhere under water. Faraday asked if the product could be water vapor, and dismissed this possibility arguing that this gas did not condense. To verify if it was hydrogen, Faraday suggested burning it. He then ignited the collected gas, and drew attention to the different noise produced by this explosion, in comparison with the noise produced when hydrogen was ignited. Moreover, Faraday pointed out that the collected gas burned without contact with external air. It was also observed that the explosion of the gas produced water. Faraday remarked that the burning of the candle produced water with the help of the atmosphere; however, now he was producing water regardless of the atmospheric air. He concluded that water "ought to contain that other substance which the candle takes from the air, and which, combining with the hydrogen, produces water." (Faraday, 1861, p. 105.)

In this series of experiments, Faraday once again aimed to convince his audience by means of analogies. To explain the action of the voltaic battery on substances, Faraday prepared a solution (by dissolving copper with nitric acid) and then retrieved one of the initial components (copper). In other words, Faraday prepared a "compound" from a known element (copper) and showed that the voltaic battery was capable of breaking down the "compound", regenerating the element he had in the beginning. Faraday then used the same device on water wishing that the public would understand that the action was of the same type. He made clear that a little acid was necessary, pointing out that it was "only for the purpose of facilitating the action; it undergoes no change in the process." (Faraday, 1861, p. 100.) However, this was not demonstrated. The public had to accept that the acid was only superficial or accidental in this case, and not an essential part of the phenomenon under scrutiny. One of the hard conclusions one could take from this reasoning is that recognizing what is essential or accidental depends on the context of the studied phenomena and might only be stated by the lecturer's (scientist, teacher, researcher) previous knowledge but never by the experiment results themselves. This highlights an inherent tension between theories and experiments in science making (Chalmers, 1993).

Experiment 7 – more analysis

Faraday repeated the decomposition of water, but this time he collected the gases produced on each electrode in separate bottles. It could be observed that one of the bottles became full of gas faster than the other. Both gases were colorless and similar in all aspects at first sight. Faraday then moved on to examine them. By testing the gas contained in the bottle that was filled faster he observed all the qualities already seen for hydrogen. Inside the other bottle Faraday put a lit splint and saw the enhancement of its combustion. Faraday pointed out that this bottle contained the other component of water which "must have been taken from the atmosphere" (Faraday, 1861, p. 108) – and was called oxygen.

Faraday explained that there were other ways to obtain oxygen. He prepared a mixture of manganese oxide with potassium chlorate and heated it in a retort to release oxygen. Faraday remarked that the gas so produced was the same as the one obtained from the decomposition of water – "transparent, undissolved by water, and presenting the ordinary visible properties of the atmosphere." (Faraday, 1861, pp. 111-112.) By placing a lighted candle in this gas, its flame became more intense. Faraday remarked: "It is wonderful how, by means of oxygen, we get combustion accelerated ... all combustions of the common kind." (Faraday, 1861, p. 115.) The same was shown to happen in the combustion of iron, sulfur and phosphorus.

At this point, Faraday seemed to consider that the public was ready for definitive conclusions from all that was tested so far:

Why does a piece of potassium decompose water? Because it finds oxygen in the water. What is set free when I put it in the water, as I am about to do again? It sets free hydrogen, and the hydrogen burns; but the potassium itself combines with oxygen; and this piece of potassium, in taking the water apart – the water, you may say, derived from the combustion of the candle – takes away the oxygen which the candle took from the air, and so sets the hydrogen free... (Faraday, 1861, pp. 119-120.)

When separately collected the two gases produced in the electrolysis of water, Faraday once again drew on the analysis of the problem into simpler parts. By comparing properties considered essential Faraday identified hydrogen and oxygen. Finally, the lecturer summarized the various findings and explained them in terms of different and successive combinations of hydrogen and oxygen with other elements or with one another.

One could notice in this last quotation of Faraday's narrative a rapid mention with an anthropomorphous character, as he suggests that potassium somehow "finds oxygen in the water". The learning obstacles derived from this approach to science have been well discussed in the specialized literature and should be familiar to all chemistry teachers (Taber, Watts, 1996; Lopes, 1992).

Experiment 8 – closing the circle

To complete the reasoning it was necessary to explain why oxygen has properties similar to those of atmospheric air but more pronounced. In other words, it was necessary to explain what else exists in the atmosphere, besides oxygen. That was precisely what Faraday made in the sequel.

The next experiment aimed at investigating the composition of the atmosphere. In two separate bottles, a sample of pure oxygen and another of atmospheric air were independently put in contact with nitric oxide[3]. In the bottle containing pure oxygen an intensely red gas was formed. With atmospheric air the red gas was also formed but in smaller scale. Keeping the system isolated from the atmosphere, Faraday dissolved the red gas in water, added more nitric oxide and repeated these steps until all the oxygen present in the initial sample of air was consumed. This was suggested by the fact that new additions of nitric oxide could not produce the reddish gas anymore. Faraday concluded that the remaining gas was a part of the atmosphere that

3 In current chemical language, this gas corresponds to NO.

was not oxygen. So the atmosphere consisted of two parts: oxygen, which was responsible for combustion; and another substance, nitrogen, which did not take part in combustion but constituted most of the volume of air. The lecturer also pointed out to the low chemical reactivity of nitrogen.

Faraday then returned to the candle flame in order to extract further information from it. He had observed earlier that, besides water, the candle also produces soot – and one other product that would be focused now. Faraday surrounded a lighted candle with a container whose top was not closed but extended in a glass tube. He observed that most of the moisture produced condensed on the walls of the container and the air that left the tube at the top was able to extinguish another flame put close to it (Figure 6). Faraday then asked if there was any other gas there, besides the already expected and little reactive nitrogen. To answer that, he gathered some of the gas that emerged from the flame, added some freshly prepared limewater and shook the bottle vigorously. Faraday noted that the water became milky. Repeating the test with a bottle containing only atmospheric air, Faraday pointed out that neither oxygen nor nitrogen are capable of causing change in limewater. Therefore, the property of changing limewater should belong to the other combustion product of the candle: a gas that Joseph Black called "fixed air", for it was present in fixed (*i.e.*, solid) things, such as marble and other rocks. Then Faraday presented another simple method of obtaining carbon dioxide: by adding muriatic acid (*i.e.*, hydrochloric acid) to pieces of marble he produced large amounts of gas which also presented the properties of extinguishing a flame and clouding limewater.

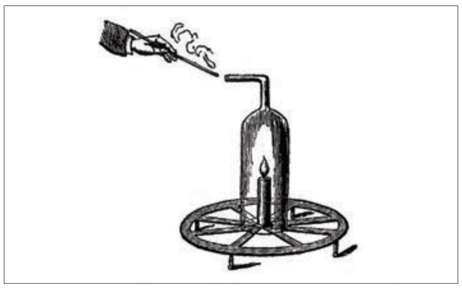


Figure 6 – Device assembled to test properties of carbonic acid. (Faraday, 2002, p. 142)

Faraday also remarked that, when a candle does not burn well, it releases smoke in the form of black particles. The smoke is carbon soot that, had it been completely burned, would be released as carbon dioxide. In order to illustrate this point, Faraday burned carbon – common coal – and showed that it burns in a characteristic way, producing sparks but not a flame.

Bearing in mind that carbon dioxide is a compound of carbon and oxygen, Faraday decided to break it down. For this, he used potassium again, the same substance already used to separate oxygen from hydrogen when put in contact with water. Faraday carefully warmed a small piece of potassium and introduced it in a flask containing carbon dioxide. The potassium "burned" slowly in the presence of this gas, but once more it combined with oxygen. To investigate the products, Faraday put the residue in water and called attention to the presence of non-soluble carbon. Another product was potash which dissolved in water. Faraday concluded by remarking that carbon is the only known elementary solid substance whose combustion product disperses as a gas – unlike, for example, iron, which burns into a solid, or phosphorus, whose ignition gives off an opaque smoke.

In this last series of selected experiments, Faraday concluded a line of reasoning that started with the observation of a burning candle. The logical sequence about the composition of the atmosphere was completed, and the question about the "other component" of the candle, besides hydrogen (*i.e.*, carbon) was resumed. The use of potassium as a tool to break down carbon dioxide is important here, since it resorts again to the analogy of the decomposition of water through the same metal. One may also observe that Faraday discussed the composition of substances basically by demonstrating both their synthesis from simple substances and its decomposition into the same ones. By doing so, Faraday was following the example of Lavoisier, whose approach to the composition of a compound followed this model.

Taking all of these considerations together, one could say that Faraday's narrative expresses something like a chemical reasoning which is intrinsically difficult to follow. Thus it deserves a more cautious approach, particularly among teachers. In a recent paper, Bensaude-Vincent (2009) describes chemistry as a laboratory science, whose practitioner's style of thinking is historically related with "knowing through making", with particular interest in the manipulation of materials in the laboratory environment (pp. 369-371). The author describes three main attributes of this style of reasoning, which are: 1) the knowledge of materials relies on the operation of physical changes and transformations of them, with great relevance attributed to the processes of decomposition and synthesis; 2) the work of chemists combines physical with mental activity, highlighting the operational difficulties in designing and performing experiments in close relation with the work with theories; and 3) following recipes of preparations well-established by long processes of trial and error plays an important role in chemists formation as well as in their practice (*idem*).

According to Bensaude-Vincent, one of the main features of chemists' work is that they tend to deal with individual substances instead of considering matter in general. For chemists are interested in understanding the specific properties and the behavior of individual materials (Bensaude-Vincent, 2008). These properties represent precisely what allow one to distinguish a substance from others that might eventually group in a class (e.g. acids, salts etc.). The specificity of such analysis is inherent to chemistry and represents part of what Bensaude-Vincent concludes to be "the most stable feature of the chemists' style of reasoning" (*idem*, p. 374). So the argument that considers essential and accidental properties in a given context, as well as the criteria which, combined, allow one to positively state the identity of a given substance is not a trivial matter, and teachers must be aware of that.

FINAL REMARKS

Faraday's *Chemical history of a candle* can be a rich source of activities for chemistry teaching, at different levels. Faraday starts from an ordinary phenomenon, well known to his public and then discusses several chemical concepts. It is interesting to note how fire is not a common subject in chemistry classes anymore, as noted by Bachelard:

In the course of time the chapters on fire in chemistry textbooks have become shorter and shorter. There are, indeed, a good many modern books on chemistry in which it is impossible to find any mention of flame and fire. Fire is no longer a scientific object. Fire, a relevant immediate object… no longer offers any perspective for scientific investigation (Bachelard, 1973, pp. 10-11).

That would be another point to be debated with training teachers. Faraday's book can help to bring back fire as a theme for the chemistry classroom. The use of Faraday's text serves as an example of the use of historical material in science teaching: one can explore its chemical content, by introducing topics that are still valid today, and that can be eventually deepened in further classes. Furthermore, as suggested above, it points to several aspects of scientific thought.

In addition to several other studies already published, this paper intended to shed a new and a complementary perspective on Faraday's series of lectures on the chemical history of a candle. By revisiting his experiments and speech we found some implicit aspects that could emerge as potential topics to be discussed among science teachers, raising questions on how hard it could be for students to understand: the role played by invisible agents in chemical processes; the tension between essential and accidental properties in characterizing a substance; how hard to see might be the points of similarity between two or more analogous chemical processes; and how the operations of synthesis and analysis relate to a particular way of reasoning in chemistry.

The use of a famous text, such as Faraday's, may also show teachers that there is no "perfect" didactic material. As we have endeavored to show, teachers have much to learn from Faraday's didactic strategies; however, even a lecturer so praised for the clarity of his exposition may face difficulties in making clear a complex train of reasoning (Cantor, 1991; Lan, Lim, 2001) and some of his analogies and explanations we may no longer wish to use. Teachers must deal with the inherent complexity of chemistry teaching, by recurrently reflecting on their curricular choices and on pupils' possible misconceptions.

Note

The full content of Michael Faraday's *Chemical History of a Candle* is public domain. The illustrations presented in this article were digitized by the authors from a Dover publication (Faraday, 2002) under written consent of their rights & permissions department.

ACKNOWLEDGEMENTS

The authors thank the anonymous reviewer for valuable suggestions. This research was supported by the Brazilian agencies *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP). JAZN thanks the Dean's Office for Undergraduate Studies, Universidade de São Paulo (PRG-USP) for a grant (*Programa Ensinar com Pesquisa*).

BIBLIOGRAPHY

Abd-el-Khalick, F., Lederman, N. G., The influence of history of science courses on students' views of nature of science, *Journal of Research in Science Teaching,* **37**, 1057-1095, 2000.

Allchin, D., Pseudohistory and pseudoscience, *Science & Education,* **13**, 179-195, 2004.
Bachelard, G., *La psychanalyse du feu*, Gallimard, Paris, FR, 1973.
Baldinato, J. O., A química segundo Michael Faraday: um caso de divulgação da química no século XIX. Dissertação (mestrado em Ensino de Ciências), Universidade de São Paulo, São Paulo, 2009.
Baldinato, J. O., Porto, P. A., Michael Faraday e a História Química de uma Vela: um estudo de caso sobre a didática da ciência. *Química Nova na Escola*, **30**, 16-23, 2008.
Bensaude-Vincent, B., The Chemists' Style of Thinking, *Berichte zur Wissenschaftsgeschichte*, **32**, 365–378, 2009.
Braathen, P. C., Desfazendo o mito da combustão da vela para medir o teor de oxigênio no ar, *Química Nova na Escola*, **12**, 43-45, 2000.
Cantor, G., Educating the judgment: Faraday as a lecturer, *Bulletin for the History of Chemistry*, **11**, 28-36, 1991.
Cavicchi, E., Faraday and Piaget: experimenting in relation with the world. *Perspectives on Science,* **14**, 66-96, 2006.
Chalmers, A. F., What is this thing called science?, 3rd ed., University of Queensland Press, Queensland, AU, 1999.
Crawford, E., Michael Faraday on the learning of science and attitudes of mind, *Science & Education,* **7**, 203-211, 1998.
Dias, V. S., Martins, R. A., Michael Faraday: o caminho da livraria à descoberta da indução eletromagnética, *Ciência e Educação*, **10**, 517-530, 2004.
Faraday, M., *A Course of Six Lectures on the Chemical History of a Candle*, Harper and Brothers, New York, US, 1861.
Faraday, M., *A Course of Six Lectures on the Chemical History of a Candle*, Dover Publications Inc., Mineola, US, 2002.
Gooday, G., Lynch, J. M., Wilson, K. G., Barsky, C. K., Does Science Education Need the History of Science? *Isis*, **99**, [2], 322-330, 2008.
Höttecke, D., How and what can we learn from replicating historical experiments? A case study, *Science & Education*, **9**, 343-362, 2000.
Höttecke, D., Silva, C. C., Why implementing history and philosophy in school science education is a challenge: An analysis of obstacles, *Science & Education*, **20**, 293-316, 2010.
James, F. A. J. L., Constructing Space for Science at the Royal Institution of Great Britain, *Physics in Perspective*, **9**, 130-185, 2007.
Knight, D., Popularizing chemistry: Hands-on and hands-off. In: Schummer, J., Bensaude-Vincent, B., Van Tiggelen, B. (Eds.) The public image of chemistry, World Scientific, Singapore, SG, 2007. p. 123-135.
Lan, B. L., Lim, J. B. S., Michael Faraday: Prince of Lecturers in Victorian England, *The Physics Teacher*, **39**, 32-36, 2001.
Lopes, A. R. C., Livros didáticos: obstáculos ao aprendizado da ciência química I – obstáculos animistas e realistas, *Química Nova*, **15**, [3], 254-261, 1992.
Manrique, F., Morales, R., Sanabria, Q. A., ¿Y por qué estas velas no se apagan? Una unidad didáctica a partir de la historia química de una vela. In: Daza, S., Quintanilla, M. (Eds.) *La enseñanza de las ciencias naturales en las primeras edades*, vol 5, Litodigital, Barrancabermeja, CO, 2011, p. 270-288.
Martins, R. A., Alessandro Volta e a invenção da pilha: dificuldades no estabelecimento da identidade entre o galvanismo e a eletricidade, *Acta Scientiarum*, **21**, 823-835, 1999.
Massarani, l., Moreira, I. C., Popularization of science: historical perspectives and permanent dilemmas, *Quark*, 32, 75-79, 2004.
Porto, P. A., História e Filosofia da Ciência no Ensino de Química: em busca dos objetivos educacionais da atualidade. In: Santos, W. L. P., Maldaner, O. A. (Orgs.) Ensino de Química em Foco, Unijuí, Ijuí, BR, 2010. p. 159-180.
Souza, K. Ap. F. D., Porto, P. A., History and Epistemology of Science in the Classroom: The Synthesis of Quinine as a Proposal. Journal of Chemical Education, **89**, 58-63, 2012.
Stinner, A., McMillan, B. A., Metz, D., Jilek, J. M., Klassen, S., The renewal of case studies in science education, *Science & Education*, **12**, 617-643, 2003.
Taber, K. S., Watts, M., The secret life of the chemical bond: students' anthropomorphic and animist references to bonding, *International Journal of Science Education*, **18** [5], 557-568, 1996.
Viana, H. E. B., Porto, P. A., The Development of Dalton's Atomic Theory as a Case Study in the History of Science: Reflections for Educators in Chemistry. Science & Education (Dordrecht), **19**, 75-90, 2010.
Vidal, P. H. O., Porto, P. A., Algumas contribuições do episódio histórico da síntese artificial da ureia para o ensino de química. História da Ciência e Ensino: construindo interfaces, **4**, 13-23, 2011.
Walker, M., Gröger, M., Schlüter, K., Mosler, B., A bright spark: open teaching of science using Faraday's lectures on candles, *Journal of Chemical Education*, **85**, 59-62, 2008.
Wandersee, J. H., Ggriffard, P. B., The history of chemistry: potential and actual contributions to chemical education. In. Gilbert, J. K., et al. (Eds.) *Chemical Education: Towards Research-Based Practice*, Kluwer Academic Publishers, Dordrecht, NL, 2002, p. 29-46.
Zoller, U. Are lectures and learning compatible? Maybe for LOCS; unlikely for HOCS, *Journal of Chemical Education*, **70**, [3], 195-197, 1993.

Received 15-10- 2012/ Approved 29-04-2013

E-learning through the eyes of the Czech students

Aprendizaje electrónico desde el punto de vista de los estudiantes universitarios

Milan Klement

Faculty of Education of Palacky University Olomouc, Zizkovo nam. 5, 771 40 Olomouc, Czech Republic, milan.klement@upol.cz

Abstract0:

The study presents the attitudes of university students towards e-learning, as one of the up-to-date forms of education, within the framework of their undergraduate studies. Above all, this regards education realized through e-learning with information, curriculum, control incentives and communication being transmitted by means of modern communication technologies and using the World Wide Web, called simply the Internet. It also illustrates the course of the research investigation, carried out from the year 2007 to 2011, and submits some of the outputs. The main objective of the above mentioned investigation having been to determine the preferences and opinions about the form, the organization of e-learning and about the tools applied, the present study is conceived as a contribution to the discussion about the possibilities and limits of the use of a fully electronic learning within the framework of the undergraduate and lifelong learning, based on the use of modern information and communication technologies.

Key words: *e-learning, electronic study support, pedagogical research, university students, nonparametric statistical methods.*

Resumen:

El estudio presenta las actitudes seleccionadas de los estudiantes universitarios ante el aprendizaje electrónico, como una de las formas de enseñanza moderna en la realización de sus estudios. Se trata de una forma de aprendizaje en la que la distribución y la presentación de la información, materiales, estímulos dirigentes y de comunicación usamos las tecnologías comunicativas modernas que utilizan la red informática mundial World Wide Web, simplemente llamada Internet. El estudio presenta el transcurso y algunos resultados elegidos de la investigación entre los años 2007 y 2011. El fin principal de esta investigación fue el conocimiento de las preferencias y actitudes de los estudiantes ante la forma, organización, herramientas individuales o elementos de aprendizaje electrónico. La investigación presentada es una aportación a la discusión sobre las posibilidades y límites de la utilización total del aprendizaje electrónico en la educación pregradual o permanente que está basada en el uso de las tecnologías informáticas y comunicativas modernas.

Palabras clave: *aprendizaje electrónico, apoyo estudiantil electrónico, investigación pedagógica, estudiantes universitarios, métodos estadísticos no paramétricos.*

INTRODUCTION

The perception of e-learning is often ambivalent and inconsistent, the main reason being an inhomogeneous terminology, to a great extent influenced by the linguistic impacts and by the diversity of approaches and technologies used (Saettler, 1990). On both sides of the Atlantic, activities related to the supporting of the education process by ICT (i.e. e-support) are not defined as e-learning, in favor of relatively set phrases of Computer-Based Training (CBT), Internet-Based Training (IBT) or Web-Based Training (WBT) (Lowenthal & Wilson, 2009). In Europe, a consensus was reached upon the use of a unified term of e-learning, which, according to the information at the e-learning portal for Europe Elearningeuropa.info, is understood as the *application of new multimedia technologies and the Internet in education, in* *order to improve its quality by enhancing access to resources, services, the exchange of information and cooperation* (Simonova, 2010).

According to this definition, e-learning covers not only a wide range of tools that are used for the presentation or the transfer of the educational content and for the management of studies, but also an entire spectrum of communication channels. The tools are used via LMS (Learning Management System), which is a prerequisite for the implementation of a truly effective learning process through e-learning. LMS thus represents a virtual ´classroom` environment comprised of tutorials, quizzes, study instructions, exercise plans or discussion forums (Mauthe & Thomas, 2004).

Apart from LMS, properly structured and didactically adapted educational texts, *referred to as e-learning supports* (Paulsen, 2003) contribute significantly to the implementation of e-learning. To get a clear and permanent definition of the term, it is therefore necessary to focus on the structure and the arrangement of individual elements that such a teaching material is composed of. Study materials for distance learning, in both classical form and the form of e-learning, have gradually evolved from textbooks. In terms of the text structure, a classical textbook (Möhlenbrock, 1982) is composed of two basic components, i.e. text components (´written text`) and extra textual components (graphical components). It should nevertheless be noted that e-learning supports have their own unique characteristics as they are intended for a particular form study, characterized above all by a higher level of independence and individuality (Bates & Poole, 2003). A characteristic feature of thus structured electronic study supports designed for e-learning is the fact that their nuclear structure is enhanced by various interactive and multimedia elements, i.e. animation, multimedia records, dynamic simulation, sound recordings, etc., as shown in the figure number 1.

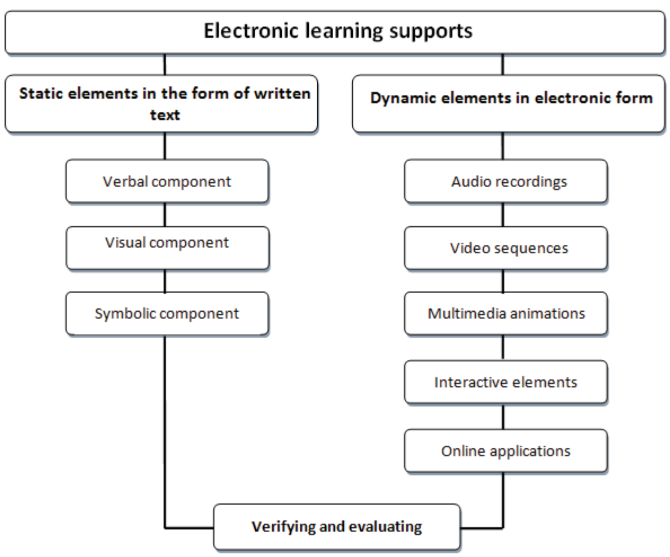


Figure1 – Electronic learning support structure

Having taken into account all the above stated facts, the author of the present study carried out a long-term investigation focused on monitoring and evaluating students' attitudes to e-learning enhanced by sophisticated electronic and multimedia enriched learning supports (Klement, 2010). These comprised and made use of tools designed to achieve cognitive, affective, as well as psychomotor learning objectives, completely in compliance with modernization trends in this area. Thus each e-learning support contained not only a static text part, i.e. verbal component of the text, a visual portion of the text, i.e.visual component of the text (images, diagrams, graphs, etc.), but also a dynamic part, i.e. dynamic component of the text in the form of multimedia extension, i.e. animation solutions, or even interactive simulations of particular steps (Chudy & Candik, 2004), through which students could acquire the necessary skills.

METHODOLOGY

The main objective of the research investigation was a collection and an evaluation of the ideas and attitudes of the students to the training carried out through e-learning. This objective was planned to be achieved through particular component parts, each of them designed to seek the views and attitudes of students to the e-learning form of study as a whole as well as to its individual components and to the very electronic structure of the learning supports. Every single component part of the research investigation was formalized into questions, which were then put together to create an anonymous structured questionnaire (Foddy, 1994), which students filled out according to the instructions supplied. At that time, the students interrogated had no pedagogical training, to which fact the terminology was adapted and their definition was simplified (e.g. instead of the term verbal component of the text, *static text information* was used, instead of the term visual component of the text, *static image information* was applied, and instead of the term dynamic element in electronic form *dynamic visual information - interactive simulation and animation* were included).

In compliance with the above mentioned, we formulated the research assumptions that would respect the modernizing trends in the field of education supported by information and communication technologies. We stemmed from the following assumptions:

- students are satisfied with the education realized through e-learning because they like the fully electronic learning environment in the form of LMS. Their interest in the above mentioned is a long-term one,
- students gain most knowledge using static elements of electronic learning supports in the form of text, as they consider them optimal for achieving cognitive learning objectives,
- most real ideas are adopted by students through static elements of electronic learning supports in the form of pictures, graphs and tables, as the latter allow them to exploit a wider range of learning strategies based on demonstration,

The investigation sample (Creswel, 2008), selected in order to verify the assumptions of the research, consisted of 501 first-year students of universities, who carried out a part of their studies through e-learning. The structure of the investigation sample is shown in the following table No. 1

Table 1 – Research sample structure

year	2007	2008	2009	2010	2011	S	$S_{\%}$
S_{women}	40	39	46	56	39	220	**43,9**
S_{men}	53	63	59	48	58	281	**56,1**
S_{year}	93	102	105	104	97	501	
$S_{\% year}$	**18,6**	**20,4**	**20,9**	**20,8**	**19,4**		**100,0**
education implemented through e-learning satisfaction level	4,3	7,8	5,7	5,8	5,2	29	**5,8**
education implemented through e-learning dissatisfied level	95,7	92,2	94,3	94,2	94,8	472	**94,2**

The validation of the research objectives set was carried out by means of the static nonparametric method of Pearson chi-square (Pearson's chi-squared test), which helped us to determine the level of the dependence of the results on a particular feature significant for a group of respondents, such as gender or age (Greenwood & Nikulin, 1996). To determine the significance of particular groups of respondents who answered the same way, basic descriptive statistics and their visualization through tables was used. For the calculation purposes, the statistical system Statistica 9.0 (Nisbet et al., 2009) was applied.

RESULTS

The ideas and the attitudes of the students concerning distance education through e-learning

The main factor examined in this part of the investigation was the level of satisfaction of the students with the organization of education implemented through e-learning, the educational content being transmitted not primarily within the framework of a regular full-time teaching, but via monitored self-study (Vasutova, 2002), making use of convenient e-learning supports, incorporated into LMS. A research premise was set up that *students are satisfied with the organization of teaching through e-learning, with the educational content being primarily mediated via e-learning supports and the LMS system providing them with the communication, evaluation and management aspect of study*. We verified this assumption by analyzing data collected throughout the investigation. In addition to the general opinion on this issue, we monitored the long-term trends in this area and we also analyzed the potential dependence of the students' opinions based on gender. The results of this verification are given in the Table 2 and the contingency Table 3.

Having analyzed the results obtained, we could state that the *students actually are satisfied with the organization of education through e-learning, supposing that the educational content is primarily mediated via e-learning supports and the LMS system provides them with the communication, evaluation and management aspect of study*, as the total of 94.2% of the respondents gave an affirmative response to the question and only 5.8% of them answered negatively. It is possible to say that *the students' satisfaction with the organization of education through e-learning is permanent,* as over the years the investigation was conducted, consistent results were obtained. The highest level of dissatisfaction with the organization of education through e-learning was recorded in 2008 and amounted to 7.8% of the respondents, while the highest level of satisfaction with the arrangement of education through e-learning appeared in 2007 and amounted to 95.7%. However, both these values only slightly deviate from the overall outputs (as regards dissatisfied respondents, the difference is about 2%, with satisfied respondents the numbers differ just by 1. 5%). It is thus possible to say that the results obtained in different years do not differ significantly, and therefore we can state that *the development trend in this area, i.e. the opinions and attitudes of students, is stable and shows neither growth nor decline*

The objectivity of the outputs was verified by the implementation of a further analysis, the aim of which was to determine potential dependence of the data obtained on the gender of the respondents. To achieve this, we made use of the chi-squared test, the results being presented in the contingency table number 2.

Table 2 – Organization of education implemented through e-learning satisfaction level in % of students (women versus men)

Contingency table, cell frequency > 10 marked in italics
Pearson's chi square: 4.1202, levels of skewness: 1, level of significance = 0.0424

Respondents' gender	Dissatisfied	Satisfied	Line sums
Women	*18*	*202*	**220**
Men	*11*	*270*	**281**
All groups	**29**	**472**	**501**

Since the calculated level of significance is 0.04, as shown in Table 2, we can state that the frequency of responses given by men and women as regards the level of their satisfaction with the arrangement of teaching through e-learning are different, and therefore the assessment partly depends on the gender of the respondents. The interpretation of the result obtained can be such that dissatisfied women are more numerous than discontented men. It is also true that the level of the respondents unhappy with the above stated situation being so low (see the total percentage of the students dissatisfied where women make up only 3.6% and men even only 2.2%), the dependence of the outputs on gender was rather surprising and incited further examination.

A possible explanation for the above stated finding could be just another assumption that in addition to e-learning, as a predominantly non-contact form of teaching, using primarily self-study and online communications, women also prefer different forms of the educational process, which can provide them with other things they value. These might for example be such components or characteristics of the educational process as a personal contact with colleagues, a personal contact with the teacher, a more directive way of monitoring the study, a smaller degree of autonomy in planning studies, and so on. Briefly, it regards those aspects of the educational process, which clearly belong to the domain of a regular full-time teaching. Another investigation assumption was therefore formulated that there exists a group of students who reject distance learning and unequivocally prefer regular full-time teaching.

As it was necessary to support the assumption by a tangible statistical output that would confirm the former with the desired degree of accuracy, a further analysis, based on the comparison of positive and negative answers by the respondents to the particular investigation questions, regarding the level of satisfaction among the students with e-learning as an appropriate form of study (students actually answered the question of whether e-learning was their preferred form of study) and the level of satisfaction among the students with the arrangement of teaching through e-learning (students were asked whether they preferred learning by means of electronic learning supports) was carried out. We conducted this analysis by comparing the results and by evaluating them via the chi-squared test. The results are shown by the contingency table number 3.

Table 3 – E-learning as an appropriate form versus organization of education implemented through e-learning satisfaction levels

Contingency table, cell frequency > 10 marked in italics
Pearson's chi square: 155.5761, levels of skewness: 1, level of significance = 0.0001

	Dissatisfied with the organization of e-learning	**Satisfied with the organization of e-learning**	**Line sums**
Dissatisfied with the form of e-learning	*21*	*23*	**44**
satisfied with the form of e-learning	8	*449*	457
All groups	29	472	501

The Calculated significance, as shown in Table 3, is 0.001, which clearly shows a high level of dependence in both areas analyzed. The interpretation of this output could be that the group of the students who are not satisfied with e-learning as an appropriate form of education is identical with the group of the students who are not satisfied with the very structure of e-learning. So there probably is a group of students, though not numerous at all, i.e. comprised of 21 students, which is 4.2% out of the total of 501 respondents, *whose attitude to educational activities via e-learning is rejection.*

The opinions of the students on particular structural elements of electronic learning supports

Our preparation and implementation of another part of the investigation mainly drew on Bloom's taxonomy of educational objectives, which, as one of the major pedagogical theories, deals with various aspects that affect the concept of education planning and curriculum development. Its contribution is perceived primarily in terms of the indication by it of the way towards specifying and operationalizing of educational goals. As early as in 1956, the lead author of the theory published a classic study entitled "The Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain '(Bloom, 1956), which was crucial, particularly because it defined the structure of cognitive training objectives in relation to various levels of thought processes. According to this model, the latter are arranged so that they follow each other from the trivial to more complex and comprehensive ones. In addition to the *cognitive circuit*, learning objectives from the other two circuits were gradually identified, i. e. the *affective circuit* (simplified as attitudes) designed along with Bloom`s cooperator D.B. Krathwohl (Krathwohl et al., 1964) and also the sensor motor or *psychomotor circuit* (simplified as skills) defined by H. Dave (Kalhous & Obst, 2002).

The results obtained in the particular component parts of this area of the investigation research are demonstrated in the following parts of the study. Each result is supported with a statistical analysis that aims at demonstrating the dependence or the independence of the results obtained on the gender of the respondents, at indicating the development trends with regards to the students' opinions and attitudes, all this based on an analysis of the answers of the respondents in each year of the research and on a comparison of the partial results with the overall ones.

Students' opinions on the acquisition of theoretical knowledge

In this case, we again applied the above mentioned investigating method to find out which structural element of electronic learning supports students prefer in order to gain theoretical knowledge when studying the subject matter by means of electronic learning supports designed for e-learning.

Based on the analysis of the results obtained, it can be said that with respect to gaining knowledge, the total of 54.1% of the respondents declared the static element in the form of textual information to be their most favourite structural element of the electronic learning supports, followed by 32.1% of respondents who preferred dynamic elements in the form of interactive animations, and 13.8 % of the respondents valuing static elements in the form of images. It is therefore possible to say that, with respect to gaining knowledge, the most preferred structural element of the electronic learning supports are static elements in the form of textual information.

Furthermore, we focused on whether the views of women and men were identical in this area. According to the results of the analysis, we concluded that the views of men and women in this area vary considerably, as evidenced by the pivot table number 4.

Table 4 - Students' opinions on the best structural element of the electronic learning supports with respect to the acquisition of knowledge (women versus men)

Contingency table, cell frequency > 10 marked in italics Pearson's chi square: 14.4260, levels of skewness: 2, level of significance = 0.0007				
Respondents' gender	**Favourite element- text**	**Favourite element – pictures, images**	**Favourite element - animations**	**Line sums**
Women	*135*	*17*	*68*	**220**
Men	*136*	*52*	*93*	**281**
All groups	**271**	**69**	**161**	**501**

Since the calculated value of significance is 0.0007, as shown in Table 4, we can conclude that the frequency of the responses given by men and women as regards their favourite electronic learning supports' structural element with respect to the acquisition of knowledge are not the same, and therefore this assessment is dependent on the gender of the respondents. The observed results can be interpreted so that in comparison with men, women more often prefer acquiring knowledge via text.

Students' opinions on the best structural element of the electronic learning supports with respect to the acquisition of real ideas

The next step in the research was to analyze the students' opinions regarding their *favourite structural element of electronic learning supports with respect to obtaining real ideas.* Having analyzed the collected data, we came to a conclusion that with respect to gaining real ideas within the framework of the studies using electronic learning supports, students regard as the most appropriate element static structural elements, in the form of static visual information (pictures, graphs, tables, etc.). To sum up, it is possible to state that *the most preferred structural element for the acquisition of real images within the framework of the study realized through electronic learning supports is the visual static information*. It is also possible to argue that *this trend in the students' opinions is stable and shows neither growth nor decline*, because the partial results observed in individual years did not differ significantly from the overall results obtained through the entire period of the investigation research conduct. The fact is illustrated by table 5.

Table 5 - Students' opinions on the best structural element of the electronic learning supports with respect to the acquisition of real ideas (percentage)

Students' opinions on the best structural element of the electronic learning supports with respect to the acquisition of real ideas (percentage)						
	year 2007	year 2008	year 2009	year 2010	year 2011	**average**
Static textual information (%)	24.7	22.5	21.9	24.0	23.7	**23.4**
Static visual information (%)	55.9	52.9	58.1	46.2	56.7	**53.9**
Dynamic visual information (%)	19.4	24.5	20.0	29.8	19.6	**22.8**

We can also prove that the above stated result is independent of the gender of the respondents, which is shown by the contingency table No. 6.

Table 6- Students' opinions on the best structural element of electronic learning supports with respect to the acquisition of real ideas (women versus men)

Contingency table, cell frequency > 10 marked in italics Pearson's chi square: 5.1077, levels of skewness: 2, level of significance = 0.0777				
Respondents' gender	**Favourite element- text**	**Favourite element – pictures, images**	**Favourite element - animations**	**Line sums**
Women	*41*	*128*	*51*	**220**
Men	*76*	*142*	*63*	**281**
All groups	**117**	**270**	**114**	**501**

Since the calculated value of significance is 0.08, as shown in Table 6, we can argue that the frequency of particular male and female responses in terms of their views on the best structural element of electronic learning supports aimed at the acquisition of real ideas are identical. This evaluation can thus be regarded as independent of the gender of the respondents.

DISCUSSION

The idea of a completely natural use of ICT, including e-learning tools and LMS, by today's generation of students, is more or less taken as a fact, based on two major arguments. The first one stems from the fact that today's adolescents and even infants deal with and manage the computer technology with a rather striking spontaneity. The second argument is based on the statistics demonstrating the level of dependence of the use of ICT on age, showing that unlike older generations; nearly all adolescents use the Internet and mobile phones (Lupac, 2011). It is around these arguments that Don Tapscott American (1998) built his essays claiming that the power model of the family was disturbed, because, unlike the past, children were taking over the teaching role and educated their parents with respect to the orientation in the digital environment. His concepts of N-GEN and that of the digital generation were soon followed by other concepts, i.e. digital natives (Prensky, 2001a), homo-zappiens (Veen & Vrakking, 2006), digitally birth (Palfrey & Glasser, 2008) and others. "Digital natives are used to receiving information very quickly. They like doing more activities at a time (i.e. multitasking). They prefer the image processing over the processing of the text. They prefer a random access to information (i.e. hypertext) and they like best working in a networked environment (online). They expect immediate praise and frequent evaluation of their work". (Prensky, 2001a). The ideas of Prensky and Tapscott were quite influential at the time and have later become subject to several attempts, more or less successful, by various researchers, to refute them (Bennett, Maton & Kervin, 2008).

Although the author of the present study is neither a supporter nor the opponent of the idea of a different approach to the education of ´digital natives`, he believes that education through e-learning, with the widest possible use of ICT, may offer a suitable scope for the verification of certain characteristics of the generation of digital natives. The above stated attitudes of the Czech university students on e-learning can thus help with the identification or the determination of the extent of a potentially existing group of students who do have digital thinking (Prensky, 2009). Since the students involved in the research implemented fall into this group (all students were born after 1990), it is possible to verify some selected features, typical for a group of digital natives, on the results identified.

1. Firstly, a group of digital natives can be characterized as *„preferring random access to information (hypertext) and giving best performance in a networked environment (online)"* (Prensky, 2001a). According to the results achieved, there is a group of the students who demonstrably refuse to study via e-learning, even with the latter being implemented through hypertext instructional materials and online environment. Although many other factors may have impact on the fact, the question arises whether the generation of the students born after 1990 (this corresponds to the general implementation of ICT in the Czech Republic) really do prefer only online educational activities or not.

1. Secondly, a group of digital natives should be *„preferring processing visual material prior to the text"* (Prensky, 2001a). In this case, the results obtained definitely confirmed the characteristic as it is clear that students absolutely prefer visual information to text.

Within the framework of such a rapidly evolving field as this one undoubtedly is, it is almost impossible to keep sufficient distance, necessary for the achievement of an ´unbiased assessment`, which itself is a prerequisite for a professional discussion supported by facts. It is thus necessary to perceive the above stated findings rather as stimuli for further discussion, resulting in a more responsible and balanced approach to the needs of the students whose studies are, though only partly, implemented through e-learning.

CONCLUSIONS

Although the above stated results cannot be regarded as significant, they indicate trends that should be taken into consideration by up-to-date education making use of electronic distance learning texts and LMS. The attitudes of the students could provide us with a guideline helping to find the optimal way towards satisfied, educated and professionally prepared tertiary education graduates and graduates of lifelong learning programmes. The investigation research conducted shed some light on some of the preferences and attitudes of the students related to this field, which can be regarded as long-term. It can therefore help all those who want to design e-learning tools to meet the needs of their students or pupils the best way possible.

The authors recomment the following guidelines for future work involving: 1. design of appropriate e-learning tools; 2.conducting surveys of attitudes and opinions of students on education via e-learning, and 3. carrying out investigations focused on the issue of the evaluation of electronic learning supports. These guidelines are based, in part, on the research results presented in this paper.

1. It is necessary to accept the fact that the ´classical` concept of distance learning (from which e-learning is often said to have derived) is focused on the text, in the form of a distance learning text or electronic learning supports, as they are often referred to, as the main carrier of information (knowledge, skills, attitudes, etc.).
2. It is essential to recognize the fact that e-learning allows the use of electronic distance learning texts or electronic learning supports, as they are often referred to, comprising several carriers of the educational content, which are very often of multimedia character.
3. Simulation and virtual reality makes for the extension of the field of achieving psychomotor educational goals through e-learning by experimental activities in virtual labs and via virtual simulations.
4. When using the above stated education forms, it is necessary to choose an appropriate teaching strategy, reflecting the possibility of using such carriers of the educational content, which would match the objectives to be achieved.

ACKNOWLEDGEMENTS

The paper was written within the framework of the no P407/11/1306 project entitled “Evaluation of study materials designed for distance education and learning”, supported by GA R.

BIBLIOGRAPHY

Bates, A., & Poole, G. *Effective Teaching with Technology in Higher Education*. San Francisco: Jossey-Bass/John Wiley, 2003.

Bennett, S., Maton, K., & Kervin, L. *The ‘digital natives’ debate: A critical review of the evidence*. British Journal of Educational Technology 39(5), 2008.

Bloom, B. S. *The Taxonomy of Educational Objektives.The Clasifications of Educational Goals, Handbook I*, New York: David Mc Key Company, 1956.

Creswell, J. W. *Educational Research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River: Pearson, 2008.

Foddy, W. H. *Constructing questions for interviews and questionnaires: Theory and practice in social research*. Cambridge, UK: Cambridge University Press, 1994.

Greenwood, P.E., & Nikulin, M.S. *A guide to chi-squared testing*, J.Wiley, New York, 1996.

Chud , Š., & Candik, M. Vyuka *multimédií a multimediálních technologií v ucitelství informatiky.* In e-PEDAGOGIUM 4 (3)., pp. 22-33, 2004.

Kalhous, Z., Obst, O. *Školní didaktika*. Praha: Portál, 2002.

Klement, M. *Mo nosti evaluace vzd lávacích materiál ur en ch pro distan ní vzd lávání a e-learning*. In M. Chráska (Ed.) Trendy ve vzd lávání 2010. Olomouc: Votobia, 2010.

Kluge, S., & Riley, L. *Teaching in Virtual Worlds: Opportunities and Challenges*. In Issues in Informing Science and Information Technology 4(5), pp. 127-135, 2008.

Krathwohl, S. Krathwohl, D. R., Bloom, B. S., & Masia, B. B. *Taxononmy of Educational Objectives. Handbook II: The affective domain*; Longman Group Ltd, 1964.

Lowenthal, P. R., & Wilson, B. *A description and typology of the online learning landscape*. In: M. Simonson (Ed.), 32nd Annual proceedings: Selected research and development papers presented at the annual convention of the Association for Educational Communications and Technology. Washington D. C.: Association for Educational Communications and Technology, 2009.

Lupac, P. M*ýty (a realita) digitální generace*. Lupa.cz, 2011.

Mauthe, A., & Thomas, P. *Professional Content Management Systems: Handling Digital Media Assets.* John Wiley & Sons, 2004.

Möhlenbrock, R. *Modellbildung und Transformation.* Bad Salzdetfurth: Verlag Barbara Franzbecker, 1982.

Nisbet, R., Elder, J., & Miner, G. *Handbook of Statistical Analysis and Data Mining Applications*. Burlington, MA: Academic Press, 2009.

Palfrey, J., & Glasser, U. *Born Digital: Understanding the First Generation of Digital Natives.* Basic Books, 2008.

Paulsen, M. F. *Online Education and Learning Management Systems - Global Elearning in a Scandinavian Perspective*. Oslo: NKI Forlaget, 2003.

Prensky, M. *Digital Natives, Digital Immigrants*. On the Horizon 9(5), pp. 1-6, 2001.

Prensky, M. *Digital Natives, Digital Immigrants: Do They Really Think Differently?* On the Horizon 9(5), pp. 7-11, 2001.

Prensky, M. H. *Sapiens Digital: From Digital Immigrants and Digital Natives to Digital Wisdom*. In Innovate, 2009.

Saettler, P. *The evolution of American educational technology*. Englewood, CO: Libraries Unlimited, 1990.

Šimonová, I. *Styly uceni v aplikacích eLearningu*. Hradec Králové: M&V Hradec Králové, 2010.

Tapscott, D. *Growing Up Digital: The Rise of the Net Generation*. New York: McGraw-Hill, 1998.

Vašutová, J. *Strategie v uky ve vysokoškolském vzd lávání.* Praha: UK PedF, 2002.

Veen, W., & Vrakking, B. *Homo Zappiens. Growing Up In A Digital Age*. Network Continnum Education, 2006.

Received 08-02- 2012/ Approved 29-04-2013

Problem based learning environmental scenarios: an analysis of science students and teachers questioning

Aprendizaje basado en problemas en escenarios ambientales: un análisis de interrogación de estudiantes de ciencias y profesores

Torres, J., [1] Preto, C.[2], Vasconcelos, C.[3]

[1] Centro de Geologia da Universidade do Porto [2] Escola Secundária,
[3] Faculdade de Ciências/Centro de Geologia da Universidade do Porto, Portugal, jmstorres@gmail.com, carla_preto@hotmail.com,csvascon@fc.up.pt

Abstract

In a society driven by science and technology, education should facilitate the development of competences and critical thinking, preparing students to solve problems. Accordingly, problems can act as a stimulus for students learning and questioning, especially high order questioning, is a useful tool for the learning process. The purpose of this study was to: (i) quantify and classify the questions raised by students that arise from different scenarios (problems); (ii) analyze the motivation of students; (iii) quantify and classify the issues presented by their teacher as possible questions to be asked; and (iv) compare the number and type of questions raised by students with those suggested by their teachers. The study concludes that all scenarios lead to the raising of almost all types of questions, with a majority of encyclopaedic ones. Most students considered this approach motivating although some difficulties were pointed out.

Key words*: problem based learning, questioning, scenarios, science education, environmental education.*

Resumen

En una sociedad impulsada por la ciencia y la tecnología, la educación debe facilitar el desarrollo de las competencias y el pensamiento crítico, preparando a los estudiantes para la resolución de problemas. Por consiguiente, los problemas pueden actuar como un estímulo al aprendizaje y al cuestionamiento de los alumnos, en especial las preguntas de orden superior, herramientas fundamentales para el proceso de aprendizaje. El propósito de este estudio fue: (i) cuantificar y clasificar las cuestiones planteadas por los estudiantes que derivan de diferentes escenarios (los problemas), (ii) analizar la motivación de los estudiantes; (iii) cuantificar y clasificar los problemas presentados por su profesor como preguntas posibles de plantear; (iv) comparar el número y tipo de preguntas planteadas por los estudiantes con las sugeridas de sus profesores. El estudio concluye que todos los escenarios conducen al planteamiento de casi todo tipo de preguntas, con una predominancia de las enciclopédicas. La mayoría de los estudiantes consideró este enfoque motivador a pesar de algunas dificultades señaladas.

Palabras clave*: aprendizaje basado en problemas, cuestionamiento, escenarios de problematización; enseñanza de las ciencias, educación ambiental.*

INTRODUCTION

Since we live in a world of permanent change, strongly influenced by scientific and technological progress, there is a strong need to increase the scientific literacy of students. School plays a major role in the formation of the individuals' personalities, making them more responsible, informed and critical in order to ensure that they will be able to use knowledge adequately. Studies indicate that it is not possible to ensure scientific literacy using traditional instructional methods (Hodson, 1998). The learning of science needs to be more meaningful, relevant and interesting and students have to be more actively participant. Giordan and Vecchi (1996) consider the creation of disturbing situations crucial to significant knowledge construction, as students look for new solutions. Many studies (Chin, 2001; Dahlgren & Öberg, 2001; Chin & Chia, 2004; Palma & Leite, 2006; Oliveira, 2008; Loureiro, 2008) advocate questioning as a fundamental and privileged mean to prompt learning, being a powerful tool to improve the learning quality (Orlik, 2002). Indeed, it compels students to find solutions to the problem presented either by their teachers or by themselves. Questions raised by students unleashes important processes in the construction of scientific knowledge as it enables students to express their previous knowledge, to observe, to investigate, to create, to explain, to criticize, to take decisions and to develop their concepts and attitudes (Schein & Coelho, 2006). In fact, "through the thinking cognitive skill of questioning, thinking may have the potential to generate learning (Cuccio-Schirripa & Steiner, 2000, p. 210). However, students' questions must prompt inquiry and must be of a high cognitive level in order to promote a meaningful development of the apprentice. The quantity and quality (in terms of cognitive level) of questions varies according to the scenario (Dahlgren & Öberg, 2000; Loureiro, 2008; Oliveira, 2008), the methodologies, and depending on whether they are formulated individually or in groups (Palma & Leite, 2007). In spite of the importance of raising questions, students are reluctant to formulate them in the classroom possibly because they do not want to attract too much attention, or because they are not encouraged by teachers to do so (Marbach-Ad & Sokolove, 2000). It is important to investigate the ways to encourage and to promote the questioning by students, as well as to analyse the ways teachers use this learning approach. This study analyses how different scenarios worked in terms of promoting questioning. Questions raised by students and anticipated by their teachers were counted and analysed, and the students' motivation during their task was evaluated.

PROBLEM BASED LEARNING, QUESTIONING AND SCENARIOS

Problem based earning (PBL) is an inquiry-based learning (IBL) approach where problems play a major role acting as a stimulus for students' learning. This method is based on the principle of using daily-life problems as a point of departure for the learning process (Lambros, 2004; Vasconcelos & Almeida, 2012). Thus the problem is introduced in the beginning of the unit of study, hence ensuring that students know why they are learning and what they are learning, thereby increasing their motivation. In this way, all the information gathered by the students is learnt with the purpose of solving a problem (Chin & Chia, 2004). According to this method, the learning process begins with the identification of the problem itself: students are presented with a scenario generally related with the real world that will promote debate as well as the motivation to find something relevant to their personal lives. Moreover, students formulate questions that help to diagnose their knowledge and their difficulties. Through this process students learn to identify what they already know about a subject, what are their learning needs and which is the best way to solve the problem and achieve a relevant knowledge (Dahlgren & Öberg, 2001; Chin & Chia, 2004). The PBL process follows specific heuristic stages beginning with the preparation to the perception of the problem, where the teacher motivates the students. The students work in groups and are presented with a problematic situation (scenario), which is supposed to create a necessity to get the solution hence to learn more. Once they have encountered the problem, they have to identify what they already know, what they need to know and how they will achieve the information needed. After working in groups and getting a solution, students will check it in class, by presenting their arguments (Orlik, 2002; Lambros, 2004). In an IBL approach, students should be questioning, examining books, and other sources of information, writing hypothesis, analysing data, writing conclusions and communicating the results. Indeed, some authors argue that, although students achieve different autonomy levels within this approach, they are encouraged to develop their solving problems capabilities, which prepares them to be self-oriented and concerned citizens (DeBoer, 2004). Questioning is then recognized as a useful tool that facilitates the learning process, acting as a linkage between thinking and learning (Oliveira, 2008). Dewey (1933) argues that a question can evoke and encourage answers as well as may promote researching. Questions are common in our daily life as well as in classroom (Palma & Leite, 2006), being frequently applied in different ways and with different purposes. However, under the scope of PBL, questions should develop critical thinking and problem solving competences. As Aja and Espinel (2000) stated, good questions are those that generate processes of logical thought development.

Several studies indicate that, although teachers pose many questions in class, students formulate few questions and questions of low cognitive levels (Cuccio-Schirripa & Steiner, 2000; Oliveira, 2008; Vasconcelos et al, 2011). As Dillon (1990, p. 7) stated ''children everywhere are schooled to become masters at answering questions and to remain novices at asking them''. Although students rarely raise questions within a classroom context (Cuccio-Schirripa & Steiner, 2000; Oliveira, 2008; Vasconcelos et al, 2011), many authors state many reasons that justify the need for students to do so, such as: the emphasis on students' questions conveys the message that inquiry is a natural component of scientific subjects; students reveal their thoughts and concepts when raising questions; students' questions help teachers reach a broader understanding of the subject and might also increase students' understanding and assimilation of concepts (Marbach-Ad & Sokolove, 2000; Chin & Kayalvizhi, 2002). In fact, questions raised by students make them think about their own concerns (Orlik, 2002), activate their prior knowledge, facilitate their understanding of new concepts and increase their curiosity, promoting significant knowledge building and solving problems capabilities. Still, they become more enthusiastic when they search the answer to their own questions (Chin & Kayalvizhi, 2002). Considering this value of questioning within the learning process, it is very important that schools endorse the development of this ability to prepare students to be critical and to face an ever-changing society (Chin & Kayalvizhi, 2002). Note that both high and low cognitive level questions are relevant for learning (low cognitive questions can lead to the raise of questions of high cognitive levels). However, under the scope of PBL approach, high cognitive level questions are the ones that promote a more meaningful content insight and learning. This study uses a taxonomy of students' formulated questions that follows an adapted pattern of Dahlgren and Öberg (2001) and Chin and Chia (2004). The taxonomy includes seven categories as follows: Encyclopaedic Questions, that demand an unambiguous and not complex answer, such as a definition (e.g. What is QUERCUS?); Meaning-Oriented Questions, that do not have a direct answer, oriented towards finding a phenomenological meaning of certain terms or concepts (e.g., How does acid rain gets formed?); Relational Questions, that focus on relationship between features or cause/effects relations (e.g., Which diseases might be related with pollution?); Value-Orientated Questions, that demand for a judgment based on some criteria (e.g., What is the difference between pollution and contamination?); Solution-Oriented Questions, that focus on looking for solution(s) for a problem (e.g., What can citizens do to improve the situation?); Prediction Questions, that lead with imaginary situations and hypothesis (e.g., Can human population be extinct due to the excess of chemical and toxic residue?) and Debate Questions, that stimulate the discussion and understanding of society values, with non objective answer (e.g., Is it ethical to destroy what keeps us alive?). These categories can be split into two other: questions of a high cognitive level and questions of a low cognitive level (Hofstein et al., 2005; Carvalho & Dourado, 2009). The encyclopaedic questions are of a low cognitive level and the remaining questions are of a high cognitive level. In fact, the answers to the latter are complex; they require thought and interconnection between different concepts. The scenarios presented to students are very relevant when it comes to motivation and the quality of the questions raised. Thus, these scenarios should captivate, intrigue, defy, and encourage the formulation of questions (Leite et al., 2008) while being suitable for the age group of the students (Lambros, 2004). They should also emotionally involve the students. Rather than leading them instantly to the solution, they should promote the association of different subjects/topics. An inadequate scenario will harm the process of raising questions. Some studies indicate that the use of concept cartoons generates high levels of motivation and the fact of integrating written text in dialogue stimulates students to learn more easily (Keogh & Naylor, 1999). On the other hand, some authors refer that the quantity of information could influence students' problematization (Dahlgren & Öberg, 2001).

METHODOLOGY

To attain the objective of this study, three different scenarios (news, concept cartoon and drawing) in environmental science were developed and applied to three teachers and their 95 science students of an urban school in Oporto, Portugal. The teachers were all female, with ages ranging from 41 to 54 years. Teacher one (54 years old) and teacher two (41 years old) have a degree in Biology, while teacher three (48 years old) has a degree in Geology and a graduate degree in Geoscience. The students, with ages ranging from 16 to 20, attended five different classes of high school's final year. Students of classes one and two were familiar with this strategy. In fact, they had already worked with PBL scenarios in previous years, as well as in the year of this study. Thus, they had already analysed PBL scenarios, raised questions and collaborated to achieve a solution. Students of classes three, four and five had never worked with these scenarios, having been taught in more traditional ways. As we wanted to analyse the questions that arise from the analysis of the problematic situation (scenario), our focus relies only in this stage of the PBL process. The scenarios were firstly given to the teachers, who were asked to anticipate the questions that would be raised by their students. The scenarios were then given to the students, during a 90 minutes class. Students were asked to work in small groups, with four or five elements each, and to raise questions related to the three scenarios. Moreover, they were asked to answer a snapshot stating their opinion on the used approach. During the class, the researchers filled in an observation grid in order to evaluate the students' participation and interest. Questions anticipated by teachers and raised by students were counted and analysed, based on a checklist adapted from Dahlgren and Öberg (2001) and Chin and Chia (2004) and the results were subsequently compared. An analysis of the snapshot and the observation grid was also conducted.

RESULTS

Analysis of questions raised by teachers and students

In this study, the three teachers anticipated 65 questions and the five classes raised a total of 350 questions, based on the analysis of three different scenarios. The number of questions formulated by each class varies substantially, from 49 to 114. The two classes that raised more questions (1 and 2) were those familiar with this strategy (Table 1).

Table 1. Number of questions raised by each class, according to each scenario

S / C	News		Concept Cartoon		Drawing		Tl	
	NQ	%	NQ	%	NQ	%	NQ	%
1	36	29,8	41	34,7	37	33,3	114	32,6
2	27	22,3	24	20,3	28	25,2	79	22,6
3	20	16,5	20	16,9	14	12,6	54	15,4
4	19	15,7	18	15,2	17	15,3	54	15,4
5	19	15,7	15	12,7	15	13,5	49	14,0
Tl	121	100	118	100	111	100	350	100

Legend: S-scenario; C- class; NQ- number of questions posed; %-percentage; Tl- total.

The number of questions anticipated by each teacher also varies, from 10 to 36. The teacher that anticipated more questions was the teacher of classes one and two – teacher two (Table 2). The number of questions raised by students in relation to each scenario was very similar. The scenario that prompted more questions was the News -121; the Drawing scenario prompted the least number of questions -111 (table 1). Similarly, the number of questions anticipated by teachers was very similar in the different scenarios; again the Drawing scenario prompts the least number of questions (table 2). Considering the type of questions raised by students, all scenarios led to almost any kind of questions, although with a higher rate of encyclopaedic questions, i.e., questions of a low cognitive level. Value-oriented questions and solution-oriented ones are those with a lower rate. Classes 1 and 2 formulated a higher number of high cognitive level questions when compared with the other 3 classes.

Table 2. Number of questions raised by each teacher, according to each scenario.

S / T	News		Concept Cartoon		Drawing		Tl	
	NQ	%	NQ	%	NQ	%	NQ	%
1	6	30,0	9	34,6	4	21,0	19	29,2
2	11	55,0	14	53,8	11	57,9	36	55,4
3	3	15,0	3	11,5	4	21,0	10	15,4
Tl	20	100	26	100	19	100	65	100

Legend: S-scenario; T-teacher; NQ- number of questions posed; %-percentage; T1- total.

Some of questions raised by students are presented in table 3

Table 3: Examples of questions posed by students.

Type of Questions	Examples of questions
Encyclopedic	"What is toxicity level?"
Meaning-oriented	"How does acid rain gets formed?"
Relational	*"What is the effect of acid rain on agriculture?"*
Value-oriented	"What are the main pollutants?"
Solution-oriented	"What can we do to attenuate earth's environmental problems?"
Prediction	*"Can human population be extinct due to the excess of chemical and toxic residue?"*
Debate	"Is it ethically correct to destroy what keeps us alive?"

Regarding the type of questions anticipated by teachers, there is also a higher rate of encyclopaedic questions (low cognitive level questions) and a lower rate of prediction and debate questions. Although teacher three raised a very low number of questions, she formulated a higher number of high cognitive level questions. Considering the scenario used, one can find small differences in the kind of questions raised by students according to each scenario. The questions that arose from the News and the Concept Cartoon scenarios are mainly encyclopaedic whereas the main questions that arose from the Drawing are debate and prediction questions (Table 4).

Table 4: Type of questions raised by students, according to each scenario.

S / Tq	News		Concept Cartoon		Drawing		Tl	
	NQ	%	NQ	%	NQ	%	NQ	%
E	54	44,6	45	38,1	19	17,1	118	33,7
Mo	22	18,2	28	23,7	14	12,6	64	18,3
Vo	0	---	9	7,6	3	2,7	12	3,4
R	12	9,9	25	21,2	19	17,1	56	16,0
So	10	8,3	1	0,8	15	13,5	26	7,4
P	6	5,0	5	4,2	20	18,0	31	8,9
D	17	14,0	5	4,2	21	18,9	43	12,3

Legend: S-scenario; Tq-Type of questions posed; NQ- number of questions posed; %-percentage; Tl- total; E- Encyclopaedic; Mo- Meaning-oriented; Vo-Value-oriented; R- Relational; So-Solution-oriented; P-Prediction; D-Debate.

The type of questions anticipated by teachers also differs in relation to each scenario. All scenarios led to a high rate of encyclopaedic questions, especially the Concept Cartoon (42,3%). When it comes to high cognitive level questions, there is also a considerable number of meaning oriented questions related to the News scenario (30%) and of relational questions related to the Drawing scenario (26,3%) and Concept Cartoon (34,6%) – table 5.

Table 5: Type of questions raised by teachers, according to each scenario.

S / Tq	News		Concept Cartoon		Drawing		Tl	
	NQ	%	NQ	%	NQ	%	NQ	%
E	6	30,0	11	42,3	5	26,3	22	33,8
Mo	6	30,0	4	15,4	0	---	10	15,4
Vo	0	---	1	3,8	4	21,0	5	7,7
R	4	20,0	9	34,6	5	26,3	18	27,7
So	3	15,0	1	3,8	4	21,0	8	12,3
P	0	---	0	---	1	5,2	1	1,5
D	1	5,0	0	---	0	---	1	1,5

Legend: S-scenario; Tq-Type of questions posed; NQ- number of questions posed; %-percentage; Tl- total; E- Encyclopaedic; Mo- Meaning-oriented; Vo-Value-oriented; R- Relational; So-Solution-oriented; P-Prediction; D-Debate.

All the scenarios led to encyclopaedic questions. However, the scenario that led to a lower percentage of this type of questions was the Drawing, for both students and teachers. This may be related with the smaller amount of informative and textual content of the Drawing when compared with the News and the Concept Cartoon.

Analysis of students' motivation

In relation to the answers given in the snapshot, almost all the students (94,6%) considered this approach motivating and positive. The three main aspects that were pointed out as more interesting were: the materials were attractive/motivating (30,1%); allowed thinking about various thematics (17,2%); and was innovative (14,0%). The least interesting aspects that were pointed out were: the thematic had already been studied in previous years (19,2%); the news (15,4%); the lack of preparation of the students on the subject (12,8%). In spite of the fact that almost all students considered this approach relevant, 41,1% indicated to have some difficulties in raising questions, especially those students of classes three, four and five. In general students showed great interest and participated in an enthusiastic way.

DISCUSSION AND EDUCATIONAL IMPLICATIONS

Generally speaking, final high school students are capable of formulating a substantial number of questions when confronted with different problematic scenarios. Although the number of questions raised was very similar in the different scenarios, the News prompted a higher number of questions. The scenarios prompted almost all kinds of questions, with a high rate of encyclopaedic questions. Different scenarios prompt slightly different type of questions. In relation to the questions anticipated by teachers, the number of questions was also very similar in the different scenarios. Moreover, there was also a difference in the type of questions formulated according to each scenario. Teachers also anticipated a higher number of encyclopaedic questions within the three scenarios. When comparing the questions raised by students with those anticipated by their teachers, one concludes that the students that raised a higher number of questions (class one and two) are taught by the teacher that also anticipated the higher number of questions (teacher two). Whereas the teacher that anticipated a higher number of high cognitive level questions was teacher three (teacher of class three), the students that raised a higher number of high cognitive level questions of (class one and two) were taught by teacher two. The majority of students considered this approach relevant, showing interest and participating actively. The students familiarized with this strategy raised a higher number of questions, as well as a higher number of questions of high cognitive level, showing fewer difficulties. These results are congruent with Oliveira (2008) findings, as she stated that if students had the opportunity of developing questions' formulating competences, students will raise a higher number of high cognitive level questions. According with these results, the authors consider that it will be important to use scenarios as a starting point of the learning process, thereby creating conditions for students to feel at ease in the process of raising questions. Bearing in mind the high number of questions of low cognitive level, both raised by students and anticipated by teachers, it is important to ponder on the role of the school in the development of competences and critical thinking of the students, thereby preparing them to solve problems in their daily life. The authors also consider that in the study of a given subject the use of different scenarios is useful to the process of raising of questions. In fact, students react differently to distinct scenarios, according to their knowledge, criticism, imagination and experiences. Wider research is needed to find out how students deal with this approach in the study of different topics, as well as how they may benefit from the use of scenarios different from the ones used in this study.

CONCLUSIONS

With this study we may conclude that the use of different PBL scenarios motivate students to work actively in science classes, as well as it leads to the formulation of different type of questions. Although the considerable number of questions raised either by students or by teachers, the results show that they still formulated a high number of low cognitive level questions. This type of questions is far from what is considered a question of a higher cognitive level within a PBL approach, which is intended to foster the development of problem- solving competences, critical thinking and intellectual autonomy.

ACKNOWLEDGEMENT

This research was carried out within the scope of the Research Project "Science Education for Citizenship Through Problem-Based Learning" (PTDC/CPE-CED/108197/2008), financed by FCT within the scope of the Thematic Operational Programme Competitivity Factors (COMPETE) of the European Union Community Support Framework III co-financed by the European Regional Development Fund (ERDF/FEDER).

BIBLIOGRAPHY

Aja, L. E. & Espinel, J. E., Oral and written questions: Factor of interactions between teacher and students in the classroom, *Journal of Science Education* 1, [2], 81 - 86, 2000.

Carvalho C. & Dourado L., "A formulação de questões a partir de cenários problemáticos: Um estudo com alunos de Ciências Naturais do 3º Ciclo do Ensino Básico português", In *Actas do Congresso Internacional Galego-Português de Psicopedagogia,* Universidade do Minho, Braga, 2615-2628, 2009.

Chin, C., Learning in science: what do students' questions tell us about their thinking? *Educational Journal* 29, [2], 85-103, 2001.

Chin C. & Chia, L., Problem-Based Learning: Using Students' Questions to Drive Knowledge Construction, *Science Education* 88, [5], 707-727, 2004.

Chin, C. & Kayalvizhi, G., Posing Problems for Open Investigations: what questions do pupils ask? *Research in Science & Technological Education.* 20, [2], 269-287, 2002.

Cuccio-Schirripa, S. & Steiner, H. E., Enhancement and Analysis of Science Question Level for Middle School Students, *Journal of Research in Science Teaching* 37, [2], 210-224, 2000.

Dahlgren, M. & Öberg, G., Questioning to learn and learning to question: Structure and function of problem-based learning scenarios in environmental science education, *Higher Education* 41, [3], 263-282. 2001.

DeBoer, G. E., Historical perspective on inquiry teaching in schools, In L. Flick & N. Lederman (Eds.), *Scientific inquiry and the nature of science: Implications for teaching, learning and teacher education*, The Netherlands: Kluwer, Dordrecht, 17-35, 2004.

Dewey, J., *How we think*, Heath, Boston, 1933.

Dillon, J.T., *The practice of questioning*, Routledge, Chapman, Hall, New York 1990.

Giordan, A. & Vecchi, G., *As Origens do Saber: das concepções dos aprendentes aos conceitos científicos*. (B. C. Magne, Trad.), Artes Médicas, Porto Alegre, 1996.

Hodson, D., *Teaching and Learning Science: Towards a personalized approach,* Open University Press, Buckingham, 1998.

Hofstein, A., Navon, O., Kipnis M. & Mamlok-Naaman, R., Developing Students' Ability to Ask More and Better Questions Resulting from Inquiry-Type Chemistry Laboratories, *Journal of Research in Science Teaching* 42, [7], 791-806, 2005.

Keogh B. & Naylor, S., Concept cartoons, teaching and learning in science: an evaluation, *International Journal of Science Education* 21, [4], 431-446, 1999.

Lambros, A., *Problem-Based Learning in Middle and High School Classrooms – A Teacher's Guide to Implementation*, Corwin Press, Thousand Oaks, 2004.

Leite, L., Costa, C. & Esteves, E., Os manuais escolares e a aprendizagem baseada na resolução de problemas: um estudo centrado em manuais escolares de Ciências Físico-Químicas do Ensino Básico, In M. Macia Baldonedo & J. Vasquez Lopez (Coord.). *Actas do XXI Congresso de ENCIGA*, (CD-ROM), Escola Manuel Chamoso Lamas, O Carballiño, 2008.

Loureiro, I., *Aprendizagem Baseada na Resolução de Problemas e a formulação de questões a partir de contextos problemáticos: Um estudo com professores e alunos de Física e Química,* Dissertação de Mestrado, Instituto de Educação e Psicologia, Braga, 2008.

Marbach-Ad G. & Sokolove, P.G., Can Undergraduate Biology Students Learn to Ask Higher Level Questions?, *Journal of Research in Science Teaching,* 37, [8], 854-870, 2000.

Oliveira, P., *A formulação de questões a partir de contextos problemáticos: Um estudo com alunos dos Ensinos Básico e Secundário,* Dissertação de Mestrado, Instituto de Educação e Psicologia da Universidade do Minho, Braga, 2008.

Orlik, Y. *Chemistry: Active methods of teaching and learning*, Iberoamerica Publ., Mexico, 2002. ISBN 970-625-280-0. In Spanish.

Palma C. & Leite, L., Formulação de questões, educação em ciências e aprendizagem baseada na resolução de problemas: Um estudo com alunos portugueses do 8º ano de escolaridade, In *Actas do Congresso Internacional PBL2006ABRP* (CD-Rom), Pontifícia Universidad Católica del Perú, Lima (Peru), 2006.

Schein, Z. & Coelho, S., O papel do questionamento: intervenções do professor e do aluno na construção do conhecimento, *Caderno Brasileiro de Ensino de Física* 23, [1], 68-92, 2006.

Vasconcelos, C. & Almeida, A. (2012). Aprendizagem Baseada na Resolução de Problemsa no Ensino das Ciências: Proposta de trabalho para Ciências Naturais, Biologia e Geologia. Porto: Porto Editora.

Vasconcelos, C., J. Torres, Dourado L.& Leite, L., Questions in science textbooks: Do they prompt students' inquiry and problem-based learning?, *ESERA Conference Book of Abstracts,* Lyon, 266, 2011.

Received 15-05- 2012/ Approved 29-04-2013

Indícios do modelo integrativo no desenvolvimento do PCK em licenciandos em química durante o estágio supervisionado

Evidence for integrative model during PCK development in chemistry student teachers during pre-service training

Perceli Gomes Elias Mariano Pereira[1], Carmen Fernandez[2]

[1]*Faculdades Integradas do Vale do Ribeira, Registro, SP,*
[2]*Instituto de Química da Universidade de São Paulo, São Paulo, Brasil,*
perceligomes@yahoo.com.br, carmen@iq.usp.br

Resumo

O conhecimento pedagógico do conteúdo (PCK, do inglês pedagogical content knowledge) é o conhecimento usado pelos professores no processo de ensino, que o distingue de um especialista da matéria e é desenvolvido pelos professores ainda durante a formação inicial. Neste trabalho investigaram-se sete licenciandos em química durante o estágio supervisionado. Os dados foram coletados a partir do instrumento CoRe (representação de conteúdo), planos de aulas, registros audiovisuais das regências e diários de bordo. A análise considerou categorias pré estabelecidas na literatura de estágios de desenvolvimento do professor. O grupo 1 de licenciandos encontra-se no primeiro estágio (Iniciante) enquanto o grupo 2 foi caracterizado no segundo estágio (Iniciante avançado). Apresentam-se algumas evidências de que o desenvolvimento do PCK de professores iniciantes ocorre por integração dos conhecimentos base. No caso deste estudo, os licenciandos estão ainda em fase de amadurecer seu conhecimento de conteúdo, muito embora apresentem alguns flashes dos demais conhecimentos componentes do PCK.

Palavras-chave: *conhecimento pedagógico do conteúdo, formação de professores, ensino de química, estágio supervisionado.*

Abstract

The pedagogical content knowledge (PCK) is the knowledge used by teachers during the teaching process. It is the knowledge which distinguishes the teacher of a discipline *from the specialist and this knowledge can be built during training program. In this paper we investigate seven pre-service chemistry teachers during pre-service training. Data were collected from CoRe (content representation), lesson plans, audiovisual record of chemistry classes and reflections. For data analysis we used categories pre developed in the literature and the teacher development stages. Group 1 is in the first stage (beginners) while group 2 is in the second stage (advanced beginners). Our research presents some evidence that beginner teachers develop their PCK based on an integrative model. In this study the pre-service teachers are still developing their content knowledge, even though we could see some flashes from the PCK components.*

***Key words**: pedagogical content knowledge, teacher education, chemical education, pre-service training.*

INTRODUÇÃO

O conhecimento pedagógico do conteúdo (PCK) é considerado o conhecimento dos professores necessário à sua profissão (Kind, 2009). Shulman (1986) propôs inicialmente três categorias para o conhecimento de professores: (a) o conhecimento do conteúdo específico; (b) o conhecimento pedagógico do conteúdo; (c) o conhecimento curricular. Grossman (1990), uma colaboradora de Shulman resume o conhecimento dos professores em quatro categorias: a) conhecimento pedagógico geral; b) conhecimento do conteúdo; c) conhecimento pedagógico do conteúdo; d) conhecimento do contexto. Entre esses, o PCK se destaca por ser o conhecimento que distingue um professor (Marcelo, 2001; Mulholl, Wallace, 2005). No modelo de Grossman (1990) o PCK depende primordialmente da concepção do professor a respeito dos propósitos para ensinar um conteúdo específico e tal concepção perpassa os demais constituintes do PCK, a saber, o conhecimento da compreensão dos estudantes, o conhecimento do currículo e o conhecimento das estratégias instrucionais. Para a autora, o PCK ocupa uma posição central dentre os conhecimentos de professores, sendo influenciado e influenciando os demais conhecimentos necessários ao professor: conhecimento do conteúdo específico; conhecimento pedagógico geral e conhecimento do contexto.

Para Magnusson et al. (1999) o PCK consiste em cinco componentes: a) Orientações para o ensino de ciências; b) Conhecimentos e crenças sobre o currículo de ciências; c) Conhecimento e crenças sobre a compreensão dos alunos sobre temas específicos de ciência; d) Conhecimentos e crenças sobre a avaliação em ciências; e) Conhecimentos e crenças sobre estratégias instrucionais para o ensino de ciências. Neste trabalho, adotou-se a conceituação do PCK dada por Grossman (1990) e revisitada por Gess-Newsome (1999).

Os estágios de desenvolvimento dos professores de química e o PCK

Independente do modelo escolhido, os componentes do PCK precisam estar em sintonia para que o processo de ensino-aprendizagem seja efetivo. Assim, as concepções dos propósitos para ensinar um conteúdo específico no modelo de Grossman ou as orientações para o ensino de ciências no modelo de Magnusson et al., devem dialogar com as estratégias instrucionais adotadas pelos professores e esse diálogo deveria ser intencional por parte do professor. As estratégias instrucionais compõem "um conjunto de atividades do professor e dos estudantes para atingir as metas e objetivos do processo de ensino e aprendizagem" (Orlik, 2002). Nesse sentido, o autor destaca ainda:

> Os objetivos gerais do processo de ensino e aprendizagem são: a.) aprender os novos conhecimentos e hábitos da Química e, b.) desenvolver as capacidades e o pensamento químico. A metodologia de ensino engloba a cooperação organizada entre o professor e os estudantes, o que permite atingir os objetivos educacionais. A metodologia leva os estudantes a um certo nível de manuseio do conteúdo de uma certa disciplina (**tradução nossa**).

Baseados em um estudo com professores em formação, Dreyfus (2004) definiu cinco estágios do desenvolvimento do professor em formação inicial que distinguem como um professor monitora os acontecimentos em sala de aula e o grau de consciência envolvido no ensino (**tabela 1**).

Abell et al. (2009) afirmam que formadores de professores deveriam dar atenção explícita aos componentes individuais do PCK. Assim, tais professores teriam parâmetros para a construção do PCK, aquele encontrado em professores experientes. O PCK de professores em formação deriva de sua própria prática, através das atividades escolares, desenvolvido através de um processo de integração da prática em sala de aula (Marcon et al., 2011; Jang, 2011; Nakiboglu, Karakoc e De Jong, 2010).

Gess-Newsome (1999) propõe dois modelos teóricos extremos para tentar explicar o desenvolvimento do PCK (Figura 1). O **modelo integrativo** considera o PCK como a intersecção entre os conhecimentos pedagógico, disciplinar e de contexto. O **modelo transformativo** coloca o PCK como resultado de uma transformação do conhecimento pedagógico, do conteúdo da matéria e do contexto.

Tabela 1 Estágios do desenvolvimento do professor em formação por Dreyfus (2004).

Estágio	Especificações
Iniciante	É racional e relativamente inflexível em sala de aula.
Iniciante avançado	O professor desenvolve o conhecimento estratégico e experiências em sala de aula e os problemas contextuais começam a orientar o comportamento dele.
Competente	O professor faz escolhas conscientes sobre as ações, conhece a natureza do tempo e do que é e não é importante.
Proficiente	Intuição e prática começam a orientar o desempenho e o reconhecimento holístico entre os contextos é adquirido. O professor pode prever eventos.
Perito/ experiente	Compreensão intuitiva das situações. O desempenho no ensino é fluído. O professor não escolhe conscientemente seu foco de atenção.

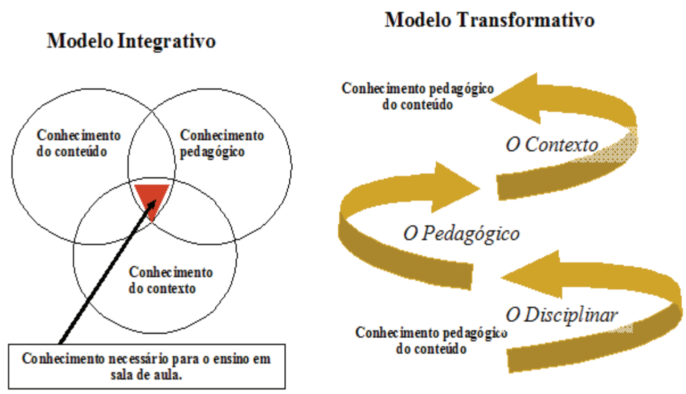


Figura 1. Modelos do conhecimento docente propostos por Gess-Newsome (1999).

No modelo integrativo, o PCK não existe como um domínio de conhecimento e o conhecimento de professores seria explicado pela intersecção de três conhecimentos - o conteúdo, a pedagogia e o contexto. Ensinar segundo essa visão seria o ato de integrar esses três domínios. No outro extremo (modelo transformativo) o PCK seria a síntese de todos os conhecimentos necessários para a formação de um professor efetivo. Nesse caso, o PCK seria a transformação do conhecimento do conteúdo, da pedagogia e do contexto até uma forma distinta – a única forma de conhecimento que traria impacto na prática dos professores. Na literatura há dados empíricos embasando ambos os modelos (Kind, 2009).

Loughran et al. (2000), consideram o PCK como uma mistura de elementos em interação e que, quando combinados, ajudam a dar indícios do PCK dos professores. São doze os elementos propostos por esses autores (**Figura 2**). O modelo de interação dos elementos do PCK representa a sobreposição de cada um, influenciando o PCK diretamente e os elementos mutuamente. O PCK, portanto, é um amálgama de todos esses elementos.

Esses modelos de construção do PCK podem ajudar os formadores de professores a preparar um currículo voltado para essa formação plena.

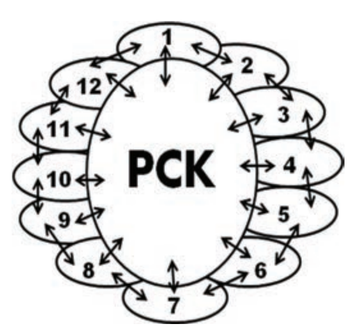


Figura 2. Modelo de interação dos elementos do PCK, segundo Loughran et al. (2000).

(1- Visão de aprendizagem; 2- Visão de ensino; 3- Compreensão do conteúdo; 4- Conhecimento e prática das concepções alternativas; 5- Tempo de ensino/unidade de trabalho; 6- Contexto – escola, sala de aula, série; 7- Compreensão dos estudantes; 8- Visão do conhecimento científico; 9- Prática pedagógica; 10- Tomada de decisão; 11- Reflexão; 12- Elementos explícitos *vs*. elementos tácitos das práticas/crenças/ideais.

Os procedimentos e as ferramentas de acesso ao PCK.

Identificar o PCK de um professor é um processo complexo, pois se trata de um conjunto de conhecimentos implícitos e que precisam se fazer explícitos para serem analisados (Baxter, Lederman, 1999). Além das entrevistas, outros procedimentos são adotados como a observação em sala de aula, análise de currículos e dos planos de aulas, verificação dos resumos mensais e dos projetos dos professores (Lee e Luft, 2008; Van Driel e De Jong, 2001; Nakiboglu, Karakoc e De Jong, 2010; Loughran et al., 2000). Os diários de bordo também são instrumentos que auxiliam a acessar o PCK, permitindo uma reflexão sobre a aula.

Um instrumento bastante utilizado para acessar o PCK é o CoRe - Representação do Conteúdo (Loughran et al., 2000, 2004; Garritz et al., 2007). Trata-se de um instrumento formado por perguntas que o professor responde depois de definir as ideias principais de um conteúdo específico. No CoRe, um grupo de professores pensam sobre um dado conteúdo que costumam ensinar e refletem quais as principais ideias que devem ser ensinadas aos alunos. Depois respondem a um questionário para cada uma dessas ideias.

A questão que norteou a pesquisa foi: Quais os indícios de PCK em licenciandos em química durante o estágio supervisionado?

METODOLOGIA

A pesquisa ocorreu com dois grupos de licenciandos em química no penúltimo semestre do curso, na disciplina de prática de ensino e estágio supervisionado das faculdades integradas do Vale do Ribeira na cidade de Registro-SP. O PCK foi acessado através do instrumento CoRe, do registro audiovisual das aulas de regência, dos diários de bordo e dos planos de aula da regência. As análises foram feitas a partir da triangulação dos dados coletados e foram utilizadas as categorias de Loughran et al. (2000) acopladas ao modelo integrativo de Gess-Newsome (1999) apresentadas na **Figura 3**.

O **grupo 1** era constituído pelas licenciandas Jaci, Vera, Bia e Ana (nomes fictícios). Elas cursaram a licenciatura em química de 2006 a 2009 e tinham idade entre 20 e 25 anos. Dentre as quatro alunas, apenas Jaci já havia trabalhado como professora substituta em escola pública. Foram filmadas duas regências, uma aula teórica e outra experimental. A aula teórica ficou sob a responsabilidade de Jaci e Bia, e a aula experimental foi ministrada por Ana e Vera. O conteúdo versava sobre pH e os indicadores ácido-base. A primeira aula visava a introdução da definição de pH e pOH, além dos cálculos para a sua determinação. A segunda aula, experimental, compreendia a demonstração dos indicadores ácido-base. Durante as regências, os alunos do ensino médio tiveram pouca participação.

O **grupo 2** era constituído pelos licenciandos Miguel, Sergio e Paulo (nomes fictícios). Eles cursaram a licenciatura em química de 2006 a 2009 e sua idade variava de 20 a 30 anos. Na época da regência, os três licenciandos trabalhavam no laboratório de uma indústria local e nunca haviam lecionado. Foi filmada uma regência (2 aulas em um dia) que contemplou a teoria e a prática. Na prática experimental foram feitas demonstrações relacionadas com a teoria explicada. Os três licenciandos se alternavam nas exposições, tanto teóricas quanto práticas. O grupo realizou a regência numa escola rural. O conteúdo da aula versava sobre os fatores que interferem na velocidade de uma reação química. Houve participação dos estudantes, incentivados pelos estagiários.

As regências das aulas dos grupos foram transcritas e as análises foram divididas em episódios e turnos (T) que correspondem ao trecho analisado (Carvalho, 2006). Cada episódio foi caracterizado nas distintas categorias que compõem os elementos do PCK (**Figura 3**). Da mesma forma foram analisados os planos de aula, CoRe e diários de bordo.

RESULTADOS

A **tabela 2** mostra os indícios dos conhecimentos necessários para a construção do PCK e a **tabela 3** mostra um resumo geral desses indícios observados nos dois grupos.

Tabela 2. Indícios dos conhecimentos para a construção do PCK dos grupos 1 e 2.

Categorias	Grupo 1				Grupo 2		
	Jaci	Bia	Vera	Ana	Miguel	Sergio	Paulo
1. Visão de aprendizagem	i	i	i	i	p	p	P
2. Visão de ensino	r	r	r	r	r	r	R
3. Compreensão do conteúdo	i	i	i	i	r	p	I
4. Conhecimento e práticas das concepções alternativas	r	r	r	r	i	i	i
5. Tempo de ensino/ Sequências Didáticas	p	p	p	p	p	p	p
6. Contexto-escola, sala de aula, série	-	-	-	-	p	p	p
7. Compreensão dos estudantes	r	r	r	r	p	p	p
8. Visão do Conhecimento Científico	r	i	i	i	i	i	i
9. Prática Pedagógica	p	p	p	p	i	i	i
10. Tomada de decisão	i	-	-	-	p	p	p
11. Reflexão	p	p	r	i	p	p	p
12. Elementos explícitos x elementos tácitos das práticas/ crenças/ideais	r	-	-	-	-	-	-

(i) Incipiente - quando o licenciando não tem esse conhecimento ou teve uma formação insuficiente para adquiri-lo); (r) Regular (quando seu conhecimento não é o suficiente para ser utilizado como um dos conhecimentos do PCK); (p) Possível (quando esse conhecimento pode contribuir para a construção do PCK).

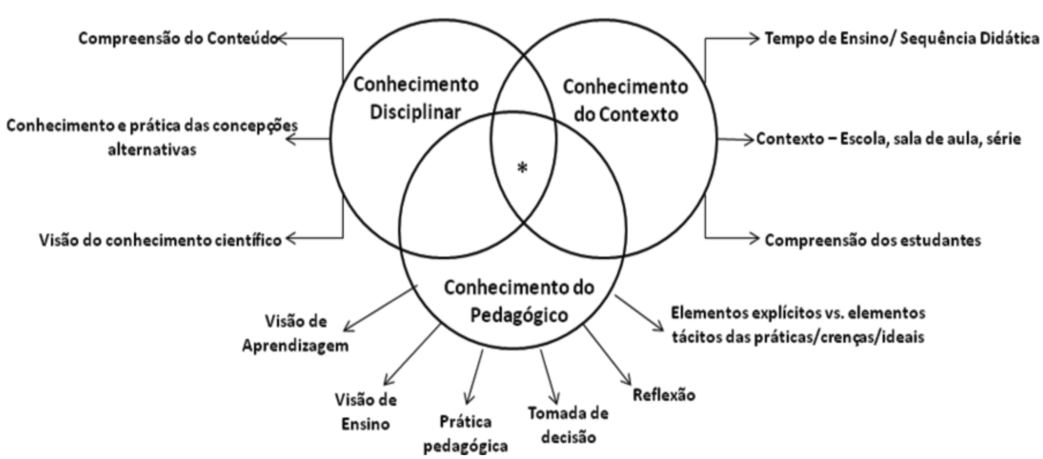


Figura 3. Modelo integrativo do conhecimento de professores (Gess-Newsome, 1999) acoplado aos elementos do PCK propostos por Loughran et al. (2000). * = conhecimento necessário para o ensino na sala de aula.

Para o **grupo 1**, no componente **conhecimento disciplinar**, categoria 3, as licenciandas apresentam lacunas na formação acadêmica. Na categoria 4, as licenciandas não conheciam na literatura as concepções dos alunos referentes a esse conteúdo. Em relação à categoria 8, as licenciandas demonstraram que ainda estão descobrindo a relação dessa categoria e sua importância para a aprendizagem. Há, portanto falhas relevantes na formação, resultando numa falta de integração dessas categorias, comprometendo o conhecimento disciplinar. No componente **conhecimento do contexto**, a categoria 5, as licenciandas do grupo 1 têm um conhecimento curricular que as ajuda no preparo da aula. Na categoria 6 as licenciandas não têm maior desenvoltura devido à falta de interação com os estudantes que elas não convivem. Na categoria 7, as licenciandas possuem um conhecimento acadêmico sobre o que os alunos compreendem, o que é necessário e extremamente útil para elas no momento da regência. Para esse componente, há uma integração superficial que contribui para o trabalho das licenciandas. No componente **conhecimento pedagógico**, na categoria 1, as licenciandas avaliam os estudantes de forma pontual. Na categoria 2 as licenciandas não permitem que os estudantes tenham suas conclusões, elas direcionam as respostas numa concepção-centrada-no-professor que envolve o estímulo-resposta. Na categoria 9 as licenciandas constroem a prática através das suas observações das práticas de outros professores, o que é também útil para elas e contribuiu para a prática na regência. Na categoria 10 as licenciandas agiram de maneira não planejada. Na categoria 11, as licenciandas demonstraram perceber a importância da prática do mesmo conteúdo e a mudança de metodologia de ensino, mas também falharam ao considerar a aprendizagem apenas pela observação e acreditaram nos resultados oriundos de uma avaliação pontual. Na categoria 12, as licenciandas utilizaram esse conhecimento ao prever algumas dificuldades dos alunos, mas não conseguiram saná-las. Para esse componente, há uma integração superficial, porém, que se tornou útil para o trabalho das licenciandas.

Analisando os indícios do PCK do conteúdo *pH* pelo **grupo 1** através dos componentes de conhecimentos disciplinar, do contexto e dedagógico através das distintas categorias, conclui-se que, de maneira global, o PCK das licenciandas do grupo 1 é bastante incipiente e percebem-se falhas nos distintos componentes.

Tabela 3. Resumo dos indícios do PCK dos grupos 1 e 2.

Componentes do Conhecimento	Categorias	Qualificadores dos indícios do PCK	
		Grupo 1	Grupo 2
A) Disciplinar	3 - Compreensão do conteúdo 4 -Conhecimento e prática das concepções alternativas 8 - Visão do conhecimento científico	Incipiente Regular Incipiente	Regular Incipiente Incipiente
B) Contexto	5 - Tempo de ensino/ sequências didáticas 6 - Contexto – escola, sala de aula, série 7 - Compreensão dos estudantes	Possível Inviável na regência Regular	Possível Possível Possível
C) Pedagógico	1 - Visão de aprendizagem 2 - Visão de ensino 9 - Prática pedagógica 10 - Tomada de decisão 11 – Reflexão 12- Elementos explícitos versus elementos tácitos das práticas/ crenças/ideais	Incipiente Regular Possível Incipiente Possível Regular	Possível Regular Incipiente Possível Possível Não avaliado

No **grupo 2** os licenciandos mostraram-se confiantes na regência, fizeram perguntas que indicavam segurança e conhecimento do conteúdo. No componente **conhecimento disciplinar**, a categoria 3, os licenciandos do grupo 2 não apresentaram muitas lacunas na formação acadêmica, apenas sobre catalisadores. Para a categoria 4 os licenciandos não pesquisaram na literatura sobre as concepções dos alunos referentes a esse conteúdo, comprometendo a compreensão deles sobre o conhecimento dos estudantes. Na categoria 8 os licenciandos mostraram concepções acerca desse conhecimento que limitaram o seu ensino do conteúdo. Não ocorreu a integração dessas categorias, comprometendo o conhecimento disciplinar. No componente **conhecimento do contexto**, a categoria 5, os licenciandos souberam adequar o currículo ao tempo disponibilizado para a regência. Na categoria 6, os licenciandos apresentaram segurança na aula, mesmo tendo pouco contato com a escola e com os alunos. Na categoria 7, os licenciandos souberam o momento de permitir a participação dos alunos e intervir quando necessário. No componente **conhecimento pedagógico**, para a categoria 1, os licenciandos tiveram uma visão de avaliação de acordo com o conteúdo e o tempo previsto para a regência. Para a categoria 2, os licenciandos utilizaram estratégias que melhor se adequaram ao contexto da aula. Na categoria 9 os licenciandos tiveram dificuldades em articular o tempo para a regência. Na categoria 10, os licenciandos fizeram intervenções necessárias no contexto da aula. Na categoria 11, os licenciandos fizeram reflexões que mostraram seus pensamentos acerca da regência, indicando que eles necessitam de mais formação e mais experiências. Para a categoria 12 os licenciandos, para essa regência, não mostraram crenças sobre o conteúdo específico da aula. Para esse componente, há uma integração superficial que contribuiu para o trabalho dos licenciandos.

Para o grupo 2 dos licenciandos, analisando os indícios do conteúdo *fatores que interferem na velocidade de uma reação química* dentro dos componentes conhecimento disciplinar, conhecimento do contexto e conhecimento pedagógico, conclui-se que o PCK também é incipiente, mas com alguns indícios de modificações. Esse grupo apresenta um conhecimento de conteúdo mais articulado, o que reflete nos demais conhecimentos.

CONSIDERAÇÕES FINAIS

Neste trabalho investigou-se um grupo de licenciandos em química durante a realização do estágio supervisionado e buscaram-se indícios do PCK analisando quais os conhecimentos que compõem o PCK são acionados durante o estágio.

Observou-se no grupo 1 uma nítida separação entre os componentes conhecimento disciplinar, do contexto e pedagógico. Nesse momento, as licenciandas estão tentando adquirir componente disciplinar e há muitas falhas de conteúdo químico que são reveladas nos distintos instrumentos utilizados e a atenção das mesmas está focada no conteúdo. Elas parecem não conseguir lidar com os outros conhecimentos necessários à pratica pedagógica, pois estão focadas nas próprias dificuldades com relação ao conteúdo. No momento do estágio não foram capazes de observar os alunos nem suas dificuldades.

No grupo 2 observa-se uma maior aproximação dos componentes pedagógico e de contexto, mas uma fragilidade do componente disciplinar. O grupo centraliza a sua prática na apresentação dos *slides*, nas demonstrações e na participação dos alunos, mas a aula evidencia apenas os fenômenos químicos. Esse grupo parece ter mais domínio do conteúdo específico, embora evitem abordagem molecular do conteúdo, permanecendo apenas no fenomenológico. Os licenciandos observam os alunos e incentivam a participação. A prática da regência ocorreu de acordo com o planejado pelo grupo e eles se sentem satisfeitos e os alunos demonstram compreender o assunto ensinado.

Em relação aos estágios de desenvolvimento do professor em formação (Dreyfus, 2004), pelos resultados e análises apresentadas, as licenciandas do grupo 1 encontram-se no primeiro estágio (*Iniciante*), pois se mostraram racionais e inflexíveis nas ações em sala de aula. O grupo 2 dos licenciandos encontram-se no segundo estágio (*Iniciante avançado*) pois desenvolveram estratégias que os ajudou a articular conteúdo ao tempo disponível.

Neste estudo com esses dois grupos de licenciandos temos evidências de que a construção do PCK de professores iniciantes é melhor explicada pelo Modelo Integrativo (Gess-Newsome, 1999). No caso do grupo 1, as licenciandas estão em fase de amadurecer seu conhecimento disciplinar, muito embora apresentem alguns flashes dos demais conhecimentos. O grupo 2 apresenta uma relativa segurança no conteúdo, o que se traduz em sala de aula, em maior incentivo à participação dos alunos. Entretanto, esses licenciandos apresentam uma visão de conhecimento pedagógico incipiente. Assim, as análises apontam para o modelo integrativo de desenvolvimento do conhecimento de professores. Assim, os distintos conhecimentos mereceriam uma atenção individualizada num primeiro momento para depois serem paulatinamente integrados na prática do estágio supervisionado. A insegurança com o conteúdo disciplinar força os licenciandos a uma postura mais centrada no professor limitando o papel dos alunos a expectadores, como foi observado no grupo 1. À medida que melhora o conhecimento do conteúdo, as atuações em sala de aula parecem tender a um ensino mais dialógico, como se observou no grupo 2. Por outro lado, apenas um bom conhecimento do conteúdo não é suficiente. Em muitas ocasiões observa-se que, apesar das licenciandas apresentarem falhas de conteúdo sérias, conseguiram de alguma forma sustentar a atuação em sala de aula por um domínio, embora pequeno, do conhecimento pedagógico e de contexto.

No Modelo Integrativo, os componentes do PCK seriam desenvolvidos individualmente e integrados na prática. Nesse estudo parece ser esse o caminho dos licenciandos analisados, muito embora eles estejam muito incipientes nos domínios dos distintos conhecimentos, especialmente no conhecimento do conteúdo, o que reflete sobremaneira nos demais.

AGRADECIMENTOS

Aos licenciandos da Faculdade Scelisul investigados e ao CNPq pelo apoio financeiro.

LITERATURA

Abell, S. K.; Rogers, M.; Hanuscin, D. L.; Lee, M.; Gagnon, M. Preparing the next generation of Science Teacher Educator: A model for developing PCK for teaching Science Teachers. *Journal of Science Teacher Education,* **20**, 77-93, 2009.

Baxter, J.A.; Lederman, G. Assesment and measurement of pedagogical content knowledge. In: Gess-Newsome, J.; Lederman, G.(org.). *Examining pedagogical content knowledge: the construct and its implications for science education.* Kluwer Academic Publishers, 1999, p.147-161.

Carvalho, A.M.P. Uma metodologia de pesquisa para estudar os processos de ensino e aprendizagem em salas de aula. In: Santos, F. M. T.; Greca, I. M. (Org.). *A pesquisa em ensino de ciências no Brasil e suas metodologias.* 1 ed., Ijuí: Unijuí, 2006, p.13-48.

Dreyfus, S.E. The Five-Stage Model of Adult Skill Acquisition. *Bulletin of Science, Technology & Society,* **24**, [3], 177-181, 2004.

Garritz, A.; Porro, S.; Rembado, F.M.; Trinidad, R. Latin-American teachers' pedagogical content knowledge of the particulate nature of matter. *Journal of Science education,* **2**, [8], 79-84, 2007.

Gess-Newsome, J. Pedagogical content knowledge: an introduction and orientation. In Gess-Newsome, J.; Lederman, N. G. (Eds.). *Examining pedagogical content knowledge: the construct and its implications for science education*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 1999, p. 3-17.

Grossman, P. L. *The making of a teacher: teacher knowledge and teacher education.* Teachers College Press, New York, 1990, 185p.

Jang, S.J. Assessing college student's perceptions of a case teacher's pedagogical content knowledge using a newly developed instrument. *High Educacion,*.**61**, 663, 2011.

Kind,V. Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education,* **45**, [2], 69-204, 2009.

Lee, E.; Luft, J. Experienced Secondary Science Teachers' Representation of Pedagogical Content Knowledge. *International Journal of Science Education,* **30**, [10], 1343-1363, 2008.

Loughran, J.; Gunstone, R.; Berry, A.; Milroy, P.; Mulhall, P. Science cases in action: developing and understanding of science teachers' pedagogical content knowledge. *National Association for Research in Science Teaching*, New Orleans, 2000, p.1-36.

Loughran, J.; Mulhall, P.; Berry, A. In search of pedagogical content knowledge in science: developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching,* **41**, [4], 370-391, 2004.

Magnusson, S.; Krajcik, J.; Borko, H., Nature, sources, and development of pedagogical content knowledge for science teaching. In: Julie Gess-Newsome e N. G. Lederman (Org.). *Examining pedagogical content knowledge: the construct and its implications for science education*. Kluwer Academic Publishers, Dordrecht/Boston, 1999, p. 95-132.

Marcon, D.; Graça, A.B.S.; Nascimento, J.V. Reinterpretação da estrutura teórico-conceitual do conhecimento pedagógico do conteúdo. *Revista Brasileira de Educação Física*. Esporte, São Paulo, **25**, [2], 323-339, 2011.

Marcelo, C. El aprendizage de los formadores en tiempos de cambio. La aportación de las redes y el caso de La Red Andaluza de Profesionales de la Formación. Profesorado. *Revista de Curriculum y Formación de Profesorado,* **5**, [1], 1-17, 2001.

Nakiboglu, C.; Karakoc, O.; DE JONG, O. Examining pre-service chemistry teachers' pedagogical content knowledge and influences of teacher course and practice school. *Journal of Science Education,* **2**, [11], 76-79, 2010.

Orlik, Y., Métodos de la enseñanza de Química. In: Orlik, Y. *Química: metodos activos de enseñanza y aprendizaje.* Iberoamerica Publ., México, 2002.

Shulman, L. S. Those who understand: knowledge growth in teaching. *Educacional Researcher,* **15**, [2], 4-14, 1986.

Shulman, L. S. Knowledge and teaching: foundations of the new reform. *Harvard Educational Review,* **57**, [1], 1-21, 1987.

Received 21-10- 2012/ Approved 29-04-2013

Assessment of a visit to an optics laboratory during university science week

Evaluación de la visita a un laboratorio de óptica en la semana de la ciencia

J. A. García [1], F. J. Perales [2], L. Gómez-Robledo [1] , J. Romero [1]

[1] Departamento de Óptica. Facultad de Ciencias. Universidad de Granada. España.

[2] Departamento de Didáctica de las Ciencias Experimentales Facultad de Ciencias de la Educación. Campus Universitario de Cartuja s/n. Universidad de Granada. 18071 - Granada. España, fperales@ugr.es.

Abstract

Non-formal science education plays an increasingly relevant role in the popularization of science, especially in the case of science museums, which have been a recent focus of educational research in science education. However, in Spain the visits by non-university students to university faculties are also increasingly widespread, which usually occurs during the celebration of "Science Week". In this paper we show a first approach to the assessment of that experience, in particular, visits to the physics and optics laboratories of the University of Granada. To enable us to do this, different questionnaires were developed and applied to teachers and students. We discuss the results of those and advocate a greater involvement of non-university teachers to increase the success of such visits.

Key words: *non-formal science education, popularization of science, assessment, non-university education.*

Resumen

La educación científica no formal juega un papel cada día más relevante en el ámbito de la divulgación científica, especialmente en el caso de los museos de ciencia, lo que ha supuesto una reciente atención de la investigación educativa hacia dicho contexto. No obstante, en España también van cobrando importancia las visitas a las facultades universitarias de ciencias por parte de alumnos no universitarios, lo que se suele producir con el motivo de la celebración de las "Semanas de Ciencia", cada día más extendidas. En este trabajo hacemos una primera aproximación a la evaluación de dicha experiencia en el caso de la Universidad de Granada, en concreto para los laboratorios de física, y de óptica en particular. Para ello se han elaborado y aplicado cuestionarios dirigidos a los profesores y alumnos participantes. Se comentan los resultados de los mismos y se apuesta por una mayor implicación del profesorado no universitario para incrementar el éxito de dichas visitas.

Palabras clave: *educación científica no formal, divulgación científica, evaluación, educación no universitaria.*

INTRODUCTION

Visits to museums and science centers play an increasingly important role in non-formal science education, as is evidenced by the exponential growth experienced by the number of visitors to these areas in recent years. An example of this is the Faculty of Sciences of the University of Granada

(Spain) where 10 or 15 years ago visits by groups of non-university students were sporadic. However, in recent years demand has grown enormously as has the number of laboratories that are open during these visits.

The organization of "Science Week" has probably been the fact that has contributed most to this growth. 45 schools attended the 38 different activities that were held in the 2010 edition. The interest of secondary schools in making these visits is illustrated by the speed with which the available places are exhausted and the number of schools requesting to participate.

The analysis of this type of activity and the effect they have on students' learning processes have been treated by many researchers, showing that the affective and social aspects of learning benefit most from these visits, but conceptual and procedural learning gains too if the most influential factors are optimized (Guisasola et al., 2005). In an earlier work (Garcia et al., 2010) some of these benefits had been noted after the students' visit to the Optics laboratory in Granada University.

However, the specific aims of such visits have not been fully clarified, the literature showing that most teachers do not usually explain them or prepare activities before, during or after them (Cox-Petersen et al., 2003; Griffin, 2004; Tal et al., 2005), although, according Guisasola et al. (2005), when the teacher prepares the visit and reflects on the activities afterwards in class, the learning experience is more significant from both a conceptual, affective and collective point of view.

Moreover, one should ask oneself what the motivations and expectations of the students themselves are of this type of activity because, a priori, it would be desirable to design them in such a way as to optimize the learning process.

All this has meant that the fundamental aim of this work is to know the expectations of teachers and students when they come to do activities like those described here. More specific goals would result if the activity were well designed or has to be modified in any way, so that it can be identified with the students' image of physics, in general, and optics, in particular, seeking as far as possible to optimize it.

DESCRIPTION OF ACTIVITY

During "Science Week 2010", the Faculty of Sciences of Granada offered 38 activities on different days and times, allowing the configuration of 83 routes with an average of 4 activities each. All routes were followed by 83 groups of secondary school (12-16-year-old) and Baccalaureate (17-18 year-old) students with an average of 25 students per group. This involved the participation of a total of 45 schools and 2075 students. The activity described here, in the *Optics Laboratory*, was done by 12 groups from 9 different educational centers, totaling approximately 300 students.

Activity Assessment

In order to achieve the proposed aims, we designed two pre-visit surveys, one for the school teachers responsible and the other for the students, and a post-visit survey for students to complete after they concluded the visit.

The teacher who was interested that the students should take part in the activity could find information about it in the web page. A script could be downloaded that showed the 16 experiments that could be done as well as the two surveys prior to the visit, asking them to complete them. The first survey was intended primarily to involve the teacher, as far as possible, in the development and design of the activity and to discover what the motivation for such activity was. Therefore, the first two questions concerned what they considered as essential experiments for their students and what could be excluded for lack of time. The third one enabled the teacher to make any comments and / or suggestions, and, finally, they were asked to reply, using a number from 1 (strongly disagree) to 5 (strongly agree), to a series of statements regarding the visit and its connection with their teaching.

The prior survey that the students had to fill in was limited to a set of statements that they also had to assess from 1 (strongly disagree) to 5 (strongly agree). The first five wanted to know their expectations about the intended visit, that is, to know what their motivations were in the activity they would engage in and their opinion on this subject. The last statements focused on optics, and in particular on their knowledge and interest in it.

Although it was clearly stated that teachers should deliver both surveys before starting work so that we could tailor the visit to their interests, only 7 of the 9 centers that did the activity completed it according to the rules. When asked about why they had not done so, the answer that was most frequently given was that all the experiments seemed well planned, so they left it to the organizers to consider what experiments to do and what not.

In order to assess the activity itself, one of the authors remained in the laboratory watching both the students and their teachers, while another author was doing the activity with students. After the visit, the two pooled their notes about it. This evaluation had two objectives, firstly, to be self-critical, that is, based on what they had seen, to analyze what should be done, and in what direction the activity should be changed. They also sought to analyze the attitude and interest of participants. The organizers had a short conversation with the teacher on arrival to find out their interests, after that they watched to see how they acted during the visit and asked them at the end what their main conclusion of the activity had been.

This way of evaluating this type of visit, or generically, a Science museum, has already been used by some authors. For example, Falk and Storksdieck (2005) followed the movement and interaction of visitors to a science museum to see if there was a relationship between motivation shown in prior surveys and attitude shown during the visit.

There are many interesting aspects of the students' conduct to evaluate, however, one must be aware of the complexity that this entails. Even so, it is especially interesting to see if they maintained their attention throughout the entire activity and whether there were differences between boys and girls. As evidenced by Jarvis and Pell (2002), it would be desirable to increase the interest and to maintain it over time. These same authors found that that interest was closely related to the teacher who accompanied them on the tour, so if s/he interacted with the students and with the guide, they showed more interest than if the teacher remained much more passive.

After the visit the survey was given to the teacher and they were asked that after a week they should give it to their students and, once filled in, it should be sent to us. The survey asked them to assess the activity compared with what they expected before it happened. Although the teachers appeared very willing, the reality is that it we only received 28 surveys from students in two centers. However, in the next section we will discuss the main results derived from these responses. The format of the survey was similar to the one they had filled in before, although rather shorter. Three main questions were put: that comparing the fact of the visit with what they had expected before making it, if they had enjoyed themselves; if they thought they had learned anything and, finally, asking them to make any suggestions they wanted.

RESULTS

Prior survey of teachers

When asked what experiments they considered essential for their students to see (Question 1) and which could be left out for lack of time (question 2), the most popular answer was that it would be desirable to perform all the experiments, but in case some had to be omitted it should be those that were least relevant to their students' curriculum. This seems to show that what the teacher wants is that when tackling the contents in class they can refer to the activity, therefore, it thereby constituting a teaching aid for them.

The second type of answer that recurred could be called "not responding"; included in this are those left blank and those that do not indicate a specific experiment as essential or otherwise, in which case teachers only intended it to serve as motivation and left in the air its possible future use in the classroom.

As to which specific experiments appeared most often in these answers, we must say that there is a high variability depending primarily on the characteristics of the group (if they are of 1st or 2nd of Baccalaureate, whether they have seen some content related to themselves or not, and so on..). The third question gave them the possibility of making any suggestion or indication that they wanted, leaving the option blank; only some teachers commented that the level of students should be taken into account.

The last issue is that showing a series of statements on which they were asked to indicate their degree of agreement; the purpose of these statements was to learn the motivations and approaches that the teachers had made when programming this activity. Table 1 shows the percentage of times the number was marked to indicate if the respondent totally disagreed (1) or strongly agreed (5) with the corresponding statement. As can be seen in two of the statements there is total unanimity: they did not make the visit simply because they had to undertake excursions during the course and that they felt that, given the script, the visit would be very interesting.

Table 1.- Percentages of teachers' responses to the survey (1: strongly disagree ... 5: completely agree) (N = 7).

ITEM	1	2	3	4	5	Average
I planned it fundamentally as a motivating fact	--	--	--	29	71	4.7
I hope it will help in my teaching work	--	--	--	14	86	4.8
The experiments I see will help me to explain Physics	--	--	--	29	71	4.7
Basically, it will be a complement to the student's curriculum	--	--	**29**		71	4.4
I think this type of activity will make my students study Physics with greater interest			**14**	29	57	4,4
We have to make two excursions in the academic year and this is convenient and cheap	**100**					1
I think of it basically as an enjoyable and sociable activity	**71**	**29**				1.4
In view of the script I think it will be very interesting					100	5
We will work on it beforehand	**57**	**29**		14		1.7

From these various statements, it appears that the activity was thought of as something that would help them in their teaching to explain physics, but they also expected it to be a supplement to the students' curriculum that would allow them to improve their concept of the subject. In addition, most of them did not regard it simply as enjoyable and sociable, and finally, they indicated that they would do little or no work on it in class beforehand. This answer was surprising since as some authors (Guisasola et al., 2005) point out, the best results are obtained when a specific task is done, both before and after the activity.

From these responses, we assume that teachers use this type of visit to break the routine of teaching and, incidentally, for students to attend laboratory experiments not typically carried out in secondary schools (not in this class or any other), hoping that such activity will awaken a greater interest in the sciences. However, this exception carries with it a clear disconnection between the content of the visit and their regular classroom programming, understanding that the visits are the responsibility of the organizers. This means, as claimed by Lemelin and Bencze (2004), that no significant conceptual development will occur, since this only happens when the visit is explicitly linked to learning objectives that relate school work and the visit. This assumption coincides with that shown by Guisasola and Morentin (2009), who suggest that this may be because they do not consider the visits as part of their professional duties.

Prior survey of students

Table 2 shows the mean and standard deviation of the scores given to each statement, and the percentage of agreement and disagreement with them.

Table 2. Parameters of student responses to the survey (SD = standard deviation; Agreement: percentage of students responding 4 or 5; Disag.: Percentage of students who answer 1 or 2) (N = 122).

ITEMS	Response Parameters			
Views about the visit	Mean	SD.	Agreement	Disag.
I'm looking forward to going to enjoy myself with my friends	3.33	1.25	38.52	26.23
I'm looking forward to going because there's no class that day	2.30	1.36	20.49	59.84
I'm looking forward to going because I think I'll learn a lot	3.98	0.98	69.67	8.20
I'm not looking forward to going. I'm going because it's compulsory	1.39	0.92	4.92	89.34
I'm excited about going to visit the University laboratory	4.31	0.90	77.05	3.28
Views about Physics				
Physics is my favorite subject	2.81	1.25	30.33	41.80
Physics is enjoyable and fun	2.47	1.10	16.39	50.82
Physics is very difficult	3.43	1.12	46.72	20.49
Physics seems to me a very useful subject	3.84	0.99	67.21	6.56
Knowledge of Optics				
I can give examples of refraction and reflection of light and explain why it happens	2.74	1.20	25.41	45.08
The phenomena of Optics are close to me in my daily life	3.26	1.20	42.62	29.51
I think I know almost nothing about Optics	2.81	1.22	26.23	45.08
What most interests me about Optics is vision	3.02	1.03	27.05	26.23

The first statements seek to know what the students' intentions are prior to making the visit. The two statements that reflected the greatest unanimity are 4 and 5. The first makes it clear that the reason they wanted to come to do the activity was not, in any case, because it was compulsory, that is, they viewed it with pleasure, which undoubtedly is very much in favour of activities like this. The other almost unanimous statement is that which refers to the fact that visiting a University laboratory arousing great interest among students. This fact, which appeared in a previous paper (Garcia et al., 2010) should certainly be considered in the learning process, since everything that may make students become more motivated to study physics can assist in improving their academic performance.

The first three statements endeavor to discover their interest prior to the visit. Thus, they show that they want to have fun with friends, showing aspects of sociability and playfulness already reported by other authors. They do not want to go merely to avoid class and they demonstrate a clear intention to learn a lot from making the visit. These statements show responsible students, who want to have fun, a logical thing at their age, but they do not want to free themselves of class for one day but to learn.

Of the four statements that seek their opinion on Physics, the students agree that this is a useful but difficult subject, and not enjoyable and fun, which mostly leads them to assert that it is not their favorite subject. Thus, the European Union has shown the need to improve the concept of general physics and experimental sciences in our society (see, for example, the "Rocard Report", 2008).

As to the answers given on the statements concerning Optics, these are, of course, quite discouraging to the teachers of this subject, since a significant percentage of students, almost half of them (45.08%), believed they could not give examples of the concepts of reflection and refraction, although these phenomena have already been studied several times before, in both primary and secondary education. While most recognize that the phenomena of optics are close to their daily lives, almost 30% did not think so, a percentage similar to those who claim to know little or nothing of Optics. Also in this section, the percentage of qualified claims with a 3 (neither agree nor disagree) reached quite high values, suggesting that students were unclear what to think, perhaps, through ignorance.

Presumably, therefore, that the students were interested in visiting this laboratory in particular, and those of the University in general, and this interest should be exploited to achieve a significant improvement in their conceptions of physics and, in particular optics. In short, university laboratories should be opened to secondary school students.

Evaluation during the development of the activity

When the group arrived, and after a brief conversation with the teacher in charge, the activity began and, as it developed, both its evolution and the behavior of teachers and students were observed.

Regarding the attitude of teachers, the following observations were made:

- They participated little, but experienced it with interest.
- About half of them took photographs.
- Some took notes.
- Very few asked questioned or participated.

Moreover, as noted above, upon completion of the activity, the teachers were asked for their main conclusion about the visit. In this sense, the most common opinion was that it seemed very appropriate for their students; they believed it would help them to see physics and optics in a much more positive light and they expected to use examples of it afterwards in the classroom, although they did not specify in what sense and how they would use it. The impression made by these comments is that most teachers did not anticipate carrying out any particular activity either before or after the completion of the visit, but thought after making it, that perhaps they could use it later. On the other hand, we did not receive any negative opinion about the activity.

In one case, the teacher took copious notes and took many photographs of both the students and the experiments themselves. He indicated that he had proposed to the students that they would do a work after the visit, to which all students would have to contribute from both recreational and academic points of view.

Regarding the presenters' observation of the students:

- During the first five minutes they were rather shy.
- Girls tended to behave better while the boys tried to get attention by "joking about"
- After those five minutes, they were participatory, always ready to touch, comment or reply.
- They kept their interest and motivation throughout the activity.

These findings are consistent with the views expressed by Jarvis and Pell (2002) which also indicated that prior to the visit the girls were more anxious than boys, but as the visit went on the boys showed more interest.

Maintaining motivation and interest throughout the activity is the major stated goal, and it is very rewarding those doing the activity when it is achieved.

Another outstanding aspect of the attitude of the students is shown by the final comments that they made, considering that carrying out this activity was very appropriate since they deemed it "*short*", and volunteered that "*they liked it and had learned a lot"* a spontaneous comment that showed us that the aims had been achieved.

Concerning the appropriateness of the experiments:

From the point of view of the opinions and desires shown by the teachers, the experiments selected were very appropriate, as they have proved to motivate students to maintain their interest and participation in a meaningful way. However, they do not always relate fully with the work going on in the classroom. To improve this area, further collaboration on the part of teachers is essential.

Survey of the students after the visit

As noted above, the evaluation survey after the completion of the visit is the most incomplete aspect because the number of responses received was low. This survey focused on the following aspects of the visit:

- Fun: there is unanimity that students had enjoyed themselves.
- Learning: they nearly all believed they had learned a lot.
- Suggestions: most left this blank. Those who indicated something in this section did so with the most varied opinions, such that they would like to have had more time, they could not see all the experiments or, for example, comments like: "*I have learned much, I thought Optics was just where you made glasses*"

The results of the post-visit opinions were undoubtedly very satisfactory, although we have to indicate that only just over a fifth of those who had completed the prior survey, and only a tenth of those who had attended the activity did so. Greater interest from teachers is absolutely necessary for the students to fill in the survey, as it seems, they forgot to pass on the opinion poll that was provided to the students.

FINAL REMARKS AND CONCLUSIONS

This work has focused on a first approach to the evaluation of an increasingly common and necessary science outreach activity, such as the guided visit by non-university students to university science centers. Both the activity presenters and the teachers are increasingly convinced of the need for such activities driven, in part, by the gradual decline in enrollment of science courses. Also, there is undoubtedly interest from non-university teachers to make the most of this opportunity given to them.

However, there are very few evaluation studies of such activities, outside of visits to non-formal science centers (museums, science centers, nature interpretation, and so on), where there is a certain tradition of educational research. Therefore it is necessary to go into this topic more deeply in order to optimize the results of such visits.

The following are the conclusions to be drawn from the results of the evaluations.

1. With regard to teachers' expectations about the visit to be undertaken and the nature of the experiments offered, they would prefer to have more links to the curriculum they teach. The preferred objective that teachers attributed to the experiments is their students' motivation. Finally, although they did not considered the visits routine, they did not plan previous work on them in their classrooms.
2. Turning now to the students of secondary school and Baccalaureate who participated in the visit, they showed great willingness and motivation to visit the laboratories of the University, wanted to have fun and enjoy themselves with their friends, but also to learn from visits like this.
3. Of their knowledge of optics that students had declared before visiting, they knew surprisingly little and their views were disconnected from real life.
4. The teachers usually followed the development of the experiments with interest but took little part. Nor did they seem to deduce that they could be used later in their teaching, although they considered them appropriate for their students.
5. The attitude of the students, after a short interval, was expressed in interest and participation in the course of the experiments.
6. The low number of post-visit responses from students precludes drawing evident conclusions, although we are satisfied with what has been done.

As for the *future implications of this study*, we can start by saying that the great willingness shown by teachers and students on the visits obliges us to upgrade the process and overcome the shortcomings and weaknesses that have been observed.

The aspect that surely must be insisted on in the development of the activity is to coordinate more with the teachers, the concept they have of it, and their involvement. Proper disposition of the students and the good results obtained have been proven and it is necessary for teachers to develop complementary actions to perform in the classroom, both before and after the visit; to set the activity objectives and maintain the relationship between activity and curriculum. This would, without doubt, be positively beneficial to the students.

With respect to the image of optics, we must stress that the students who made the visit knew little about the subject. It is surprising that students' knowledge of optics is so poor and students failed to see how optics relates to their daily lives since these students have seen optics topics previously at both the primary and early secondary levels. This is certainly an observation on which to reflect and that has to be related, among other variables, with current teacher education.

ACKNOWLEDGEMENTS

We wish to acknowledge the funding received for this work under the Project EDU2008-02059 from the Ministry of Science and Competitiveness (Spain).

BIBLIOGRAPHY

Cox-Petersen, A.M., Marsh, D.D., Kisiel, J. & Melber, L.M., Investigation of guided school tours, student learning and science reform recommendations at a Museum of Natural History, *Journal of Research in Science Teaching*, 40, [2], 200-218, 2003.

Falk, J. & Storksdieck M., Using the contextual model of learning to understand visitor learning from a science center exhibition, *Science Education*, 89, [5], 744-778, 2005.

García, J.A., Romero, J., Perales, F.J. & García-Sanz, R., Visita al laboratorio de Óptica: una experiencia motivadora para alumnado de ESO y Bachillerato, *Alambique. Didáctica de las Ciencias Experimentales*, 64, 109-120, 2010.

Griffin, J., Research on students and museums: Looking more closely at the students in school groups, *Science Education*, 88, [1], 59-70, 2004.

Guisasola, J., Azcona, R. Etxaniz, M., Mujika, E. & Morentin, M., Diseño de estrategias centradas en el aprendizaje para las visitas escolares a los museos de Ciencia, *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 2, [1], 19-32, 2005.

Guisasola, J. & Morentin, M., Concepciones del profesorado sobre visitas escolares a museos de Ciencias, *Enseñanza de las Ciencias,* Número extra VIII Congreso Internacional sobre Investigación en Didáctica de las Ciencias, Barcelona, 593-596, 2009.

Jarvis, T. & Pell, A,. Effect of the challenger experience on elementary children's attitudes to science, *Journal of Research in Science Teaching*, 39, [10], 979-1000, 2002.

Lemelin, N. & Bencze, L., Reflection-on-action at a science and technology-museum: findings from a university museum partnership, *Canadian Journal of Science, Mathematics and Technology Education*, 4, [4], 468-481, 2004.

Rocard, M. & others, Science Education Now*: A Renewed Pedagogy for the Future of Europe*, in: http://www.oei.es/salactsi/Informe_Rocard.pdf, 2008.

Tal, R., Bamberger, Y. & Morag, O., Guided school visits to natural history museums in Israel: Teachers' roles, *Science Education,* 89**,** [6], 920– 935, 2005.

Received 19-05- 2012/ Approved 29-04-2013

Investigar la explicación de los educandos en clases de ciencias: las bases culturales y biológicas

Research the explanation of students in science classes: the biological and cultural basis

Herbert Gomes da Silva, María Elena Infante-Malachías

Programa Interunidades em Ensino de Ciências e Escola de Artes, Ciências e Humanidades, Universidade de São Paulo, São Paulo, Brasil, herbertgomes@usp.br, marilen@usp.br

Resumen

Este artículo propone una mirada desde la biología del conocer para la enseñanza de las ciencias. Un estudiante como un observador construye su conocimiento a partir de las referencias incorporadas en la interacción que ocurre en el entorno de la escuela y la comunidad, ésto lo hace a través del lenguaje que crea el espacio relacional. La interacción entre los estudiantes se realiza de acuerdo con la estructura biológica de cada uno lo que permite el acoplamiento estructural. En este trabajo analizamos las explicaciones de los estudiantes para preguntas elaboradas en una secuencia didáctica interdisciplinaria. Fueron generadas tres categorías y nueve subcategorías de análisis que se presentan y discuten. Éstas permitieron inferir que las relaciones de la vida cotidiana les permiten a los estudiantes establecer interacciones recurrentes, que son las experiencias de las referencias utilizadas en las explicaciones elaborada por ellos.

***Palabras clave**: interacción, referencias, explicación, biología del conocer, conocimiento.*

Abstract

This paper proposes a view from biology of knowledge to teach science. A student as an observer constructs his knowledge from the references embedded in the interaction in the school environment and his community; this is done through language that creates the relational space. The student interaction is performed in accordance with the biological structure of each individual allowing the structural coupling. In this paper we analyze the students' explanations to questions developed in an interdisciplinary didactic sequence. Were generated three categories and nine subcategories of analysis that are presented and discussed in the text. These categories allowed us to infer that the relations of daily life will allow students to establish recurrent interactions, which are the experiences of the references used in the explanations made by them.

***Key words**: interaction, references, explanation, biology of knowledge, knowledge.*

INTRODUCCIÓN

Los educandos están en una constante interacción con el medio en que viven y con otros individuos, esta acción es tan recurrente que puede no ser percibida durante el quehacer cotidiano. En esta perspectiva, el concepto de interacción puede ser comprendido como las relaciones del sujeto con el medio o las relaciones con otros individuos. Las interacciones de un educando tienen influencia en la forma que éste determina las referencias de la realidad que lo rodea.

La manera a través de la cual el estudiante interactúa es un reflejo de su estructura cognitiva y neurológica, lo que le permite una plasticidad de dinámicas (Maturana & Varela, 1980; 1988; 1998) para definir la forma como responde a los estímulos o de la manera por la cual formula sus proposiciones y explicaciones con respecto a aquello que aprende. En esta perspectiva, la acción que influencia la interacción, puede ser comprendida como aprendizaje.

La acción de la interacción es un quehacer humano en su espacio de vivir, en su fluir como ser vivo. A este respecto Maturana & Varela (2001) afirman en un aforismo clave de este ciclo de interacción del individuo con la realidad que lo rodea que: "Todo hacer es un conocer y todo conocer es un hacer". De esta forma, el proceso educacional como espacio de interacción del educando debería promover intencionalmente este ciclo entre conocer y hacer, una vez que este espacio es pensado y planificado para que eso ocurra. Nos parece importante destacar aquí que aunque no sea planificada la interacción va a ocurrir en todo y cualquier ambiente escolar como la sala de clases, los pasillos, el gimnasio deportivo, las áreas al aire libre, durante las clases y en los recreos por mencionar algunos espacios y actividades. De esta forma, los educandos están sujetos y son actores de una constante interacción.

Los dominios de interacción del individuo pueden ser comprendidos con respecto al medio como "el dominio de su operación como un todo en el espacio de todas las interacciones" (Maturana & Varela, 1998). De esta manera, el ambiente escolar al estimular el hacer estará incentivando y fomentando el proceso de aprendizaje, esto es, el conocer. Cuando el educando se encuentra envuelto en este ciclo constante, su forma de interactuar se va modificando junto con el medio que lo rodea y junto a las referencias que se van estableciendo y que van siendo construidas por el sujeto-educando. Maturana (1998) define el educar como:

> "el educar constituye un proceso en el cual el niño o el adulto convive con el otro y, al convivir con el otro, se transforma espontáneamente, de manera que su forma de vivir se torna progresivamente más congruente con el del otro en el espacio de convivencia." Maturana (1998, p. 29).

Esta concepción de educar se puede comprender como alusión al conocimiento formalizado en los contenidos disciplinares y en las relaciones establecidas con los educadores, los compañeros de clase, los compañeros de la escuela, los mejores amigos, los padres, esto es, todo aquello que el educando establece como importante en sus relaciones.

En este dominio explicativo entonces, un objetivo central de la escuela y de la enseñanza seria proporcionar oportunidades al educando para que este desarrolle sus capacidades y habilidades y no apenas para indicarle sus inhabilidades. Otro objetivo importante en esta visión es el de contribuir para que el educando construya coherentemente su conocimiento. Este conocimiento le permitirá comprender el mundo en el cual vive. Para que estos objetivos sean alcanzados es necesario ayudar explicita y claramente al educando para que éste se adueñe y asuma su posición de sujeto con respecto al conocimiento y a su propio desarrollo educacional.

Así, la educación escolar debería estar fundamentada en principios que permitan que el propio educando establezca conexiones entre los contenidos del currículo escolar, de las experiencias y de su realidad. (Fourez, 2003; Lemke, 2006). Maturana (2001) cuando insiste en que "la realidad es una proposición explicativa", define una perspectiva para el educando frente a la realidad, perspectiva ésta, que puede cambiar la forma como el sistema de enseñanza aborda sus acciones dentro del campo de la enseñanza de las ciencias. Este cambio tiene como centro propulsor y a la vez como factor principal la importancia de la proposición del educando al explicar la realidad en que vive. En la visión del gran educador brasileño Paulo Freire (Freire, 1996) esta centralidad de lectura de la propia realidad por los sujetos a través de su propia palabra, se traduce en la lectura no ingenua del mundo. Insistimos en esta lectura de la realidad a través de la palabra del educando como una forma de atribuir sentido al contenido curricular de ciencias, abordado en particular en este texto.

De esta forma, tomando en cuenta la perspectiva de realidad como construida por el proceso de interacción del educando con ella, la enseñanza de las ciencias podrá situarlo en el papel de observador activo y crítico del propio vivir cotidiano, en el entender la vida, en la forma de construir su conocimiento y en la manifestación de su experiencia a través del lenguaje.

El lenguaje es una manifestación comportamental humana, una forma de interactuar con la realidad y de influenciar la manera de intervención en el medio y en las relaciones con los otros individuos. La concepción de lenguaje en una visión Bakhtiniana, considera la noción de sujeto delante de un contexto con varios elementos influyentes, pudiendo ser estos contextos históricos, culturales y sociales. Esta misma noción considera la comprensión y el análisis, la comunicación efectiva y los sujetos y discursos envueltos en ella (Brait, 2006). Al analizar el sujeto envuelto en este lenguaje, podemos identificar otro campo que ejerce una gran influencia sobre él, su constitución biológica, esto es, su constitución como ser vivo con una fenomenología biológica que lo torna un fenómeno biológico. Un fenómeno biológico es todo fenómeno que envuelve la realización del vivir de por lo menos un ser vivo (Maturana & Varela, 1998). Como un ser vivo, el educando no puede ser comprendido fuera de esta constitución, y su proceso de aprendizaje a través de la interacción no puede ni debe ser ignorado

En el contexto que acabamos de exponer, buscamos en la propuesta de investigación de este artículo, analizar las referencias iniciales que el educando establece para sus explicaciones a través del lenguaje. Por otro lado, pretendemos indagar el papel de la interacción para la construcción de referencias de los educandos en clases de ciencias de la naturaleza.

La referencia epistemológica base de la investigación

El desarrollo de esta investigación se llevó a cabo considerando la perspectiva epistemológica de la biología del conocer de Humberto Maturana y de manera particular el concepto de ciencias. Este es definido a partir de la perspectiva del observador con respecto a la realidad que lo rodea y en acuerdo, o en convergencia con otros individuos envueltos en una vivencia científica. De acuerdo con Maturana (1998) "la realidad es una proposición explicativa". De esa forma la comprensión del concepto de ciencias en este texto, involucra la explicación de la realidad fundamentada en la experiencia en el vivir de un grupo de individuos. La diferencia entre el conocimiento producido de manera científica y el conocimiento que no es científico, reside en los métodos a través de los cuales la explicación fue realizada y que está conscientemente explícita para el sujeto que observa. También es importante considerar que este sujeto es aceptado por el grupo con el cual comparte su explicación de la realidad, sentido común científico o comunidad científica (Kunh, 1996).

De esta forma, el aprendizaje es la reacción del ser vivo a una interacción con el medio o con otros seres vivos, lo que resulta en conocimiento. Así, el individuo comienza a seleccionar la forma que interactúa a partir de este conocimiento. Después que ocurre el aprendizaje, la manera que el individuo interactúa no es por casualidad o simplemente un comportamiento aleatorio (Wieser, 1972). Existe a partir de ese momento una intencionalidad, una opción comportamental y una manera de interactuar determinada por el individuo.

A partir de esta perspectiva surge el sujeto que observa. El hombre se posiciona delante de la realidad dentro de un proceso de interacción. Para realizar lo propuesto en este trabajo, considerando el hacer ciencia, el hombre tiene una condición inicial al proponer una explicación. Somos observadores en el observar, en el suceder del vivir cotidiano en el lenguaje, en la experiencia del lenguaje (Maturana, 1998).

El comportamiento es una manifestación que puede ser observada, éste no encierra en sí una distinción entre lo que es instintivo y lo que es aprendido (Maturana, 1988; 1990; 1998; 2002). O sea, no podemos identificar lo que es aprendido o lo que es instintivo, pero podemos observar este comportamiento en la interacción. Cuando observamos el comportamiento seleccionado de un ser, manifestado en su interacción, estamos hablando de conductas consensuales, como definido por Maturana (1998, pág 71).

En esta investigación se procuró observar la explicación, como conducta consensual, a través de la manifestación comportamental de existencia del ser humano: el lenguaje. Esta afirmación se origina en el pensamiento de Maturana & Varela (2001) cuando afirman que: "Toda reflexión, inclusive la que se hace sobre los fundamentos del conocer humano, ocurre necesariamente en el lenguaje, que es nuestra manera particular de ser humanos y estar en el hacer humano".

METODOLOGÍA

Los sujetos de la investigación

Consideramos el proceso de aprendizaje como objetivo de la investigación para la enseñanza de las ciencias. En esta perspectiva, el aprendizaje se origina a partir del proceso de interacción, siendo éste el elemento constructor de las explicaciones para la realidad y sus conceptos científicos. Para esta finalidad trabajamos con un grupo de educandos de una escuela de la red pública del Estado de San Pablo en Brasil, la escuela estatal Casimiro de Abreu[1]. Los estudiantes fueron jóvenes del 9º año de la enseñanza básica por representar la última etapa de este periodo de escolarización y, al mismo tiempo por poseer en el currículo contenidos de ciencias que permitían un abordaje interdisciplinar entre conceptos de química, física y biología de forma no fragmentada. El grupo de estudiantes fue formado por tres cursos regulares con un total de 81 jóvenes con edades entre 13 y 15 años. La investigación fue realizada en octubre de 2011, durante el segundo semestre escolar.

[1] Escuela de período integral, localizada en la ciudad de São Paulo, en la región centro, barrio Vila Paiva.

La secuencia didáctica aplicada en la investigación

El trabajo fue desarrollado durante una secuencia de 5 clases de 60 minutos de duración cada una. Cada una de las clases tenía objetivos específicos de acuerdo con el aumento del nivel de complejidad de las actividades, grado de interacción y participación de los estudiantes formulada a través del lenguaje (Tabla 1). La investigación fue realizada en dos momentos principales. El periodo entre la primera y la segunda respuesta fue para estimular interacciones planificadas e intencionales a través de actividades didácticas permitiendo así la observación de las manifestaciones del comportamiento de los estudiantes, las cuales son objeto de análisis en este artículo.

Tabla 1: Planificación de las clases de acuerdo con los objetivos (lo que hacer) y acciones que los estudiantes deberían realizar (reacción de los estudiantes a las actividades)

Clase	Objetivo	Propuesta de acción
1ª	Estimular la manifestación de las concepciones de los estudiantes para explicar a través de la escritura	Los estudiantes deberían responder la pregunta: ¿El color blanco existe? Elaborando una respuesta escrita
2ª	Estimular la observación y formulación de hipótesis explicativas	Experimentos con rayo de luz
3ª	Identificar, asociar y describir el contenido propuesto sobre la visión (I)	Invitación a la participación, aula dialogada y presentación de *slides* digitales: rayos de luz (Física)
4ª	Identificar, asociar y describir el contenido propuesto sobre la visión (II)	Invitación a la participación, aula dialogada y presentación de *slides* digitales : visión, sistema perceptivo y cerebro (Biología y Química)
5ª	Instigar las concepciones para el explicar, a través de la escritura	Los estudiantes deberían responder la pregunta: ¿La sensación del color blanco existe? Elaborando una respuesta escrita

En la primera clase fue propuesto a los estudiantes la respuesta a la pregunta: ¿El color blanco existe? Durante la segunda clase fueron realizados experimentos diversos con rayos de luz. El primer momento consistió en la utilización de una luz blanca como faja de luz incidiendo sobre un prisma. En el segundo momento se utilizó una ampolleta L.E.D (*Light Emiting Diode*), compuesta por unidades que representasen los colores primarios del rayo de luz: verde, azul y rojo. A partir del tercer momento, a través de un lente biconvexo convergente de pequeña distancia focal (una lupa escolar), puesta entre la ampolleta y una superficie blanca, fueron alternadas las fuentes de luz de la siguiente forma: un L.E.D encendido; dos L.E.D encendidos y tres L.E.D. encendidos, diversificando las combinaciones de colores. Posteriormente, La superficie blanca se cambió por una superficie roja, otra verde y otra azul. Finalmente, fue utilizada una ampolleta de luz negra sobre las diversas superficies (blanca, roja, verde y azul).

Durante la tercera clase fue realizada una clase dialogada sobre las propiedades físicas de los rayos de luz. En la cuarta clase, los contenidos conceptuales comprendían el funcionamiento de la visión en los seres humanos, anatomía del ojo, la percepción del ambiente, el sistema neural y como las sinapsis se distribuyen en el cerebro, además de la interacción del ser humano al percibir el ambiente. En la quinta y última clase se le propuso a los estudiantes que respondieran una nueva pregunta, que contenía una alteración importante: ¿La sensación del color blanco existe?

RESULTADOS Y DISCUSIÓN

Los datos analizados fueron las respuestas por escrito de los estudiantes, producidas en la primera y última clase de la secuencia didáctica propuesta. Las respuestas de los estudiantes fueron analizadas y categorizadas de acuerdo con el sistema conceptual propuesto en este trabajo y las ideas de la teoría de la biología del conocer de Humberto Maturana y Francisco Varela.

Los estudiantes elaboraron respuestas a la pregunta inicial propuesta, sin intervención del profesor; ¿El color blanco existe? Las respuestas después de analizadas y categorizadas permitieron la identificación de los fundamentos que ellos utilizan para realizar sus explicaciones. A partir de la interpretación de las respuestas de los estudiantes, fueron identificadas tres categorías con nueve sub categorías originadas a partir de estas (Tabla 2).

Tabla 2: Categorías y subcategorías de referencias, identificadas en las explicaciones de los estudiantes para la primera pregunta: ¿El color blanco existe? Para cada categoría se indica el número de estudiantes clasificados dentro de cada una. En total 81 estudiantes participaron de la actividad y 16 no respondieron.

Categorías	Sub categorías	Ejemplos
1.Contextuales (n= 38)	a) Objetos	... El blanco está presente en muchas cosas: hojas de papel, zapatos, ropas, tintas, esmaltes.
	b) Constatación	Sí, yo veo el blanco en varios lugares.
	c) Experimentos	Si tu tomas un cristal y lo pones en la luz, los colores aparecen.
	d) Significados	El blanco es el color de la paz.
2.No-contextuales (n= 19)	e) Descriptiva	Es algo que existe en nuestros ojos que capta y manda la imagen a nuestro cerebro.
	f) Conceptual	Nuestro cerebro procesa las imágenes con el color blanco y podemos verlo.
3.Conceptuales Hipotéticas (n= 8)	g) Impositiva	Sí, porque es la forma de luz intensa.
	h) Divergente	Depende, si tú vas por tu visión, el color blanco existe. Pero si vas por la ciencia, el color blanco no existe.
	i)Relato personal	Como el prisma es transparente, y para mi es imposible lo transparente crear una luz blanca.

Para comprender las categorías generadas en este estudio, explicamos a continuación la naturaleza y el origen de las mismas:

1. ***Referencias contextuales*** – Estas explicaciones se fundamentan en situaciones del cotidiano, en la vivencia directa dada por la percepción, tienen relación directa con el mundo que rodea al estudiante, un mundo posible. Esta categoría fue dividida en cuatro subcategorías: a) *objeto* - la referencia que sirve de prueba es un objeto con el cual el individuo tiene contacto; b) *constatación* – la referencia es la validación por la experiencia o prueba directa que sirve como hecho comprobatorio; c) *experimento* – utiliza como referencial la descripción de un relato vivido por el individuo y d) *significado* – todo lo que representa algo de sí mismo, esto es, valores intrínsecos de los estudiantes o formados socialmente (Bakthin, 2006).
2. ***Referencias no contextuales*** – Las explicaciones son formulaciones que pueden ser aplicadas a diferentes contextos, o que no necesitan de contexto para su entendimiento. Esta categoría fue dividida en dos subcategorías: e) *descriptiva* – cuando el estudiante describe la experiencia sin revelar en su discurso el contexto en el que ocurrió el episodio y f) *conceptual* – En este caso el estudiante utiliza un concepto que no permite dudas con respecto a su posición, es casi un enunciado.
3. ***Referencias conceptuales hipotéticas*** – Las explicaciones surgen de una manera independiente de un histórico de vivencias y son consideradas como enunciados en las explicaciones de los estudiantes. Fue dividida en tres subcategorías: g) *impositiva* – que finaliza la explicación de forma categórica sin espacio para argumentaciones contrarias; h) *divergente* – cuando la explicación presenta elementos discordantes que demuestra una posición heterónoma, autoritaria o una opinión de negación al propio enunciado, i) *relato personal* – cuando la explicación revela la idiosincrasia del estudiante, indicando que ésta fue el resultado de su reflexión apoyada en sus valores.

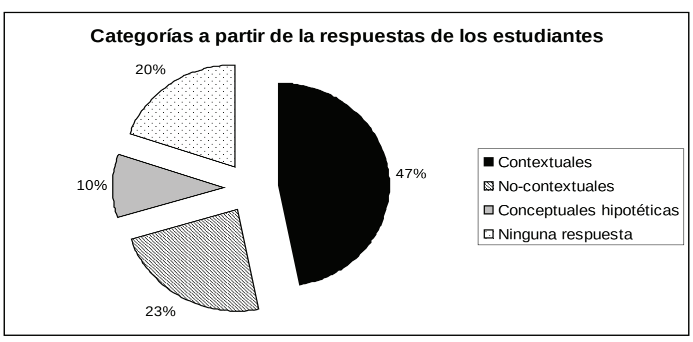


Figura 1. Distribución de las explicaciones de los estudiantes en las categorías que resultaron del análisis de sus respuestas. Se indica el porcentaje obtenido para un total de 65 respuestas.

En la figura 1, fueron representadas las explicaciones de los estudiantes de acuerdo con las categorías elaboradas después de la interpretación de las mismas. Como se puede observar, la mayoría de los estudiantes utilizó en sus textos discursos correspondientes a la categoría contextual (47%; 38 estudiantes) para explicar la pregunta inicial. De esa forma, es posible identificar situaciones observadas en el cotidiano de los estudiantes utilizadas para comprobación de sus conclusiones. Esta información es de gran importancia porque los estudiantes utilizan como principal referencia de sus explicaciones, el mundo que los rodea.

Durante el transcurso de las cinco clases sin intervención directa del profesor, los estudiantes vivieron situaciones que les permitieron comparar sus explicaciones con las explicaciones científicas provenientes de la biología, física y química, al respecto de los fenómenos estudiados. Durante la última actividad de la secuencia fue nuevamente propuesta la pregunta inicial con una modificación: el uso de la palabra sensación. Sin embargo, como el objetivo aquí no es el estudio de los contenidos conceptuales, y si de la identificación de las referencias que los estudiantes utilizan para tomar sus decisiones y explicar el mundo, esa alteración en la pregunta no fue relevante para la ejecución de la tarea.

Al responder la pregunta realizada en la última clase: ¿La sensación de color blanco existe? Los estudiantes mostraron argumentos más elaborados y sus explicaciones estaban estructuradas con base en los conocimientos científicos presentados y discutidos en las clases anteriores, construidos durante el transcurso de las vivencias ofrecidas por la secuencia didáctica. El análisis de la pregunta final será divulgado en otro artículo que caracterizará la interacción como elemento fundamental para la expansión de las referencias de los estudiantes en las clases de ciencias.

El acoplamiento estructural (Maturana y Varela, 2001) se produce cuando dos o más individuos en un proceso de interacción recurrente se interfieren entre sí provocando cambios en todos los involucrados. Los estudiantes en clase, su vida escolar y su vida en la comunidad, están en acoplamiento estructural con otras personas, lo que promueve una interacción recurrente en su vida cotidiana. Este acoplamiento estructural se realiza mediante el uso del lenguaje todos los días, lo que causa las interacciones recurrentes que pueden o no pueden establecer conductas consensuales entre los estudiantes, y esto es lo que sucedió en el grupo que participó en las actividades propuestas en esta investigación.

CONCLUSIONES

Frecuentemente en la práctica escolar, se señala la importancia de la memoria para la enseñanza-aprendizaje de ciencias. Esto se revela cuando exigimos respuestas “padrón” de nuestros estudiantes y cuando desconsideramos las explicaciones de éstos, por considerarlas ingenuas o no científicas. Para Damásio (2010), lo que normalmente llamamos de memoria es una memoria compuesta por las actividades sensitivas y motoras relacionadas con la interacción entre el sujeto y el objeto durante un tiempo determinado. Esto, en las palabras del autor, significa que la memoria es pre-conceptuada por nuestra historia y creencias previas. La memoria perfectamente fiel y “pura” para un conocimiento científico es un mito. Damásio (2010) afirma que nuestro cerebro retiene una memoria de lo que sucedió en una interacción, y esa interacción incluye fundamentalmente nuestro pasado, y muchas veces el pasado nuestro como especie biológica y cultural.

De esta forma, siempre percibimos mediante una interacción y no de una receptividad pasiva, por este motivo, recordamos contextos y no cosas aisladas (Damásio, 2010).

Desde nuestra perspectiva y a partir de la biología del conocer proponemos que la educación científica debería suceder en el espacio relacional de los estudiantes. Esto debería ocurrir a partir de la planificación de actividades que estimulen el lenguaje científico en el espacio en que el educando se relaciona y también brindarle experiencias que promuevan la interacción y que le sirvan de referencia en la construcción de sus discursos. Proponemos que esta manera de abordar la enseñanza de las ciencias haría que el lenguaje científico, pudiera manifestarse de manera no mecánica ni literal sino en la forma de construcción de explicaciones en las relaciones de los estudiantes sea en la escuela como en la vida comunitaria.

BIBLIOGRAFIA

Brait, B. *Bakhtin: conceitos chaves* / Beth Brait (org.). 3 ed. – Contexto: São Paulo, 2006.

Bakhtin, M. *Marxismo e Filosofia da linguagem: problemas fundamentais do método sociológico da linguagem*. Traducción de Michel Lahud y Yara Frateschi Vieira. 13 ed. Hucitec: São Paulo, 2006.

Damásio, A. R. *Self comes to mind: constructing the conscious brain*. Pantheon Books, New York, 2010.

Fourez, G. Crise no ensino de ciências? *Investigações em Ensino de Ciências*, 8 (2), 109-123, 2003.

Freire, P. *Pedagogia da autonomia: saberes necessários á prática docente*. Paz e Terra, São Paulo, 1996.

Lemke, J. Investigar para el futuro de la educación científica: Nuevas formas de aprender, nuevas formas de vivir. *Enseñanza de las Ciencias*, 24 (1), 5-12, 2006.

Maturana, H. R. Autopoiesis, structural coupling and cognition: a history of these and other notions in the biology of cognition. *Cybernetics & human knowing*, vol. 9, No.3-4, pp 5-34, 2002.

Maturana, H. *Cognição, ciência e vida cotidiana*. Organización y traducción Cristina Magro, Víctor Paredes – Ed. UFMG: Belo Horizonte, 2001.

Maturana, H. *Emoções e linguagem na educação e na política*. Ed. UFMG: Belo Horizonte, 1998.

Maturana, H. Reality: the search for objectives or the quest for a compelling arguments. Irish J. Psychology, 9 (1), 25-82. (issue on constructivism), 1988.

Maturana, H. *Science and daily life: the ontology of scientific explanation*. In W. Krong, G. Kuppers, & H. Nowotny (Eds), *Selforganization: portrait of a scientific revolution*. Pp. 12-35. Dordrecht: Kluwer Academic Publisher, 1990.

Maturana, H. & Varela, F. J. *Autopoiesis and cognition: the realization of the living*. Boston studies in the philosophy of science; v. 42, 1980.

Maturana, H. & Varela, F., *A árvore do conhecimento: as bases biológicas da compreensão humana*. Palas Athenas: São Paulo, 2001.

Maturana, H & varela, F., *The tree of knowledge*. Boston: Shambala New Science Library. 1988.

Maturana, H. & Varela, F., *De máquinas y seres vivos – autopoiesis, la organización de lo vivo*. Ed. Universitaria: Santiago de Chile, 1998.

Kuhn, T. *The structure of scientific revolutions*. 4ª ed. Perspectiva S. A.: São Paulo, 1996.

Wieser, W. *Organismos, estruturas, máquinas: para uma teoria do organismo*. Editora Cultrix: São Paulo, 1972.

Received 13-07- 2012/ Approved 29-04-2013

Disease detectives at work: a lesson on disease transmission for secondary school students

Detectives de enfermedades en el trabajo: una clase sobre la transmisión de la enfermedad para los estudiantes de escuela secundaria

Mary E. Dawson

Department of Biological Sciences, Kingsborough Community College of The City University of New York, Brooklyn, New York, 11235, USA, Mdawson@kingsborough.edu

Abstract

The recent outbreak of the H1N1 virus, or swine flu, sparked weeks of discussion in a secondary school life science course. Therefore, this activity was designed to address students' questions about, and strengthen their understanding of the concept of disease transmission. In this exercise, students act as disease vectors and detectives; both transmitting a simulated disease to each other, and tracing the infection back to its source. As such, students practice science inquiry skills, and address a social perspective of science.

Key words: *simulated disease transmission, active learning, biology lessons*

Resumen

El brote reciente del virus H1N1, o de gripe de los cerdos, fue discutido en las semanas de las ciencias en los cursos de escuela secundaria. Por lo tanto, esta actividad fue diseñada para tratar las preguntas de los estudiantes relacionadas, y consolidar su comprensión del concepto de transmisión de la enfermedad. En este ejercicio, los estudiantes actúan como vectores y detectives de la enfermedad; ambos que transmiten una enfermedad simulada el uno al otro, y rastreando la infección a su fuente. Como tal, los estudiantes practican habilidades de la investigación de la ciencia, y tratan una perspectiva social de la ciencia.

Palabras clave: *transmisión simulada de la enfermedad, aprendizaje activo, biología*

INTRODUCTION

It has been demonstrated that students who have early positive experiences with science are more likely to become interested in careers in research, medicine, environmental science, and even zoo keeping (Gould, Weeks, Evans, 2003). Moreover, students who describe themselves as having had negative experiences in science classes, even as far back as elementary school, reported finding science difficult and boring (Gould, Weeks, Evans, 2003), and frequently avoided pursuing a profession that might require a science background.

More recent research suggests that there may be other reasons why students avoid science. The traditional way in which science is taught, especially in secondary schools, may be unappealing to many students. Informational lectures, presented by a "sage on a stage", followed by the typical paper and pencil assessments may cause a lack of engagement in the subject on the part of the student. This lack of investment leads some students to find science boring (Joyce, Farenga, 2000).

Active learning, defined as any activities students do in a classroom other than just listening to the instructor's lecture, creates a sense of relevance and personal investment for science students (Paulson, Faust, 2000). Active learning provides an opportunity for students to interact with the professor and fellow students, which promotes the development of higher order thinking skills (Bonwell, Eison, 1991), and allows students to stop passively receiving information, and to interact with the information in a meaningful way. Moreover, research shows that students understand material better and retain it longer if they can react to the lecture or course material actively (Paulson, Faust, 2000). These factors make it more likely that active learners will stay in college and graduate. Therefore, it seems likely that engaging younger students in active learning, particularly middle school students, may pave the road for future success in science. Making science more accessible to students, while at the same time fostering positive student/ teacher interactions may eliminate some of the factors that lead to science disinterest and avoidance.

METHODOLOGY

In the recent past, the H1N1 virus, also known as "swine flu" was a hot topic in the media, and in the biology classroom, as well. As reports of this illness began to spread, and worldwide panic seemed imminent, students became extraordinarily curious about the flu, and how it might become a pandemic. This highly visible outbreak provides a unique opportunity to illustrate the process of disease transmission, with a hands-on laboratory activity.

In addition to addressing a current event, the lesson provided a way to address several of the National Science Foundation Education Standards. For example, students were conducting scientific inquiry, and examining science in person and social perspectives. Prior to the start of the lab activity, a lively discussion about the recent epidemic was conducted, and students were eager to discover how the disease transmission route could be so rapid and so widespread.

This exercise fit seamlessly into a lesson on the immune system. A class of 10th grade high school biology students participated in this lesson. During a three-hour laboratory class, 24 students were divided up into groups of 6 students.

National Science Education Standards Addressed by Activity in This Article

Science As Inquiry (5-8):
- Abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry.

Science in Personal and Social Perspectives (5-8)
- Personal health
- Natural hazards
- Risks and benefits
- Science and technology in society

History and Nature of Science (5-8)
- Science as a human endeavor
- Nature of science

Secondary School

The eight categories of content standards are
- Unifying concepts and processes in science.
- Science as inquiry.
- Physical science.
- Life science.
- Earth and space science.
- Science and technology.
- Science in personal and social perspectives.
- History and nature of science.

(National Research Council. 1996. *National Science Education Standards*. Washington, DC: National Academy Press.)

ASSESSMENT

Students may be assessed through their participation in the exercise, and their written responses to the questions included. In Exercise 1, students are required to draw conclusions based on their observations. They will present their findings to the class. The lab reports produced by each team in exercise 2 should be reviewed and assessed by the other teams in the class. Exercise 3 can be used a homework assignment, providing the students with an opportunity to reflect on what they have learned, and then apply this knowledge to real life situations, thus adding context to their knowledge acquisition.

Extension

The results from this exercise can also be used to underscore lessons in:
- the impact of disease on different socioeconomic classes
- bio-terrorism and biological warfare lessons in history/and or current events
- the historical implications of major outbreaks of contagious diseases

DISCUSSION

Evidence indicates that learning should be interest driven. The relatively recent newsworthiness of the H1N1 virus, commonly known as swine flu, captivated a group of high school students studying life science. They became increasingly interested in how this disease could be transmitted so rapidly and so easily, and were eager to learn about disease transmission. Creating a hands-on activity enables instructors to demonstrate a powerful concept in a very meaningful, easy to visualize way. The students were excited to sleuth the disease transmission pathway, and the concept of how a disease is easily transmitted and spread was clearly understood by all students. Furthermore, the students gained exposure to the field of epidemiology. The lesson had a very positive impact on the class, and sparked many hours of discussion about diseases and their transmission, particularly swine flu. Subsequent discussion involved topics such as biological warfare, and what impact it would have on society; how diseases such as bubonic plague, cholera and small pox can have huge historical implications; and the reasons why economically disadvantaged members of a society might be more likely to suffer the ravages of disease.

One shortcoming of the exercise was the fact that precision was important to a successful outcome. That is, it was important for students to keep a precise record of which students they exchanged "bodily fluids" with. Therefore, this exercise requires close supervision by the lab instructor, thereby lending itself best to small groups. One suggestion is that the instructor should keep track of which students had what solutions, such as in a "blinded" fashion on the blackboard for all to see.

CONCLUSIONS

This lesson proved to be an excellent, inexpensive, and easy to implement format for bringing a highly visible news item into the science classroom. It is easily adapted for use at both the middle and high school level. Students were excited to explore the science behind something they read about and watched on television every day. Furthermore, they were able to practice scientific inquiry and apply the scientific method to a socially relevant problem. The students were amazed to see how their deductive reasoning skills could be employed to parse out which of their classmates were the disease vectors, and the route of disease transmission. Finally, this lesson was the launching point for many future discussions about disease transmission, and scientific inquiry.

BIBLIOGRAPHY

Bonwell, C. and J. Eison. Active Learning: Creating excitement in the classroom. ASHE-ERIC Higher Education Report No. 1. Washington , DC: George Washington University. Available: http://www.ed.gov/database/ERIC_Digests/Ed394441, 1991.

Caine, G., R. N. Caine, and C. McClintic. Guiding the innate constructivist. *Educational Leadership*, 60(1): 70-73, 2002.

Gould, J.C., Weeks, V, and Evans, S. 2003. Science Starts Early. *Gifted Child Today,* 26 (3), 38 – 41, 2003.

Joyce, B. A., & Farenga, S. J. Young girls in science: Academic ability, perceptions, and future participation in science. *Roper Review*, *22*(4), 261-262, 2000.

Orlik, Y. Ch. 10. Modern class organization and extra class work in chemistry. *Chemistry: Active Methods of Teaching and Learning.* , Iberoamerica Publ., Mexico, 2002.

Paulson, D., and J. Faust. http://calstatela.edu/centers/cetl/instspeak/scl/activelearning, 2000.

APPENDIX 1

Materials

Instructors should prepare two sets of the following, one for each exercise.
- 5 disposable 5-ml transfer pipettes per student/ 6 students per group (commercially available)
- 1 test tube per student/ 6 per group
- 1 bottle of distilled water - 15 ml per student/ 90 ml per group of 6
- 1 bottle of 0.1 N NaOH - 15 ml per student/ 90 ml per group of 6
- About 10 mL phenol red per group of 6
- A wax crayon or permanent marker

Safety note: Care should be taken when handling these chemicals. As is true for all work in the laboratory, instructors and students should wear goggles, a lab coat, and proper gloves, and standard safety practices observed.

Preparation of Solutions

Distilled Water

Decant 200 ml of distilled water into a disposable plastic bottle (commercially available) and label with a number and record. Prepare one 250 ml beaker-full for each lab group except one. The remaining group will receive the NaOH solution

1 N NaOH

Measure 40.0 g of NaOH (Fisher Scientific) on a triple beam balance. Add this mass to a 1 L volumetric flask and dilute with distilled water up to the 1 L mark. Decant about 200 ml of this solution into a disposable plastic bottle (commercially available) and label with a number (different from the HCl solution above) that you will record**.** Prepare one 250 ml beaker-full and **place at one lab table only**. Make sure to keep track of the solutions and their identifying numbers.

Once prepared, these solutions have a long shelf life and can be kept indefinitely if capped. Instructors should decant the distilled water and the NaOH solution into 250 ml beakers and provide one at each of the student lab stations. (NOTE: only one table gets the NaOH).

Students should be instructed in the use and proper disposal of transfer pipettes. All solutions should be dispensed using disposable 5 ml transfer pipettes. Pipettes should be rinsed and disposed of in a standard trash receptacle.

The following activity was designed for high school students, but it can be adapted for a middle school life science course. The exercise best lends itself to working in small groups of six students per group.

ACTUAL LESSON
HOW ARE DISEASES TRANSMITTED?

Introduction

Are you able to count how many times you have been sick in your life? Probably not, because in reality you have been sick more times than you can possibly remember or count. Now think back to the last time you were sick. What were the symptoms? How long were you sick? Did you see a doctor, or did you "tough it out" on your own? Were you able to figure out how you got sick?

Diseases are insidious in the way they spread. A sneeze, a cough, a handshake or even seemingly harmless kisses are some of the many ways in which diseases may be transmitted. Some diseases, such as the common cold, run their course within a week to ten days and have virtually no lasting effects. Other diseases, like swine flu, hepatitis, AIDS, West Nile Virus and Ebola Virus can be much more devastating.

Biological weapons such as anthrax and small pox are effective and deadly because they can be easily transmitted in the air we breathe and by the things we touch. Today we will investigate how diseases are transmitted from one individual to another.

Materials

At each laboratory station you will find the following material:

- A bottle of stock solution with a number on it
- a clean test tube
- several 5 ml disposable transfer pipettes
- Phenol red solution
- A wax crayon or marker

All stock bottles contain dilute (0.001N) hydrochloric acid (HCl), except one, which contains 0.1N sodium hydroxide (NaOH). Both solutions look the same, and are to be considered bodily fluids for the rest of the exercise. The NaOH solution represents the infected fluid, and therefore, the disease-spreading agent. The person in possession of this solution is the carrier of the disease, and can easily transmit it to others by exchanging bodily fluids with them.

Exercise 1 (Time required: 1.5 hours)

Method

1. Transfer three pipettes full of stock solution (about 15 ml) into a clean test tube. Keep this pipette for step 3.
2. Randomly select another student in your group with whom you will exchange solutions (bodily fluids).
3. Put one pipette full of your solution into the other person's to complete the exchange. Rinse this pipette and discard it in the trash.
4. Record the name and stock number bottle of the person you exchanged fluids with.
5. Repeat this exchange with two more people from the class. **Use a clean pipette each time. Remember to rinse and the discard the pipette before taking another.**
6. Return to your laboratory station and, using a clean pipette, add one drop of phenol red to your test tube. Phenol red will react with NaOH to produce a change in color from clear to red. No such change occurs with HCl.
7. Record the results from your test tubes in your lab notebook.

Your instructor will record the names and contacts of infected individuals on the black board. Along with your classmates, you should try to find the original source of the infection, and determine the route of transmission throughout the class. Discuss the following questions in groups of two or three. You will share your conclusions with the entire group.

I. Is it possible to predict the maximum number of individuals who could be infected after three rounds of transfers? If so, what is that number?

11. Why might the observed number of infections differ from the predicted number?

Exercise 2 (Time required: 1.5 hours)

Method

In Exercise 1 you observed the results of disease transmission within a limited group of individuals. What do you predict might happen if the number of contacts you make is greatly increased? Would your chances of becoming infected also increase? Why or why not?

With these questions in mind, you are to formulate a hypothesis and develop an experiment to answer the following question:

Do the chances of becoming infected with a contagious disease increase when the number of contacts with possibly infected individuals increases?

Your hypothesis should be an "if/then" statement. For example: "If" a disease is airborne, "then" breathing may cause me to become infected. Have you instructor review your hypothesis and experimental design before proceeding.

Your experimental design should test your hypothesis, and will use the same materials as Exercise 1. You will be provided with new numbered stock solutions, clean pipettes, and clean test tubes. List and number the steps in your experimental design.

After you have made your observations and collected your data, analyze these data and draw conclusions from them. Present these data, using charts and/or graphs, along with your conclusions. Since scientists rarely work alone, "brainstorming" with your classmates is encouraged. Use the following format to prepare your final report.

Disease Transmission

Question: Do the chances of contacting a contagious disease increase when the number of contacts with possibly infected individuals increases?

Hypothesis:

Materials:

Experimental Design and Methods:

Data and Analysis:

Conclusions:

Exercise 3 (Homework)

Use what you have learned in this exercise to compose a real life scenario in which a disease is being spread. Discuss how you would go about detecting the source of the disease, and what steps you would take to prevent further contamination?

Received 28-11- 2011/ Approved 29-04-2013

Drawings, words and butterflies in childhood education: playing with ideas in the process of signification of living beings

Diseños, palabras y mariposas en la educación infantil: juego con las ideas en el proceso de significados sobre los seres vivos

Celi Rodrigues Chaves Dominguez [1], Sílvia Luzia Frateschi Trivelato[2]

[1] Escola de Artes, Ciências e Humanidades (EACH-USP), Universidade de São Paulo, Av. Arlindo Bettio, 1000, CEP 03828-000, São Paulo, SP
[2] Faculdade de Educação, Universidade de São Paulo, Av. da Universidade, 308, CEP: 05508-040, São Paulo, SP, Brasil.
celi@usp.br,slftrive@usp.br

Abstract

The purpose of this research was to investigate, referenced on Vygotsky's work, how the process of attributing meanings to living beings occurs among young children. To this end, a group of sixteen 4-year-olds were monitored in their activities relating to the development of the project "Small Animals", during which they made an in-depth study of butterflies. This work was carried out using a qualitative methodology. It was found that the children negotiated the meanings of words among themselves during the discursive interactions. It was concluded, from this investigation, that the children not only assimilated some knowledge about butterflies but also incorporated into their drawings similar modes of representation as those they encountered in the scientific materials made available to them, with special emphasis on the sequential format of presentation of the phases of the life cycle of butterflies.

Key words*: child education, children's drawings, science teaching, language, Vygotsky*

Resumen

La finalidad de esta investigación – realizada en la Guardería Oeste, localizada en el campus de la Universidad de São Paulo – Brasil, fue investigar, a partir del referencial de Vigotski, como ocurre el proceso de atribución de significados sobre los seres vivos, entre niños cuando están participando de interacciones discursivas mediadas por los adultos. Para esto, un grupo compuesto por 16 niños de 4 años fue acompañado durante ocho meses en las actividades relacionadas al desarrollo del proyecto "Pequeños Animales", cuando estudiaron con mayor profundidad las mariposas.En este trabajo, se utilizó la metodología cualitativa. Se constató que los niños fueron negociando entre sí los significados de las palabras, en el transcurrir de sus propias interacciones discursivas. En esta investigación, se concluyó, que los niños, además de apropiarse de algunos conocimientos sobre las mariposas (aspectos morfológicos, fases del ciclo de la vida, diversidad de las especies, hábitos alimentarios y estrategias de defensa contra los predadores), incorporaron, en sus dibujos, modos de representación semejantes a los encontrados en los materiales de divulgación científica disponibles a los niños, mereciendo destaque el formato secuencial de la presentación de las fases del ciclo de la vida de las mariposas.

Palabras clave: *educación infantil, enseñanza de ciencias, lenguaje, Vigotski, dibujo infantil, atribución de significados*

INTRODUCTION

The purpose of our work is to explore how young people process and categorize attributes of living objects. To this end, we present an analysis of drawings and dialogues produced by sixteen 4-year-old children who responded spontaneously to the researcher's request that they "draw something about the Small Animals project" which the children primarily studied butterflies.

Early childhood drawing

Several authors claim that children's thinking is ludic, i.e., when they play or draw, children think about the reality of their surroundings and produce knowledge and impressions about it (Soundy, 2012; Swann, 2009; Fello, Paquette & Jalongo, 2007; Kishimoto 1996; Dias 1996; Santa-Roza 1993). In this study, we consider drawing as a language young children use to interact ludically with the world and to understand it (Soundy, 2012; Ferreira 2003; Moreira 1999).

Drawing is a way to allow children to express their thoughts and construct meanings for them. (Ferreira, 2003) It is these meanings that we are interested here, since they are the product of thought and reveal the process of construction of ideas. As Soundy (2012) asserts "when adults spend time talking with children about their artwork, they see glimpses of imagination at work, as well as effective uses of language." (p. 45)

For Vygotsky (2000), the act of imagination is thus manifested through different recombinations that children make of real elements; in other words, each drawing is therefore the representation of a recreation of the reality known by children. The author claims that it is only possible to create starting from what is familiar.

Several authors (Chang, 2012; Kim, 2011; Derdyk, 1989) see drawing as a way of acting upon the world whereby it invents and tests its hypotheses and theories about how the world functions. Derdyk (1989) also emphasizes the importance of verbal language that enables the child to name its drawings and them.

Soundy (2012) points out when children are stimulated to speak about their drawings "such conversations place teachers in a better position to understand children's thought processes, extend their meaning through interaction, and contribute to their future development as visual meaning-makers." (Soundy, 2012)

Brooks (2009) warns us not to interpret solutions for graphic problems as expressions of thoughts concerning scientific questions. That is why, in the analysis of drawings, it is important to take into account the dialogues of their authors.

In Brooks' work, this researcher stresses that group drawing not only helps children to visualize their own ideas and projects but also enables them to reach "a higher level of thinking." According to the author, "when young children are able to create visual representations of their ideas they are more able to work at a metacognitive level". (Brooks 2009, p. 340)

Based on the above considerations, we analyze the two types of texts produced by the children: drawings and dialogues.

The roles of verbal language and symbolization based on Vygotskian references

According to Vygotsky (1998), for young children, speaking is part of the solution of practical tasks like drawing a picture. Therefore, in our research, our analyses of drawings always include the dialogues of those that produced them. At four or five years of age, children are still unable to think in silence i.e., their thinking is not yet interiorized. Thus, the need to speak is associated with that of planning and organizing actions to be executed.

For Vygotsky (1998), the development of language and the ability to symbolize lead to changes in the possibilities of perception and of the field of attention, since language enables us to pay closer attention to some aspects than to others, allowing for new rearrangements of reality by means of innumerable sequences and different groupings.

Another contribution of language is that it expands the capacity of memory. Referring specifically to the role of memory in the early years of life, Vygotsky (2003) asserts that, for young children, thinking is synonymous to remembering. With respect to creative productions, the author emphasizes that creative ability is directly linked to memory. (Vygotsky, 2000)

In the context of this work, these graphic productions serve as evidence of what was in the children memories and what captured their attention at the moment they produced them.

However, we must not forget that, although the drawings are individual, they were produced in a group as the children talked among themselves. As Vygotsky argues (1998), "for children, signs and words constitute first and foremost a means of social contact with other people." (p. 38)

This author also states that "the meaning of words evolves" (Vygotsky 1998, p. 151). This is because, through the use of communicative speech, the sense of words is negotiated and their meanings are attributed accordingly (Kim, 2011). Therefore, inviting the children to draw butterflies was like inviting them to think and talk about butterflies, to establish relationships and to develop their thoughts about the subject a little more. We can thus state that our data constitute records of the actual process of negotiation of meanings.

METHODOLOGY

The study group was composed of sixteen 4-year-olds and a teacher. During the four-month period of obsevation, the researcher acted as a participant, following the activities relating to the "Small Animals" project, which took place twice a week. The animals that most captured the children's interest were butterflies.

During the observation time, the teacher proposed a wide variety of activities aimed at motivating the children to learn more about the little animals and to think about the subject, making records using different languages like roundtable conversations, children's stories, caterpillars observations in the terrarium, dramatizations, drawing, modeling, painting, collage and research into informative materials.

Just before we concluded our data collection, the children were invited to make a drawing of the project. As soon as each of the children finished the task, they were asked to explain everything they had drawn (Soundy, 2012). The material produced by a group composed of four children who interacted during this production is presented below. The children sat together around the same table and talked during the entire time they were drawing. Children's names are assumed.

Aspects of the process of signification revealed by the drawings

Presented below are the four drawings produced. It should be kept in mind that the information in the captions was obtained from the declarations of the authors.

Fig 1 Rafael's drawing
(1- flower for the butterfly to rest on; 2- butterflies; 3- cocoon; 4- ladybug)

Fig 2 Felipe's drawing
(1- butterflies; 2- cocoon; 3- tree)

Fig 3 Clara's drawing
(1- cocoon; 2- larva; 3- grub; 4- a "pile" of leaves; 5- butterflies; 6- flower for the butterflies to rest on; 7- daughter ladybug; 8- mother ladybug; 9- path for the ladybugs to meet; 10- little balls for the grub to eat inside the cocoon)

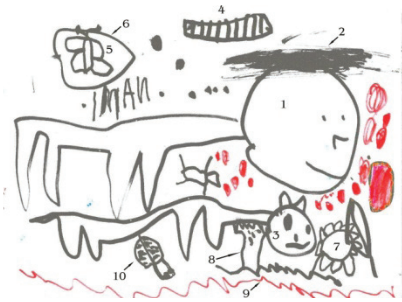


Fig 4 Tiago's drawing
(1- lion; 2- lion's mane; 3- cat; 4- caterpillar; 5- butterfly; 6- cocoon; 7- flower; 8- tree; 9- brushwood; 10- ladybug; 11- little balls the caterpillars enter to turn into butterflies)

One of the interesting aspects is the fact that some elements are repeated in all the drawings, such as butterflies in their adult form, the presence of plants (trees, flowers, brushwood), the cocoons and the presence of ladybug. This preoccupation is very peculiar, for it points to the idea that the children were quite clear about the context of production of their drawings.

In this context, the children included in their drawings the indispensable conditions for maintaining the life of the animals, such as, for instance, the needs of butterflies for a home, a place to rest. This is evidenced by the flowers (Fig.1, 3,4), by the brushwood (Fig. 4) and by the tree (Fig. 2). Another interesting aspect is the appearance of several stages in the life cycle of these insects, as indicated by the presence of a cocoon (Fig. 1, 2), of all the stages of life (Fig. 3, 4). We also can mention several morphological aspects of the animals: segmentation (Fig.2, 3, 5); the presence of wings on all the butterflies (Fig. 1, 2, 3, 4); the presence of antennae (Fig. 2, 5) – and the little balls in the drawings of Clara and Tiago (Fig. 4, 5).

Despite their similarities, a look at the set of drawings shows that they are visually very different, indicating that these productions are authentic and preserve the individual characteristics of each author, and are not stereotyped or copies. In addition to the graphic aspects, one can also see differences among the elements included in each of the productions, and even in each child's motivation while drawing.

This brief analysis of the drawings is the first evidence that, although these productions are individual, they also make up a single collective production since they somehow complement one another.

Roles of verbal language in the construction of meanings

The transcriptions of the children's dialogues during the production of their drawings are presented below.

Clara: First I'm drawing a flower to put the butterfly on.
Rafael: Hey, if you do it, I'll do it. If you draw a flower, I'll draw a flower.
Felipe: I won't draw a flower.
Rafael: Now, I'm going to draw the one of (..)
Clara: I didn't even draw it.
Rafael: Leave it. I'll draw the flower for the butterfly to stay on.
Clara: But that one I'm going to draw in the daytime.

The main function of the first dialogue is to enable Clara to plan her action. However, upon hearing her, Rafael begins a negotiation about how each one will or will not include the significant "flower" on the paper. In other words, the dialogue initially plays only a planning role. Nonetheless, because it is spoken aloud, it also assumes a communicative function when it is heard.

For both Rafael and Clara, the meaning of "flower" refers to "a place for the butterfly to rest". But when the boy says he will include this element because Clara said she would also do it, the girl immediately made a differentiation: "But that one I'm going to draw in the daytime." It is interesting to note that these statements indicate that "flower" is not seen merely as a decoration, but rather as an element that delimits the context, representing the natural environment in which butterflies live.

Tiago: Draw a cat now.
Clara: In a cocoooooon.
Rafael: I'm drawing a co... red of the cocoon. You're right, the cocoon I was going to draw.
Clara: I'm going to make a huge cocoon. Look at the enormous cocoon!
Rafael: That doesn't even exist.
Clara: But I'm going to draw a huuuuge butterfly. (...)
Tiago: *I'm going to draw a tiny cocoon. (...) Here, a tiny cocoon. I'm going to draw another cocoon.*

Before Tiago even entered the room, he said he would not make a drawing about the project, however, when Clara announced she was going to draw a "cocoon", he immediately started producing a series of representations about the theme of "butterflies". It is interesting to note that Tiago not only decided to talk about cocoons but also started participating in the context that was being negotiated: the size of the cocoon.

While Tiago's cocoon is "tiny", Rafael questions the fact that Clara produces an image of an "enormous cocoon," stating that it doesn't exist. Once again, one sees the preoccupation of representing a real butterfly, a live being and not an "artistic" butterfly. In response to Rafael's questioning, Clara included another characteristic as a way to give her drawing coherence: "draw a huuuuge butterfly." This strategy the girl uses also indicates she has a notion that there is a connection between cocoon and butterfly as two forms of life of the same animal.

Clara: There'll come a thing... a teeny-weeny thing. It'll be crawling.

Tiago: I'm going to draw a butterfly passing by.

Clara: Hey...what was it like... that thing there that's...

Rafael: A cocoon. I'm drawing.

Clara: What is that really? Ah. Ahhh, that one... [laughter]

Rafael: Drop the cocoon, Clara; you keep on pushing the table the whole time.

Clara: Looks like... ahh...a (little arrow)...I don't know.

Rafael: A little larva, Clara.

Researcher: Ah, is it a little larva?

Clara: It's a little larva. This here's a little larva, the...oh, it...

Tiago: Hey! I'm gonna draw the little larva.

Clara: Aaaa thingy. A.., what it's called?

Rafael: I don't remember.

Clara: Here's the little larva.

Rafael: Cocoon!

Clara: Nooooo! See the cocoon here! (points at the outline of a cocoon on her paper)

Rafael: Little larva, of course.

Clara: No, little larva was this one. Teeny-weeny larva. (again points at her paper)

Clara: Yeah, it's the... oh... it's the.., what's the... what's it called?

Rafael: I don't know (I know).

Clara: Ah... ah... .

Tiago: The earthworm.

Clara: Yeah, the earthworm.

At this point, Clara interrupted her outlining twice, lifting her pencil off and away from the paper. The first time was when she couldn't remember the words "little larva," and the second time, when she couldn't name the grub, which Tiago called "earthworm." Only after her classmates helped her find the word corresponding to the stage of life she was describing verbally did she resume drawing.

This situation points to the importance this girl places on naming and to the fact that talking really serves to regulate action, since Clara was only able to resume drawing when she found what she considered a suitable word.

Once again, we see that size is significant for children, since this characteristic enables the girl to differentiate between "little larva" and "grub."

Another aspect we perceive in Clara and Tiago's dialogues, as well as Rafael's, is the movement performed or suffered by the animal, in another condition indicating its existence as a living being – the little larva "will be crawling", the "butterfly passing by."

Researcher: *What's the name of the "butterfly earthworm"? La...?*

Tiago: *I'm gonna draw it...*

Researcher: *La... la...*

Clara: *I'll do it, la...*

Researcher: *Larva, isn't it?*

Clara: *I'm gonna make a grub. The grub, it's wide*[1]*. Then it's gonna eat a lot…Big fat grub… The leaf that was here, piles of leaves, piles, piles, piles.*

Clara: *And it ate a pile, it ate and ate. And then it stayed inside the cocoon.*
[a child making some sounds]

Clara: *It stayed inside the cocoon, and turned into a butterfly.*

Rafael: *Ah, I did the cocoon after you. Haha.*

Clara: *Let me. (…)I'm doing the butterfly.*

In this portion of the conversation the researcher intervened to refresh the children's memory with the word "grub" (lagarta) as an alternative for "earthworm." However, pronouncing just the first syllable of the word ("la…") was not enough to remind the children of this relationship, indicating that "earthworm" was a reference they found more suitable for butterfly larvae.

Therefore, when the researcher spoke the complete word (lagarta[1]), the girl immediately made an inversion of the letters which made more sense for the meaning she attributed to this life form, that of a voracious animal. The dialogue, in addition to indicating a possible association of the ideas of growth and development with the act of eating – considering the distinction made between the little grub (teeny-weeny) and the grub (big fat grub) –, also allows us to reflect about the relationship between the description of the meaning of the word grub [lagarta] and the significant "grub" itself, which, to be accepted by Clara as a representative of the "butterfly worm" phase, had to undergo an inversion of its letters that would give meaning to this word[1].

The sequence constructed by the child – after "eating a pile" the grub stayed inside the cocoon and turned into a butterfly – allows us to assume that the food was considered an indispensable condition for development. Moreover, it should be noted that although it corresponds to a phase in the life cycle of butterflies, the children used the word "cocoon" as a synonym for shelter, i.e., a "place for the butterfly to stay."

Clara: It's surviving here, the butterfly.[she said, indicating the cocoon she had drawn first]

Researcher: Is it surviving?

Clara: Yeah. Because I'm making some little balls for them to eat.

Researcher: OK. Ah, and it eats while it's inside the cocoon.

Clara: Yeah.

Researcher: Right. Hmm...

Clara: Mine eats.

Researcher: Yours eats.

Tiago: Lemme see...

Clara: But it doesn't really eat...!

In this conversation, the relationship between food and survival becomes even more evident, for the girl states that the grub's survival inside the cocoon is possible thanks to the insertion of little balls for the animal to eat.

It is interesting to note that, in response to the researcher's question, Clara explained that she recognized the difference between a "real" butterfly and the one in her picture. One could thus wonder: if Clara knew that butterflies do not eat in the cocoon phase, why did she include food in her picture, even though most of the time she demonstrated her intention of representing a real butterfly?

Although she knew what grownups and books say about the cocoon phase, for Clara, the existence of a live being that can survive without food did not make sense, so she could not leave the cocoon without the "little balls" because she wanted to ensure the animal's survival. Thus, introducing food into the cocoon in her picture was a way to attribute meaning to the information that might still be incoherent to her. Therefore, Clara used her imaginary ability to reorganize the elements of reality.

The way in which Clara appropriated several items of knowledge about butterflies – the phases of their life cycle, the grub's voracious appetite, the anatomical aspects of each phase, and flowers for the butterflies "to rest on" – did not occur passively or randomly, but instead, in a way coherent with her inner reality: one must eat frequently to stay alive.

Tiago: *Look, look, here's the little ball. It's the little ball.*

Researcher: *And what are those little balls for you, Tiago? What is the caterpillar... what do those little balls do?*

Tiago: *The caterpillar goes here into the little balls and it turns into a butterfly.*

Researcher: *Oh, inside the little balls.*

Rafael: *It's the cocoon, isn't it Tiago?*[Tiago nods his head affirmatively.]

Researcher: *So they're the cocoons, these little balls? Oh, Tiago, how wonderful.*

Here, once more, speech as a regulatory function is transformed into communicative speech. However, although Clara and Tiago included little balls in their pictures, they attributed different meanings to this word/figure. Therefore, when Clara said "little ball" – even though she immediately

1 In Portuguese, the word *lagarta* contains all the letters of the word *larga*, with only a minor change in the location of the letter R. (grub = lagarta; wide or fat = larga)

explained the meaning she attributed to the term – Tiago, upon hearing it, appropriated the word based on his own references, giving it a meaning that seemed to make more sense at that moment.

After Tiago described what he was referring to when he drew "little balls," Rafael named these little balls by asking: "It's the cocoon, isn't it Tiago?" Tiago agreed, demonstrating that they both shared the same definition for the word "cocoon."

From the findings we came up with based on an analysis of the data obtained, below we present a few considerations about the process of signification and of the implications of the characteristics of these interactions when working on biological subjects with young children.

FINAL REMARKS

The practical drawing task was continually permeated with dialogues, confirming Vygotsky's (1998) proposition about the need young children have to talk in order to carry out this kind of activity (Brooks, 2009; Soundy, 2012).

During the entire exercise, the children revealed that they were clearly aware of the butterfly context approach. To draw "live butterflies," they included in their pictures the elements related to life: food, habitat, shelter and development. Among the scientific items of knowledge assimilated by the children we can highlight their notions about life cycle and metamorphosis, morphological aspects of butterflies, feeding habits and locomotion strategies.

Drawing pictures, therefore, required that the children think about butterflies in a specific way, taking as reference what they knew of these animals from a biological standpoint. It is interesting to note that during the development of the project, in addition to scientific materials, toys, children's stories, works of art, etc. were also used. However, the different experiences they had in the daycare center through the use of such diverse materials and activities enabled the children to "play with ideas about butterflies," providing them with a rich repertoire of memories about the subject and enabling them to know how to refer to butterflies when seen as living beings, and not, for instance, as imaginary characters in children's stories or cartoons.

Nothing was initially predetermined regarding the form and/or results expected from the production of the pictures. It was precisely this repertoire of memories that allowed for the emergence of "loose ideas." The spoken expression of these ideas constituted a mode of thought organization and of action planning. The speeches also exerted the function of communication, since, upon being heard, they triggered conversations and changes in the elaboration of the drawings (Soundy, 2012; Brooks, 2009).

We can therefore state that the drawing task enabled reciprocal interferences in the children's fields of memory and attention, leading them to produce drawings that, while preserving individual aspects, are the fruit of the discursive interactions and the negotiations that took place. It could be asserted that the set of four drawings is also a single collective production.

It is also worth mentioning, as Vygotsky (2003) argues, that for young children words elicit a set of meanings, and not defined concepts. For instance, when Tiago heard the word "cocoon," it led him to draw not only a cocoon but also a series of elements referring to the butterfly's life cycle. When spoken aloud, this word interfered in the boy's field of attention, providing access to his memory and to the set of meanings associated with the word. It would thus be reasonable to wonder why it was precisely the word "cocoon" that caused the boy to change his original project. Why not the word "flower," "grub," or "butterfly?"

The term "cocoon" seems to have a greater potential as a referent of memory than the other words, perhaps because Tiago established a stronger affective relationship with this word, or, having satisfied his desire to draw the lion and the cat, he was more inclined to do what the researcher had requested (Vygotsky, 2003).

Clara, a child who makes intensive use of verbal language, enabled us to discover two aspects that stand out: the importance of naming things to draw her figures (Derdyk 1998), and the need for the meanings of words to make sense.

These findings indicate that the process of signification about butterflies, in their condition of living beings, enabled the children to identify not only the conditions necessary for life but also the most suitable ways to represent them in this context.

Finally, among the concerns educators should keep in mind when broaching subjects related to live beings with young children, it seems to us appropriate to highlight three that we consider crucial. The first is the choice of a variety of informative materials with good quality images that address the same theme from distinct perspectives (such as children's literature, scientific texts, cartoons, paintings, poems, songs, etc.).

Another important concern is that of encouraging the children's participation in discursive interactions. Lastly, it is essential that children be able to use different expressive languages routinely in order to draw, paint, model, imitate, talk and play, play and play a great deal with the ideas related to subjects they study, in order the grasp the meanings and senses that are being mediated starting from biological knowledge.

BIBLIOGRAPHY

Arfouilloux, J. C. *A entrevista com a criança*. A abordagem da criança através do diálogo, do brinquedo e do desenho. Rio de Janeiro: Zahar, 1993.

Brooks, M. Drawing, visualisation and young children's exploration of "big ideas", *International Journal of Science Education* 31 [3], 319-341, 2009. doi:10.1080/09500690802595771

Brooks, M. What Vygotsky can teach us about young children drawing. *Art in Early Childhood* 1[1], 1-13, 2009.

Chang, N. The role of drawing in young children's construction of science concepts. In: *Early Childhood Education Journal* 40 [3], 187-193, 2012. DOI: 10.1007/s10643-012-0511-3

Derdyk, E. (1989). *Formas de pensar o desenho*: desenvolvimento do grafismo infantil. São Paulo: Scipione, 1989.

Dias, M. C. M. Metáfora e pensamento: considerações sobre a importância do jogo na aquisição do conhecimento e implicações para a educação pré-escolar. In: Kishimoto, T. M. (org.) *Jogo, brinquedo, brincadeira e educação*. São Paulo: Cortez, 1996.

Drucker, M. F.; Soundy, C. S. Drawing opens pathways to problem solving for young children. In: *Childhood Education* 86 [1], 7 -13, 2009.

Fello, S. E.; Paquette, K. R.; Jalongo, M. R. Talking drawings: improving intermediate students' comprehension of expository science text. *Childhood Education* 83 [2], 80- 86, *2006.*

Ferreira, S. *Imaginação e linguagem no desenho da criança*. Campinas: Papirus, 2003.

Kim, M. S. Play, drawing and writing: a case study of Korean-Canadian young children. *European Early Childhood Education Research Journal 19 [4], 483-500, 2011.*

Kishimoto, Tizuko M. O jogo e a educação infantil. In: KISHIMOTO, T. M. (Org.) *Jogo, brinquedo, brincadeira e a educação*. São Paulo: Cortez, 1996.

Moreira, A. A. A. *O espaço do desenho*: a educação do educador. São Paulo: Loyola, 1999.

Santa-Roza, E. *Quando brincar é dizer* – a experiência psicanalítica na infância. Rio de Janeiro: Relume Dumará, 1993.

Soundy, C. S. Searching for deeper meaning in children's drawings. In: *Childhood Education* 8 [1], 45-51, 2012. DOI: 10.1080/00094056.2012.643718

Swann, A. C. An intriguing link between drawing and play with toys. *Childhood Education* 85 [4], 230-236, 2009.

Vygotsky, L. S. *A formação social da mente*. São Paulo: Martins Fontes, 2003.

Vygotsky, L. S. *La imaginación y el arte en la infância*. Madrid: Akal, 2000.

Vygotsky, L. S. *Pensamento e linguagem*. São Paulo: Martins Fontes,1998.

Received 21-03- 2012/ Approved 29-04-2013

Designing a chemistry educational game and examining reflections about it

El diseño de un juego educacional de química y su análisis

Eylem Bayir, Cagil Deniz

Trakya University, Faculty of Education, Department of Science Education, Edirne, Turkey, eylembudak76@gmail.com

Abstract

In this study, a chemistry game named "Chemistry Land-Find It" was designed. Then, a group of students' and chemistry teachers' reflections about the game were examined. It is concluded that the game may be successfully employed to stimulate learning and to facilitate learning chemistry in an enjoyable way.

Key words: *educational games, chemistry, compound*

Resumen

En este estudio, en primer lugar fue diseñado un juego de química llamado "Tierra de química – encuentralo". En segundo lugar, fueron examinadas las reflexiones de un grupo de estudiantes y docentes de química sobre el juego. Se concluye que el juego puede ser empleado con éxito para estimular y facilitar el aprendizaje de la química de una forma divertida.

Palabras clave: *juegos educativos, química, compuesto*

INTRODUCTION

Developing scientifically literate individuals is a primary aim of science education. One of the central aspects of scientific literacy is having and being able to use scientific knowledge (Matthews, 1994). In order to help students to learn and use knowledge scientific disciplines such as chemistry, which are usually thought to be very hard and boring to learn, should be taught in an interesting and enjoyable way. It is possible to promote active/constructive learning and to make learning science a fun experience by means of educational games (Budak et al., 2006; Hatipoglu et al., 2004). According to Gredler (2012), games provide unique opportunities for students to interact with a knowledge domain. Besides, the games which have very specific content are beneficial learning tools in educational settings (Randel et al., 1992). The educational games which are appropriate to students' mental, physical and spiritual development improve learning and thinking skills, retention and attitudes of students (Forman & Forman, 2008; Karaagacli, 2005; Vanags et al., 2012).

It seems that educational games are widely used in teaching science currently (Navas & Orlik; 2003; Orlik, Gil & Moreno, 2006; Orlik, 2002). The interest in developing competitive games such as board and card games for chemistry teaching especially has gradually increased (Capps, 2008; Costa, 2007; Harris, 1975; Morris, 2011). These limited games are mostly focused on a specific subject in chemistry such as chemical symbols of elements, stereochemistry of carbohydrates. However, there is also need for comprehensive chemistry games which include many interrelated subjects. For this reason, we have turned our attentions towards developing comprehensive chemistry games for elementary, secondary and high school students. This study focuses specifically on introducing the *Chemistry Land-Find It Game* which is designed by us, and examining the reflections about it. Although *Chemistry Land-Find It Game* seems to be about compounds, it includes many interrelated subject and concepts such as solubility in water, structures of organic and inorganic molecules and valency of ions.

METHODOLOGY

Context of the study:

In this study, we firstly designed a chemistry game named *Chemistry Land-Find It*, for providing opportunity for students to use their knowledge about the classification, formulation and naming of organic and inorganic compounds. Secondly, we recruited a group of high school students and chemistry teachers to play the game, and examined their reflections on the experience.

Introduction of the game:

Chemistry Land-Find It Game involves 30 compounds. While 15 of them are organic compounds (saturated and unsaturated hydrocarbons, and alcohols all of which involve at most six carbons), 15 of them are inorganic compounds (ionic and covalent). The game is played with 2 players and 1 referee. Three identical cards are prepared for each compound so we have 90 cards (30 compound x 3 card). An example from the cards is given in Figure-1.

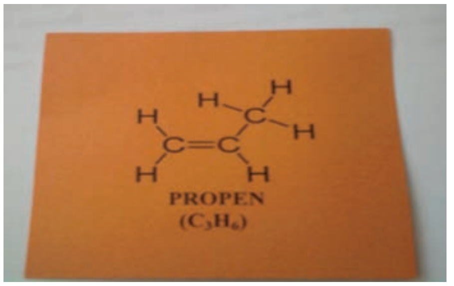


Figure-1: One of the cards in the game

Formulas (empirical and molecular) and name of the compound is written on each card. Some examples of the compounds covered in the game are C_3H_8, C_6H_6, C_2H_5OH, $C_2H_4(OH)_2$, C_3H_4, C_3H_6, C_6H_{12}, K_3PO_4, $CaCl_2$, Na_2CO_3, NF_5, N_2O_3, SF_6. A box for saving the game and a manual for introducing the rules of the game have also been prepared (Figure-2).

Figure-2: The box and the manual of the game

Rules of the game:

1. Three cards belonging to each compound are distributed to referee and two players. While all cards of players are laid as open in front of them, those of the referee are closed.
2. One of the players selects a card among referee's cards **without seeing compound which is written on it,** and gives the card to another player. This player holds the card and looks at the compound.
3. The player who has given the card asks questions which provide him/her with clues to identify the compound on the card to the other player. He/she determines the selected compound according to the answers of his/her questions by eliminating other compounds on the cards in front of them. (The ONLY answers allowed are 'Yes' and 'No'.) The cards of eliminated compounds are shut by reversing.
4. After he/she ascertains the compound, game continues with the selection of card by the player who held the card in the first round.
5. Each player should firstly ask one of these questions "Is *the compound organic?*" or "*Does the compound dissolve in water?*".
6. The question examples which players can ask are "*Is the compound an alkene?*", "*Does the compound have ionic character?*", "*Is the metal of the compound divalent?", "Is the compound in structure of cyclic?", "Does the compound have three carbons?"*.
7. Players can ask that "*Does ……(element) exist in the compound?*" only when if two compounds remain. However, it is every time possible to ask whether oxygen exists or not.
8. All the answers of questions in the game must be "*yes*" or "*no*". The names of compounds can not be asked. Players can not ask more than 10

questions. They should ask questions which provide them to eliminate as many compounds as they can.

9. Players win twenty points for each compound which they identified. However, one point is deducted from their points for each question which they asked. Therefore, in this game, it is important to identify more compounds with fewer questions. The player who has higher score than the other wins the game.
10. Compounds used in previous rounds are excluded from the game for that round.
11. Through the game, referee has three main duties: controlling the questions so that the players obey the rules, counting the number of the questions asked and recording the scores for each round.

Intervention:

After we designed it, we organized a chemistry game lesson for several hours in a high school in Edirne in Turkey. Participants of this lesson were five students (*grade 12, 17-18 years old*) and four chemistry teachers. This lesson was planned to inform participants about how the game can be used to teach and learn chemistry, and to take the reflections from the participants about it. During this lesson; firstly, the game was introduced, and a manual about rules of the game was given to the participants by the researchers. Secondly, we allowed them to play the game. Lastly, we interviewed all the participants about using the game in chemistry lessons. The views of participants were audio-taped and then transcribed for analyzing.

RESULTS AND DISCUSSION

When the views were analyzed, it was revealed that the teachers' reflections consist of eight domains. According to them, the game: *1*-teaches organic and inorganic compounds in an interesting and enjoyable way, *2*-teaches the relevant concepts to students easily, *3*-helps students to realize the relationships between concepts, *4*-brings forward mis-conceptions, *5*-addresses multiple intelligence domains, *6*-allows students to use their interpretation skills, *7*-allows students to use their learned concepts, 8-provides high interest and motivation to students for learning chemistry.

On the other hand, the students' views disperse into five domains. According to the participating students, the game: *1*-is a very enjoyable way to learn chemistry, *2*-encourages them to think in different ways, *3*-activates them physically and mentally, *4*-requires that they have understood the concepts within the game, *5*-provides the opportunity to apply previously learned concepts.

According to these results, it is concluded that the game designed by us may be successfully employed to stimulate learning and to facilitate learning chemistry in an enjoyable way. We believe that this study will be one of the corner stones as a part of a project on construction of a science games center in future in Turkey.

ACKNOWLEDGEMENTS

A brief summary of this study was presented at the 4th International Conference on Advanced and Systematic Research (ECNSI), Zagrep, Croatian, 11-13 November 2010, and it was awarded with "Best Paper Award".

BIBLIOGRAPHY

Atkins, P. & Jones, L., *Chemical Principles: The Quest for Insight*, Freeman, New York, WH, 1999.

Budak, E., Kanli, U., Koseoglu, F., Yagbasan, R., Science (Physics, Chemistry, Biology) Teaching with Games, *National 7th Science and Mathematics Education Congress.* 7-9 September 2006, Gazi University, Ankara, Turkey, 2006.

Capps, K. Chemistry taboo: An active learning game for the general chemistry classroom. *Journal of Chemical Education*, 85, [4], 518, 2008.

Costa, M. J., CARBOHYDECK: A card game to teach the stereochemistry of carbohydrates, *Journal of Chemical Education*, **84**, [6], 977, 2007.

Forman, S. & Forman, S., Mathingo: Reviewing calculus with bingo games. *Primus,* **18,** [3], 304–308, 2008.

Gredler, M., *Educational Games and Simulations: A Technology in Search of a (Research) Paradigm. In The Handbook of Research for Educational Communications and Technology,* Associate for Educational Communication and Technology, Bloomington, IN, 2001, Retrieved June 12, 2012, from http://www.aect.org/edtech/ed1/17/index.html

Harris, O., Chemistry game, *School Science Review*, **57**, [199], 352-354, 1975.

Hatipoglu, N. D., Kavak, N., Tumay, H., Budak, E., Tasdelen, U. & Köseoglu, F., Teaching Chemistry with Games, *18th International Conference on Chemical Education-IUPAC*, 3-8 August, Istanbul, Turkey, 2004.

Karaagacli, M., *Methods and Approaches in Teaching,* Pelikan Press, Ankara, Turkey, 2005.

Matthews, M., *Science Teaching; The Role of History and Philosophy of Science*, Routledge, New York, NY, 1994, 32.

Morris, T. A., Go chemistry: A card game to help students learn chemical formulas, *Journal of Chemical Education*, 88, [10], 1397-1399, 2011.

Navas, A. M. & Orlik, Y., Educational computer games on science teaching, *Journal of Science Education*, **2**, [4], 92-95, 2003.

Orlik, Y., *Chemistry: Active Methods of Teaching and Learning* (in Spanish), Iberoamerica Publ., Mexico, 2002, Chapter 10.

Orlik, Y., Gil, E. & Moreno, A., The game "Young Scientists" as an active science educational tool for extra-curricular work in the secondary school, *Journal of Science Education*, **7**, [2], 32-33, 2006.

Randel, J. M., Morris, B. A., Wetzel, C. D. & Whitehill, B. V., The effectiveness of games for educational purposes: A review of recent research, *Simulation & Gaming,* **23**, [3], 261-76, 1992.

Vanags, T., George, A. M., Diana, M. G. & Brown P. M., Bingo!: An engaging Activity for learning physiological terms in psychology, *Teaching of Psychology*, **39**, [29], 2012.

Received 18-06- 2012/ Approved 29-04-2013

Juegos educativos y aprendizaje de la tabla periódica: estudio de casos

Educational games and learning about the Periodic Table: case studies

Antonio Joaquín Franco Mariscal [1], José María Oliva Martínez [2]

[1] I.E.S. Juan Ramón Jiménez, c/ Fernández Fermina, 17, 29006 Málaga

[2] Departamento de Didáctica, Facultad de Ciencias de la Educación, Universidad de Cádiz, 11519 Puerto Real, Cádiz, España

antoniojoaquin.franco@uca.es, josemaria.oliva@uca.es

Resumen

En este artículo se presentan dos estudios de caso mediante los que se pretende indagar en torno a la adquisición de aprendizajes y actitudes despertadas en estudiantes de 10º grado cuando trabajan en torno a juegos educativos en el tema de los elementos químicos y su clasificación periódica. En uno de los casos el juego planteado implicaba aprendizaje de tipo mecánico y superficial, dirigido a la memorización de los elementos de las diferentes familias de la Tabla Periódica. En el otro se exigía aprendizaje de naturaleza más profunda de tipo significativo, orientado a la comprensión de la idea de periodicidad y las causas que fundamentan el comportamiento periódico de las propiedades de los elementos. Los resultados obtenidos sugieren en el primer caso, actitudes más favorables en los alumnos aunque centrada en la componente lúdica de la tarea, mientras en el segundo apuntan hacia mayores niveles de implicación cognitiva en relación al contenido estudiado, si bien el interés despertado parecía menor y los logros alcanzados fueron limitados.

Palabras clave: *actitudes de los alumnos, aprendizaje mecánico, aprendizaje significativo, clasificación periódica de los elementos, juego educativo*

Abstract

In this paper, two case studies are analyzed in order to investigate the acquisition of learning and attitudes aroused in students in grade 10 when working with educational games about the Periodic Table of elements. In one case, the game involved learning mechanical and superficial material directed to the memorization of the elements of the different families of the Periodic Table. In the other, significant learning was required, aimed at understanding the idea of periodicity and the causes underlying the periodic behaviour of the properties of the elements. The results obtained suggest the first developed more favourable attitudes in students while focusing on the recreational component of the task. On the other hand, the second pointed to higher levels of cognitive involvement *in relation to the content studied, although the interest aroused seemed less and achievements were limited.*

Key words: *attitudes of students, rote learning, meaningful learning, Periodic Table, educational game*

INTRODUCCIÓN

Esta investigación forma parte de una tesis doctoral cuyo objetivo era analizar el efecto del juego educativo como recurso didáctico en la enseñanza de la clasificación periódica de los elementos químicos en alumnos de educación secundaria (15-16 años) (Franco, 2011). Dicho trabajo se basó en parte en la evaluación de los aprendizajes de los alumnos a lo largo de una propuesta didáctica que incorporaba un conjunto de recursos lúdicos como elemento central para favorecer el aprendizaje de los estudiantes y actuar en el posible cambio de actitudes del alumno hacia las ciencias. En líneas generales la propuesta didáctica se mostró útil para el aprendizaje en general y la motivación del alumnado en particular. No obstante, se encontraron diferencias sustanciales en las actitudes despertadas ante aquellos juegos que exigían solamente aprendizajes de tipo asociativo o memorístico, y aquellos otros que requerían aprendizajes más profundos de tipo significativo. En este artículo se analizan las diferencias encontradas entre ambos casos tomando como referencia sendos juegos que perseguían respectivamente los dos tipos de propósitos señalados.

APRENDIZAJE A TRAVÉS DE JUEGOS Y ENSEÑANZA DE LAS CIENCIAS

En los últimos años ha surgido una gran efervescencia de publicaciones y propuestas educativas, gran parte de ellas de tipo lúdico, en torno a los elementos químicos y a la Tabla Periódica. En bastantes de estas propuestas se emplean juegos educativos muy variados y otros recursos recreativos, como modo de fomentar metodologías de enseñanza de tipo activo (Orlik, 2002) encontrando puzzles de muy diverso tipo (Helser, 2003; Franco y Cano, 2011), juegos de mesa (Linares, 2004), de naipes (Granath y Russell, 1999, Faria, Oliveira y Codognoto, 2010), bingos (Tejada y Palacios, 1995), etc. A estas actividades basadas en juegos podemos sumar otras que, sin recurrir propiamente a ellos, se plantean de un modo atractivo al hacer uso de recursos de tipo no formal como los documentales y el cine, la literatura, las adivinanzas, el teatro, las nuevas tecnologías, etc.

Parece existir un consenso al señalar que el juego constituye un elemento relevante en el desarrollo cognitivo y afectivo de niños y adolescentes (Garaigordobil, 1990). La aproximación al conocimiento a través del juego posibilita oportunidades para crear y desarrollar una serie de estructuras mentales (Piaget, 1979), que abren una vía al desarrollo del pensamiento abstracto (Vygotsky, 1982), así como una estimulación en aspectos relacionados con la atención y el recuerdo, la creatividad y la imaginación del alumno (Vygotsky, 1982; Bruner, 1986). En el ámbito específico de la enseñanza de las ciencias, Yager (1991), por ejemplo, señalaba que *"tomar parte en juegos focalizados"* sitúa al alumno en un escenario que facilita su motivación y que le permite trabajar en torno a destrezas de muy diverso tipo. Asimismo, los juegos didácticos ofrecen al estudiante la oportunidad de ser protagonistas de su aprendizaje.

Dentro de este conjunto de actividades podemos distinguir entre aquellas dirigidas a que los alumnos retengan o memoricen información, por ejemplo el aprendizaje de símbolos y nombres o de ubicación de los elementos en la Tabla (Peña, 2007; Franco, Oliva y Bernal, 2012) o retención de normas de formulación y nomenclatura química (Franco y Cano, 2008; Muñoz-Calle, 2010), y aquellas otras que requieren aprendizajes más profundos orientados a dar un sentido a la Tabla Periódica o aplicarla para interpretar propiedades o hacer predicciones (Faria, Oliveira y Codognoto, 2010; Franco, 2011). Resulta claro que los mecanismos de aprendizaje que se ponen en juego en ambos casos son distintos, y que las actitudes que pueden despertar a raíz de ello en los alumnos también pueden diferir. De hecho en el segundo caso tendríamos un aprendizaje más profundo, con demandas de implicación del alumnado más altas, y, en consecuencia, que exigen un mayor esfuerzo. Dado que el aprendizaje a nivel cognitivo está mediado por factores de tipo emotivo (Pintrich *et al.*, 1993), cobra sentido la indagación sobre cómo la complejidad cognitiva de la tarea afectaría a las actitudes positivas que potencialmente despiertan los juegos educativos en los estudiantes.

En este artículo se presentan dos estudios de caso mediante los que se pretende indagar en torno a la adquisición de aprendizajes y actitudes despertadas en alumnos de secundaria cuando se enfrentan a juegos educativos en el tema de los elementos químicos y su clasificación periódica. En uno de los casos el juego planteado implicaba aprendizaje de tipo mecánico y superficial, dirigido a la memorización de los elementos de las diferentes familias de la Tabla Periódica. En el otro, se exigía aprendizaje de naturaleza más profunda de tipo significativo, orientado a la comprensión de la idea de periodicidad y las causas que fundamentan el comportamiento periódico de las propiedades de los elementos. En éste, los estudiantes tenían que poner en práctica los conocimientos previos, establecer relaciones entre lo nuevo y lo viejo, y dar un sentido lógico a la información y a los procesos que se facilitan. A través de la comparación de resultados en ambos casos deseábamos comprobar en qué medida las demandas y dificultades de la tarea cognitiva que tenían que

Tabla 1. Propósitos de aprendizaje para la propuesta didáctica para alumnos de grado 10

Saber ciencias	Hacer ciencias	Saber acerca de las ciencias
Primer nivel de profundización		
- Apreciar la gran diversidad de elementos, y su papel como constituyentes de la materia. - Conocer los nombres y símbolos de los elementos químicos, así como los grupos principales. - Enumerar y comprender algunas propiedades físicas y químicas que sirven de base para clasificar a los elementos. - Conocer los criterios utilizados en diversos intentos de clasificación periódica como tentativas previas a la Tabla Periódica actual.	- Identificar elementos químicos en materiales del entorno. - Interpretar información a partir de valores de propiedades. - Identificar en la Tabla Periódica diferentes familias. - Diseñar y realizar experiencias para clasificar elementos a partir de su conductividad. - Diferenciar elementos en función de algunas de sus propiedades características. - Reconocer propiedades químicas de los elementos: reactividad, estequiometría, etc. - Clasificar elementos químicos en función de sus propiedades.	- Reconocer la importancia de una simbología universal para los elementos químicos. - Valorar la presencia de la química en la vida diaria. - Identificar la regularidad y la ordenación, como criterios en la clasificación periódica. - Estimar el carácter provisional de la ciencia a través de la evolución de la Tabla Periódica. - Valorar la utilidad de los modelos científicos. - Ser conscientes de las limitaciones de la Tabla Periódica, y del carácter aproximativo y parcial de todo conocimiento.
Segundo nivel de profundización		
- Conocer los "ladrillos" de la materia y el carácter universal de los elementos químicos. - Conocer y diferenciar algunos de los primeros modelos atómicos. - Asimilar conceptos inherentes a la clasificación periódica: número atómico, número másico, masa atómica, isótopos, octeto. - Conocer aplicaciones de los isótopos. - Conocer limitaciones de la Tabla Periódica.	- Buscar y sintetizar información sobre el átomo y los modelos atómicos. - Analizar datos procedentes de la Tabla Periódica para inferir la composición atómica. - Resolución de problemas y cuestiones sobre composición y propiedades de los elementos. - Interpretar y predecir la estabilidad de los átomos y su reactividad química en función del modelo de capas y la regla del octeto. - Inferir la evolución de propiedades atómicas.	- Reconocer el orden en el Universo como base de nuestra comprensión del mundo, a través de la invarianza de los elementos químicos y de las partículas que los componen. - Valorar la importancia y la utilidad de los modelos atómicos en la interpretación y predicción de hechos. - Reconocer las virtudes y las limitaciones de los modelos atómicos de Thomson, Rutherford y capas, y de la propia Tabla Periódica.

desarrollar afectaría a las actitudes de los alumnos ante el juego planteado y a la dinámica que se desencadena en torno a él.

DISEÑO DE LA INVESTIGACIÓN

El escenario de investigación se sitúa en el desarrollo de una unidad curricular dedicada al tema de la Tabla Periódica a nivel de 10º grado (16 años), desarrollándose a lo largo de 24 sesiones de una hora cada una. La muestra de estudiantes estuvo formada por 38 alumnos pertenecientes a dos grupos distintos de un instituto público, matriculados en la asignatura de Física y Química que es una materia optativa dirigida a aquellos alumnos que desean cursar en el futuro opciones de ciencias. Dichos sujetos mostraban un perfil de estudiante trabajador, con interés por la asignatura y con un rendimiento académico medio alto.

El tema estaba dividido en dos partes que se correspondían con dos niveles de profundización, uno inicial y otro avanzado. Los contenidos tratados en cada uno de ellos se expresan en las Tabla 1.

La metodología en el aula fue de tipo activo, implicando directamente a los alumnos en su proceso de aprendizaje y trabajando de forma colaborativa en pequeños grupos. Las actividades planteadas fueron de naturaleza muy variada. Sin embargo, debido a que el eje fundamental de esta investigación consiste en analizar el potencial del juego educativo como recurso didáctico, los juegos y otras tareas de tipo lúdico fueron frecuentes.

Los instrumentos de recogida de información en la investigación fueron el portafolio del alumno, el diario del profesor investigador y dos cuestionarios finales administrados al concluir la unidad curricular, uno destinado a la evaluación de aprendizajes de tipo conceptual de los estudiantes y otro dirigido a que éstos comparasen los juegos empleados desde el punto de vista de cuatro indicadores: sencillez, utilidad, atractivo e interés. Para cada indicador los alumnos debían de señalar el juego más y menos valorado entre todos los empleados en la propuesta didáctica, doce en total. Nos ceñiremos en este estudio solamente a los ítems de los cuestionarios y los fragmentos del diario y los portafolios que guardan relación con el problema planteado.

Del conjunto de recursos lúdicos empleados en la propuesta hemos seleccionado dos juegos para mostrar las diferencias que manifiestan los alumnos en cuanto a aprendizajes finales y actitudes desarrolladas. Para ello, se han elegido el "*Juego de las familias*" (Franco, Oliva y Bernal, 2012) y el recurso "*Mi vida periódica*" (Oliva, 2010). A continuación describimos brevemente las características de estos dos juegos.

Juego 1: "El juego de las familias". Basado en el célebre juego de naipes de las familias, tenía como meta reunir todos los elementos químicos que pertenecen a una misma familia o grupo de la Tabla Periódica. Desde el punto de vista del aprendizaje, este recurso didáctico persigue la adquisición de aprendizajes asociativos de tipo memorístico, concretamente pretende que el estudiante sea capaz de identificar y reconocer las distintas familias de elementos que componen la Tabla Periódica. Por otra parte, este juego se desenvuelve en un contexto competitivo ya que todos los estudiantes rivalizan entre sí intercambiando las distintas cartas para intentar reunir las distintas familias de elementos. Contribuye así con un cierto incentivo de rivalidad entre el alumnado. El lector interesado puede consultar las normas del juego y el material empleado con los alumnos en Franco, Oliva y Bernal (2012).

Juego 2: "Mi vida periódica". La segunda tarea planteada también puede considerarse como un juego, al reunir como en el caso anterior las principales cualidades de este tipo de recursos: poseer una meta, tener un carácter lúdico y presentarse en un contexto competitivo. Tomando como referente la analogía de la Tabla Periódica con un calendario (Goh y Chia, 1989) este recurso posee dos metas bien definidas. Por un lado, establecer ejemplos de situaciones periódicas en la vida cotidiana del alumno, y por otro, hacer predicciones estableciendo regularidades en un calendario como modelo que se asemeja a la Tabla Periódica. De este modo, el juego aborda la comprensión de la idea de familia a través del concepto de periodicidad (Oliva, 2010), y permite asimismo analizar las limitaciones que presenta el Sistema Periódico como modelo científico. Como han sugerido algunos autores (Raviolo, Ramírez y López, 2010), las analogías pueden ser también útiles como recurso para entender qué es un modelo, y no solo para aprender modelos. El carácter lúdico de esta tarea reside en su vinculación con la vida diaria del estudiante, así como el hecho de que se plantee de un modo activo y participativo (Oliva, 2008) en un marco de competición entre grupos en el que la puntuación obtenida dependía tanto del número de situaciones diarias periódicas propuestas como del número de regularidades encontradas entre un calendario y la Tabla Periódica. Dado que este juego se formuló casi al final de la unidad, se esperaba que los alumnos lograsen conectar las regularidades en las propiedades de los elementos con la configuración electrónica en los mismos.

RESULTADOS

Aprendizaje de los alumnos en el "Juego de las familias"

En el primero de los juegos, la consecución de aprendizajes de los nombres y símbolos se evaluó a través de una cuestión escrita formulada en el contexto del cuestionario final administrado con el siguiente enunciado "*Escribe los elementos pertenecientes a la familia del cloro*". Las respuestas dadas por los alumnos se analizaron en cuatro categorías: a) el alumno cita todos los elementos de la familia; b) el alumno cita todos los elementos de la familia excepto uno; c) el alumno cita un número de elementos igual o inferior a tres; d) la respuesta es inadecuada o en blanco. La Tabla 2 muestra los resultados obtenidos.

Tabla 2. Tipos de respuestas para la cuestión en torno a los elementos químicos que componen las familias de la Tabla Periódica

Tipo de respuesta	% alumnos
A. Se citan todos los elementos de la familia	39,5
B. Se citan todos los elementos de la familia excepto uno	26,3
C. Se cita un número de elementos igual o inferior a tres	10,5
D. Respuestas inadecuadas o en blanco	23,7

Como puede observarse, casi dos tercios del alumnado recuerdan los nombres de los elementos de la familia, olvidando sólo uno en el peor de los casos. De ahí que, desde nuestro punto de vista, se considere que el juego de las familias resultó parcialmente útil a la hora de retener y recordar la mayoría de los nombres y símbolos de los elementos químicos que componen la familia en cuestión.

Del aprendizaje adquirido por los alumnos quedó constancia también en el diario del profesor, como lo demuestra, a título de ejemplo, el siguiente diálogo que tuvo lugar en uno de los pequeños grupos en los que se organizaban los alumnos. Para la lectura del mismo hemos de situarnos en el contexto del final de una partida, una vez que se habían formado todas las familias menos la del nitrógeno. Un alumno detectó que le faltaba una carta, a pesar de que la había solicitado durante el juego.

Adrián: "Creemos que se ha perdido la carta del nitrógeno porque no hemos podido formar esa familia".

Profesor: "No es posible, ya que miré todas las familias antes de repartir las barajas. Revisar todas las familias formadas a ver si os habéis confundido".

Vanesa revisa sus familias y entre ellas aparece la carta del nitrógeno.

Adrián (a Vanesa): "Pues yo te pedí el nitrógeno y no lo tenías".

Vanesa: "No me he dado cuenta, ha sido un error". (Diario del profesor observador)

Como puede verse, este alumno (Adrián), da muestra de conocer la composición de la familia en cuestión, de modo que con espíritu crítico, es capaz de percatarse de una situación incomprensible para él ante la ausencia de la carta del nitrógeno, persistiendo en el intento hasta averiguar dónde estaba la misma.

El juego sirvió asimismo para que, en determinados momentos, los alumnos percibieran que aún no dominaban completamente los nombres ni los símbolos de los elementos de los grupos principales. Los siguientes fragmentos están sacados de los portafolios individuales de los alumnos que iban cumplimentando en paralelo al desarrollo de los juegos: *"Todavía no sé bien los nombres de los elementos de la Tabla"*,*"Es un poco difícil saberse todas las familias"* (Portafolios de un alumno).

De forma minoritaria varios alumnos también realizaron comentarios menos favorables: *"Lo peor ha sido memorizar"* (Portafolios de un alumno).

En resumen, puede decirse que este juego sirvió parcialmente para el logro de los fines para los que se formuló, que como dijimos se movían en la familiarización de los alumnos con la Tabla Periódica y la memorización de los elementos de sus familias principales.

Aprendizaje de los alumnos en el juego "Mi vida periódica"

Para evaluar el aprendizaje de la noción de periodicidad y conocer si los estudiantes eran capaces de admitir la existencia de elementos con propiedades similares, los alumnos respondieron también en el cuestionario final a la siguiente pregunta, *"¿Crees que existen elementos con propiedades parecidas entre sí? Razónalo"*. Se trataba de evaluar la percepción de los alumnos al respecto, ante un aspecto básico del razonamiento en química como es la tarea de clasificación (Scerri, 2011).

Las respuestas se agruparon en tres categorías, que se describen a continuación, cada una acompañada de ejemplos explicativos aportados por los alumnos. Además, añadimos una cuarta categoría que quedó vacía en esta muestra, si bien aparecía en alumnado de cursos superiores aunque de forma minoritaria (Franco, 2011). De esta forma, pretendíamos dejar testimonio de una carencia observada en los datos obtenidos en un ámbito sobre el que se esperaba haber obtenido mejores resultados.

- Categoría A: Admite la existencia de elementos con propiedades parecidas y ofrece algún tipo de explicación causal basada en regularidades en la configuración electrónica.

Esta categoría estuvo ausente en el alumnado de este estudio y recogía aquellas respuestas adecuadas que utilizaron explicaciones que hacían referencia a la configuración electrónica del elemento. Veamos algunos ejemplos de respuestas ofrecidas en el estudio general antes referenciado con alumnos de 12º grado: *"Sí, existen diferentes tipos de elementos según su configuración electrónica y su colocación en la Tabla Periódica depende de ello"* o *"Los elementos que pertenecen a un mismo grupo (columna) tienen propiedades químicas similares. También poseen el mismo número de electrones en la última capa"*.

- Categoría B: Admite la existencia de elementos con propiedades parecidas y ofrece algún tipo de explicación basada en regularidades en la Tabla Periódica.

La segunda categoría agrupó aquellas respuestas de carácter descriptivo que aludían a algún tipo de regularidad subyacente a la Tabla Periódica, pero sin explicar su causa. Así, algunos alumnos señalaron que los elementos del mismo grupo poseen las mismas propiedades, y otros se referían a la clasificación de los elementos en metales y no metales: *"Sí, los que están en la misma columna"* o *"Los elementos que se sitúan cerca en la Tabla Periódica tienen propiedades parecidas. Si nos movemos en horizontal o en vertical estas propiedades van cambiando"*.

- Categoría C: Admite la existencia de elementos con propiedades parecidas, pero más que aportar explicación al respecto se limitan, a citar ejemplos de elementos parecidos.

Esta categoría englobó las respuestas que justificaban la existencia de elementos parecidos utilizando ejemplos de elementos en lugar de una explicación más detallada: *"Sí, por ejemplo los gases nobles"* o *"Sí, por ejemplo el flúor y el cloro, son elementos muy cercanos en la Tabla Periódica"*.

Se encontraron también explicaciones inadecuadas como la siguiente, que además de desconocer los isótopos del carbono, confundía este concepto con el de valencia: *"Sí, como el carbono-14 y el carbono-16 que son muy parecidos excepto en sus valencias"*. Algunos alumnos pensaron que si el estado de agregación de los elementos era similar, dichos elementos tendrían también otras propiedades parecidas: *"Sí, hay elementos que tienen las mismas propiedades, por ejemplo, pueden encontrarse en el mismo estado"*.

- Categoría D: Respuestas inadecuadas o en blanco.

La Tabla 3 muestra los resultados obtenidos atendiendo a las categorías citadas.

Tabla 3. Tipos de respuestas en torno a la noción de periodicidad

Tipo de respuesta	% alumnos
A. Admite similitudes en las propiedades de los elementos basándose en regularidades en la configuración electrónica	0,0
B. Admite la existencia de elementos con propiedades parecidas y ofrece algún tipo de explicación basada en regularidades en la Tabla	55,3
C. Admite la existencia de elementos con propiedades parecidas, pero se limitan a citar ejemplos de elementos parecidos	18,4
D. Respuestas inadecuadas o en blanco	26,3

En coherencia con lo que ya hemos apuntado, ningún estudiante de 10º grado fue capaz de admitir la existencia de elementos con propiedades parecidas ofreciendo algún tipo de explicación basada en regularidades con la configuración electrónica. Este dato muestra la dificultad que supone para los alumnos de este nivel relacionar la distribución de los electrones en el átomo con las propiedades de los elementos. Cabe destacar, la respuesta mayoritaria en la categoría B, dada por un 55% de los alumnos, que se apoyan en algún tipo de explicación basada en las regularidades de la Tabla Periódica para justificar la existencia de elementos con propiedades parecidas. Por otro lado, cabe subrayar que también existe un alto porcentaje de alumnos que no dan una respuesta satisfactoria a esta cuestión.

De las respuestas de los estudiantes que hemos comentado, se desprende un nivel de implicación cognitiva mucho mayor con este juego que en el caso del juego de las familias, dado que los razonamientos promovidos van mucho más allá de la mera retención de información. A pesar de ello, desde nuestro punto de vista, el nivel de aprendizaje adquirido por los alumnos puede considerarse pobre, al no haberse conseguido el objetivo previsto en la categoría A. Este escaso aprendizaje de los conceptos de regularidad y periodicidad también se pudo detectar en algunos comentarios de los alumnos en el portafolios en los que se constata el carácter descriptivo de las reflexiones en vez de basarse en alguna relación causal: *"He aprendido que hay cosas que se repiten como en la Tabla"* o *"Las cosas se pueden repetir a diario, semanal, anual, etc."* (Portafolios de un alumno).

VALORACIÓN DIDÁCTICA DE LOS JUEGOS POR PARTE DEL ALUMNADO

Con idea de conocer las percepciones de los alumnos en torno al juego planteado, se realizó por una parte, una valoración global de cada una de las tareas lúdicas desarrolladas a lo largo de la unidad didáctica, y por otra parte, se analizaron un conjunto de cualidades de los juegos didácticos tales como su sencillez, utilidad, atractivo o interés. Para valorar los juegos desarrollados se pidió a los estudiantes que puntuasen en cada caso, en una escala de 0 a 10, su grado de predilección por cada uno de ellos. La Tabla 4 compara la puntuación dada por los alumnos en los diferentes juegos y tareas lúdicas programadas en la unidad.

Tabla 4. Valoración por parte del alumnado de las tareas lúdicas desarrolladas a lo largo de la propuesta didáctica (con asterico aquellas que son referentes de este estudio)

Juego	Puntuación
* Juego de "*Las familias*" (Franco, Oliva y Bernal, 2012)	8,8
Juego "*Elemental ganemos el Mundial*" (Franco, 2006a)	8,7
Juego del Tetris	8,5
Juego del octeto (Franco, 2011)	8,5
Puzzle "*USA elemental*" (Franco y Cano, 2007)	8,4
Juego "*Autodefinido atómico*" (Franco, 2008)	8,4
Trabajo práctico "*Conductores y aislantes*" (UNESCO, 1973)	8,3
Juego "*El experimento de Rutherford*"	7,8
Construcción maqueta del caracol telúrico	7,3
Juego "*La lotería de átomos*" (Franco, 2006b)	7,2
* Juego "*Mi vida periódica*" (Oliva, 2010)	7,0
Juego "*La búsqueda de los elementos*" (Franco, 2007)	6,1

Como puede observarse en la Tabla 4, el juego de *"Las familias"* fue la tarea lúdica mejor valorada con una puntuación de 8,8, mientras que el juego "*Mi vida periódica*" fue una de las tareas peor valoradas, a pesar de que su puntuación fue también ciertamente alta. Por otro lado, para cada uno de los cuatro indicadores citados los estudiantes debían elegir el juego mejor y peor valorado. La Tabla 5 resume estos resultados.

De los datos obtenidos se desprende una mejor valoración del juego de "*Las familias*" respecto al de "*Mi vida periódica*". De esta manera, se

Tabla 5. Porcentajes de estudiantes que valoran los dos juegos

		Sencillez	Utilidad	Atractivo	Interés
Juego de las familias	Mejor valorado	44,7 %	23,7 %	42,1 %	23,7 %
	Peor valorado	5,3 %	5,3 %	2,6 %	7,9 %
Mi vida periódica	Mejor valorado	18,4 %	0 %	2,6 %	2,6 %
	Peor valorado	0 %	18,4 %	18,4 %	26,3 %

evidencia que el primero de ellos resulta globalmente para los alumnos más sencillo, más útil, más atractivo y más interesante que el segundo. Los datos cualitativos extraídos del diario del profesor y del portafolios de los alumnos avalan estas conclusiones. Así, pudo constatarse que los alumnos pusieron rápidamente manos a la obra en la realización de la primera actividad sin que tuvieran problemas en la aplicación de las normas del juego y permanecieron jugando durante toda la clase: *"Algunos alumnos ya están en disposición de aprender antes de saber a qué van a jugar"*, *"Al tocar el timbre algunos grupos no habían acabado la última partida y permanecieron en el aula hasta concluirla"* (Diario del profesor).

Así mismo, el juego de *"Las familias"* fue rememorado en sucesivas ocasiones a lo largo de días posteriores, lo que da muestra del impacto que produjo. Sin embargo, en contraste con el éxito alcanzado por dicho juego, el otro, "*Mi vida periódica*", generó un interés inicial mucho menor, como se desprende en el siguiente comentario: *"La actividad se me ha hecho un poco aburrida"* (Portafolios de un alumno). Otro indicio de este menor interés fue el reducido número de estudiantes, ¡sólo dos!, que habían preparado esta tarea en casa el día anterior. Además, se observó que los alumnos tampoco mantuvieron el interés por la tarea mientras la hacían, como recogieron estos comentarios del profesor: *"Es una actividad más, creo que se hace bien pero no engancha demasiado"* (Diario del profesor).

Daba la impresión de que el menor entusiasmo del alumnado ante el juego propuesto era debido a la mayor dificultad intrínseca de la tarea a resolver, lo cual obligaba a una labor de concentración y de implicación más profunda. Y quizás por esta mayor dificultad se pueda comprender que el alumnado no viera claro sus propósitos ni adónde les conducía: *"Había que escribir mucho y no se aprende mucho"*, *"No sabía lo que había que hacer. Si lo sabía, pero no para qué"* (Portafolios de un alumno).

A pesar de todo ello, y aunque al principio los alumnos tuvieron dificultades para entender la finalidad de la actividad, al final ésta parece que sirvió para lo que el profesor pretendía, como muestra este comentario: *"Creo que la puesta en común en clase ha contribuido a que los alumnos alcancen los objetivos previstos con este juego"* (Diario del profesor).

DISCUSIÓN Y CONCLUSIONES

En suma, los resultados obtenidos sugieren en el primer caso actitudes más favorables en los alumnos aunque centradas en la componente lúdica de la tarea, mientras en el segundo manifiesta mayores demandas de implicación cognitiva en relación con el contenido involucrado, si bien el interés despertado parecía menor y los logros alcanzados fueron limitados. A pesar de ello, el hecho de que en este segundo caso, finalmente, se consiguiesen al menos parte de los propósitos planteados, sugiere que también resultó de utilidad para el aprendizaje de los alumnos.

Aunque estos resultados no pueden generalizarse, siendo posible que los datos obtenidos en ambos juegos dependan también del mayor o menor atractivo de cada uno desde el punto de vista de su estructura lúdica y competitiva, ofrecen al menos un marco desde el que entender las dinámicas que pueden generar distintos tipos de juego en función de los contenidos implicados. De este modo, los juegos que exigen aprendizaje asociativo, mecánico y de automatización y creación de rutinas implícitas, podrían ser extrínsecamente más motivadores para los alumnos al liberarles de una carga cognitiva adicional y permitirles que centren su atención en la dinámica lúdica del juego y, en su caso, disfruten más de la componente competitiva del mismo. Mientras tanto, aquellos juegos destinados a movilizar aprendizajes más profundos, o bien logran motivar intrínsecamente al alumno para que se centre en la componente cognitiva y de contenido de la tarea, o bien, parecen inducir a una participación obligada y protocolaria que no es percibida dentro una componente lúdica. Esto último es lo que parece que ocurrió en el caso del juego de "*Mi vida periódica*", en la que, en líneas generales, no se vislumbró un alumnado dispuesto a implicarse de lleno intelectualmente en la tarea, lo cual resulta esencial para la resolución de la misma. Resultado de ello es que los logros alcanzados fueran limitados.

El desafío estaría, pues, en lograr diseñar juegos que llegaran a aunar las dos componentes básicas que estamos manejando, de un lado la motivación extrínseca del alumnado por el juego y, de otro, la motivación intrínseca e implicación cognitiva del alumno ante tareas que exijan aprendizaje profundo. Ejemplos de juegos de este tipo lo encontramos en el empleado por Faria, Oliveira y Codognoto (2010), mediante un juego de naipes con el que el alumnado no solo mejoraba su motivación hacia el aprendizaje en las actividades de aula, sino que también propiciaba el establecimiento de comparaciones entre propiedades de los diferentes elementos químicos, y facilitaba la comprensión en torno a la naturaleza de la Tabla Periódica y a la ubicación de cada elemento dentro de la misma. Para ello sería preciso conocer mejor cuáles son los elementos que sustentan las dinámicas de los juegos, es decir, qué hace que un juego logre atrapar de una forma motivadora a los alumnos en su desarrollo; y qué mecanismos afectivos y cognitivos se suceden cuando los alumnos se enfrentan a juegos que logran aunar el interés y el aprendizaje profundo del alumnado. A esclarecer ambos puntos dedicaremos gran parte de nuestro esfuerzo en el futuro.

BIBLIOGRAFÍA

Bruner, J., Juego, pensamiento y lenguaje, *Perspectivas* **16**, [1], 79-85, 1986.

Franco, A.J., Elemental, ¡ganemos el Mundial!, *Aula de Innovación Educativa* **156**, 87-96, 2006a.

Franco, A.J., La lotería de átomos, *Alambique, Didáctica de las Ciencias Experimentales,* **50**, 116-122, 2006b.

Franco, A.J., La búsqueda de los elementos en Secundaria, *Alambique, Didáctica de las Ciencias Experimentales,* **51**, 98-105, 2007.

Franco, A.J., Aprendiendo química a través de autodefinidos multinivel". *Educación Química* **19,** [1], 56-65, 2008.

Franco, A.J., *El juego educativo como recurso didáctico en la enseñanza de la clasificación periódica de los elementos químicos en Educación Secundaria*, Tesis Doctoral, Universidad de Cádiz, Cádiz (España), 2011.

Faria Godoi, T.A.; Oliveira, H.P.M. y Codognoto, L., Tabela Periódica - Um Super Trunfo para alunos do Ensino Fundamental e Médio. *Química Nova Na Escola*, **32**, [1], 22-25, 2010.

Franco, A. J. y Cano, M. J., Playing with the 50 States and the Chemical Elements, *The Geography Teacher* **4,** [2], 10-12, 2007.

Franco, A. J. y Cano, M. J., El juego didáctico en el tema de la formulación química inorgánica en Educación Secundaria. *Journal of Science Education* **9**, [2], 89-93, 2008.

Franco, A. J. y Cano, M. J., Elemental B-O-Ne-S, *Journal of Chemical Education* **88,** [11], 1551-1552, 2011.

Franco, A. J.; Oliva, J. Mª; Bernal, S., An educational card game for learning families of chemical elements, *Journal of Chemical Education*, DOI: 10.1021/ed200542x, 2012.

Garaigordobil, M., *Juego y desarrollo infantil*, Seco-Olea, Madrid (España), 1990.

Goh, N. K. y Chia, L. S., Using the learning cycle to introduce periodicity". *Journal of Chemical Education* **66**, [9], 747-749, 1989.

Granath, P. L. y Russell, J. V., Using games to teach chemistry. 1. The old prof card game, *Journal of Chemical Education* **76,** [4], 485-486, 1999.

Helser, T. L., Elemental Zoo, *Journal of Chemical Education* **80**, [4], 409, 2003.

Linares, R., *Elemento, átomo y sustancia simple. Una reflexión a partir de la enseñanza de la Tabla Periódica en los cursos generales de Química*, Tesis Doctoral, Universidad Autónoma de Barcelona, Barcelona (España), 2004.

Oliva, J. Mª, Qué conocimientos profesionales deberíamos tener los profesores de ciencias sobre el uso de analogías, *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias* **5**, [1], 15-28, 2008.

Oliva, J. Mª, Comparando la Tabla Periódica con un calendario: posibles aportaciones de los estudiantes al diálogo de construcción de analogías en el aula, *Educació Química* **6**, 13-22, 2010.

Orlik, Y., *Química: métodos activos de enseñanza y aprendizaje*, Iberoamérica, México, 2002.

Peña, M., Palabras y frases creadas con los símbolos de los elementos químicos, *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias* **4**, [3], 557-559, 2007.

Piaget, J., *La formación del símbolo en el niño*, Fondo Cultura Económica, México, 1979.

Pintrich, P. R.; Marx, R. W. y Boyle, R, Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change, *Review of Educational Research* **63**, [2], 167-199, 1993.

Raviolo, A.; Ramírez, P. y López, E.A., Enseñanza y aprendizaje del concepto de modelo científico a través de analogías". *Revista Eureka* **7** [3], 581-612, 2010.

Scerri, E., Who is a theorist?, *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias* **8**, [3], 231-239, 2011.

Tejada, S. y Palacios, J., Chemical elements bingo, *Journal of Chemical Education* **72**, [12], 1115-1116, 1995.

UNESCO, *New UNESCO source book for science teaching,* United Nations Educational Scientific and Cultural Organization, París (Francia), 1973.

Vygotsky, L. S., El juego y su función en el desarrollo psíquico del niño, *Cuadernos de Pedagogía* **85**, 39-49, 1982.

Yager, R. E., The constructivist learning model, towards real reform in science education, *The Science Teacher* **58**, [6], 52-57, 1991.

Received 31-03- 2012/ Approved 29-04-2013

Instructional relationship of socioscientific issues-based instruction and peer-assisted learning strategy: an implication for science instruction

Relación educativa de asuntos socio-científicos de enseñanza y las estrategias asistidas de aprendizaje: las implicaciones para la enseñanza de ciencias

Jamil Mikhail Yahaya, Ahmad Nurulazam MD Zain, Mageswary A/P Karpudewan

School of Educational Studies, University Sains Malaysia, 11800 Penang, Malaysia
jamilgombe@yahoo.com, anmz@usm.my ,kmageswary@usm.my

Abstract

The review explained the relationship of two instructional approaches namely: socio-scientific issues-based instruction and peer-assisted learning strategy. It shows the similarities of the two as in active learner engagement, cooperative or group work and writing skills. In either case, the two approaches were shown to be significant in school science instruction irrespective of the similarity or difference between them. Consequently, the need for science teachers to understand them and utilise them in school science instruction has also been discussed.

Key words*: socio-scientific issues, peer-assisted learning, science instruction.*

Resumen

El artículo muestra la relación de dos métodos de enseñanza: los problemas socio-científicos y la instrucción basada en estrategia colaborativa de aprendizaje. Analisa las similitudes de los dos enfoques en el aprendizaje activo, el trabajo cooperativo o de grupo y habilidades de escritura. Los dos enfoques son significativos en la instrucción de ciencias, independientemente de la similitud o diferencia entre ellas. En consecuencia, en el texto se discute la necesidad de que los profesores de ciencias entiendan y utilicen estos métodos en la enseñanza de las ciencias.

Palarabras clave: *cuestiones socio-científicas, aprendizaje colaborativo , educación científica*

INTRODUCTION

Socioscientific issues based instruction (SSIBI) is a new instructional approach that is used in teaching controversial and socially real life problems that are scientific in nature. It is referred to as Socioscientific Inquiry - SSIn - by Eastwood, Sadler, Sherwood and Schlegel (2012) and socioscientific instruction by Nuangchalerm and Kwuanthong (2010), Latourelle, Poplawski, Schmaefski and Musante (2012) and Tomas (2009). Latourelle et al articulated that it as an instructional model which combines the controversial, socially relevant real life world issues with course content, to engage students in teaching and learning situations. It is similar to case-based and problem-based instructions in the aspect of framing science content within a story (Sadler, Barab and Scott, 2007), but slightly differs from the two in that learners are given the opportunity to explore the controversy surrounding an issue with scientific explanations and processes. The learners are also challenged to develop a position supported with scientific facts as evidences. Kosterman and Sadler (in press) have shown that using SSIBI in teaching and learning science improves students' critical thinking power. It was also shown to influence, positively, students' interest in sciences and motivates as well as stimulates higher order thinking (Latourelle et al, 2012) in addition to increasing the learners' understanding of science. Latourelle et al, also articulates that SSIBI makes students investigate a wide range of subject areas and the implications for sciences, politics, society and any other reality that affect the everyday life of the learner.

In the process of instruction, the SSIBI approach requires learners to develop a position on an issue or problem which is socioscientific in nature. That is an issue or problem that is a real world issue and socially significant to life and at the same time has ethical, moral, political, economic or religious concern. The students can present and defend their opinions supported by scientific facts in debates and argumentation. In so doing, they learn much about the contents, processes and nature of science and technology (Klosterman and Sadler, in press; Sadler, 2004, Reis and Galvão, 2009; Hammerich, 2000). Example of socioscientific issues include among others, Genetic Engineering - reproductive gene cloning, genetically modified foods; Global Warming - green house effects global climatic change as a result of human activities. Sadler, (2008) and Eastwood et al (2012) have reported the application of SSIBI in the classroom for teaching some science issues that have a social concern where students are allowed to negotiate, which calls for the utilisation of their critical thinkingrskills. Similarly, Eggert and Bögeholz applied SSIBI in classroom to measure students' use of decision-making strategy in situations relating to socioscientific isues.

However, peer-assisted learning strategy (PALS) is a type of class-wide peer tutoring in which learners are grouped to help in teaching others of relatively lower ability. It is a form of teaching in which learners are given the opportunity to utilize and at the same time extend their own knowledge, skills, ideas, attitudes and experiences to other learners of relatively the same age group (Young, 2012, Scott, 2011, Okilwa, and Shelby, 2010). It is also viewed as a method of group discussion or group analysis performed by learners to enhance their understanding of somt concepts taught. It has sometmodels as identified by Scruggs, Mastropieri and Berkeley (2012), Scott, (2011) and Young, (2012):

a. Cross-age peer tutoring
b. Same-age peer tutoring
c. Individual peer tutoring
d. Class-wide peer tutoring.

The peer assisted learning strategy (PALS) as a class-wide tutoring programme was used by classroom teachers to improve reading and mathematics skills in learners (CEC, 2011; Mattatal 2009). It involves students consciously assisting others to learn and in so doing, learning more freely and effectively among themselves. Peer assisted learning strategy encompasses peer tutoring, mentoring, modelling, education, counselling, monitoring and assessment that are differentiated from other forms of cooperative learning (Keith and Stewart 1998). In practice, learners are grouped in pairs usingaone stronger and one weaker partner to form what Mattatal called 'student dyads'. Both parties mutually benefis as studies shos that the tutor helps him/herself by increasing his/her knowledge, ideas and skills on the subjectsgtutored. This is probablyn the result of a quest to improve confidence, overcome challenges and satisfy the desire to tutor other subjects of interest (Young, 2012, Scott, 2011, Okilwa, and Shelby, 2010; Ehly, and Larsen, 1980). CEC and Mattatal have shown the integration of PALS results in the improvement of reading and mathematical skills in learners, Oekes (2012) have reportedsthe integration of PALS in classroom teaching in sciences which include chemistry, physics, biology and environmental studies.

Consequently, this conceptual review was done purposely to increase students and researchers understanding of SSIBI by comparing it with a more popular one, namely PALS. It brought out a clearer picture of where they differ and where they are similaeIt is hoped that it will pave the way for further studies by those interested in the application of the two instructional approaches. At the moment, thereyare few studies or literature that highlighs the instructionalpsimilarities or differences of the two approachese This suggests the need to make such ancomparison.

THEORETICAL FRAMEWORK

The psychological theory that underlies the two instructional approaches is the social learning theory of Albert Bandura (McLeod, 2011,; Luszczynska & Schwarzer, 2005). It describes an acquisition of valuable knowledge, ideas, skill, experience and attitudes that are developed purposely in a social group. The requirement of both SSIBI and PALS is the formation of social groups where some members serve as models, as tutees, or as presenters of concepts or position on a particular issue. The theory postulates that social learning largely depends on effectiveness and dynamics of groups and how individuals succeeded or failed during interactions. The theory adds that social learning promotes the development of students' emotional and practical skills in addition to perception of oneself and the acceptance of others despite their varied competencies and shortcomings. The cooperative work nature of the two instructional approaches is recognised by the theory, whicd emphasises learning from one another by observation, imitation and modelling (Bandura, 1988,; Ormrod, 1999,; Luszczynska & Schwarzer, 2005, Orlik, 2002, Aleksashina, 1987). Consequently, the relationships between the two instructional approaches are as conceptually outlined in the figure below which delineates the relationship of SSIBI and PALS with respect to the differences and similarities.

Similarities

Active learner-engagement

In both SSIBI and PALS, learners are actively engaged in activities that have to do with the teaching and learning process. In SSIBI, learners are given the chance to explore a controversy around a problem or an issue while working together to find out scientific evidence to defend their opinions. Similarly in PALS learners are engaged in exploring and explaining any misconception that bothers them which they may not be able to get in a traditional classroom situation.

In both methods, learners freely interact, debate or argue, thereby expressing their views, understanding or even their weakness which they may not have the chance to do inea teacher-controlled classroom.

Cooperative/group work

In both SSIBI and PALS, learners are grouped to work together. This grouping allows the weak learners' involvement in the teaching and learning process. It gives such learners a sense of belonging and encouragement. The more skilled or more knowledgeable learners become models worthy of emulation by the weaker learners. This is rooted in the social learning theory of Albert Bandura,which postulates that models are an important source of learning new behaviours and for achieving behavioural change in a given setting (Bandura, 1997). The models express their potentialities, talents or skills which create opportunities for the lower functioning learners to assume an integral role in a valued activity (PSEA, 2008). This happens in SSIBI when students are developing their group's position on a problem with scientific facts and findings as evidence to support their opinion. Similarly, in PALS the tutee learns a great deal from the model tutor and may turn out to be a tutor too as the system requires rotational tutorship.

Writing skill

Dabwosky (2000) articulated that PALS is an important avenue in making students become aware of writing as a social process. This is true of SSIBI in that, while developing a position on a particular controversial problem, students find and write down evidences and come out with a written product for debate, dialogue or argument. In both systems of instruction, the writing session is one way of providing another social context (Dabwosky, 2000) in which the student can discuss problems and challenges. They thus become more knowledgeable, experienced and skilled in the topic that they are writing about. Better writing and learning resulted from conversation and constant questioning of views as observed by Dabwosky, which is found in SSIBI and PALS.

Interdisciplinary perspective

SSIBI and PALS sessions are meaningful ways of introducing students to a process in which a particular problem or issue can be approached from different academic disciplines. Latourelle *et al* also articulates that socioscientific issues-based teaching and learning makes students investigate a wide range of subject areas in science, society, politics, economy and any other reality that affects the everyday life of the learner. In other words, the interdisciplinary nature of learning is explored in PALS and SSIBI (Latourelle et al, 2012). Dabwosky (2000) contended that students develop a better understanding of their community, academic discipline and finally their reality.

Differences

Although both SSIBI and PALS have some similarities in their instructional approach in engagement of learners in the teaching and learning activities as well as encouraging group work, writing skills and interdisciplinary exploration of knowledge, ideas, skills and experiences, there are still some differences between the two as discussed below.

Subject Area

SSIBI as an instructional approach is exclusively used in socioscientific issues teaching and learning. In other words, the system is used to address controversial problems that are real world problem with scientific basis and or process and at the same time having ethical, moral, political economic or religious concern. The model allows learners to do research to explore the controversy surrounding the problem keeping in mind the ethical, moral etc concerns of the problem. On the other hand, PALS is also used on other subject areas as it was shown to have been used in reading and mathematics skills improvement.

Focus

PALS focuses on the improvement of learners understanding in a particular area such as reading skills, numerical abilities and other sciences only, neglecting the social significance of the learning content to the students. But, SSIBI explores and focuses on controversies surrounding an issue or problem taking into consideration ethical, moral, political, economic or religious concerns of the problem. PALS targets problem of learners directly without regard fof any controversy therein and so nothing is done in the exploration of controversy, only the exploration of misconceptions and skills.

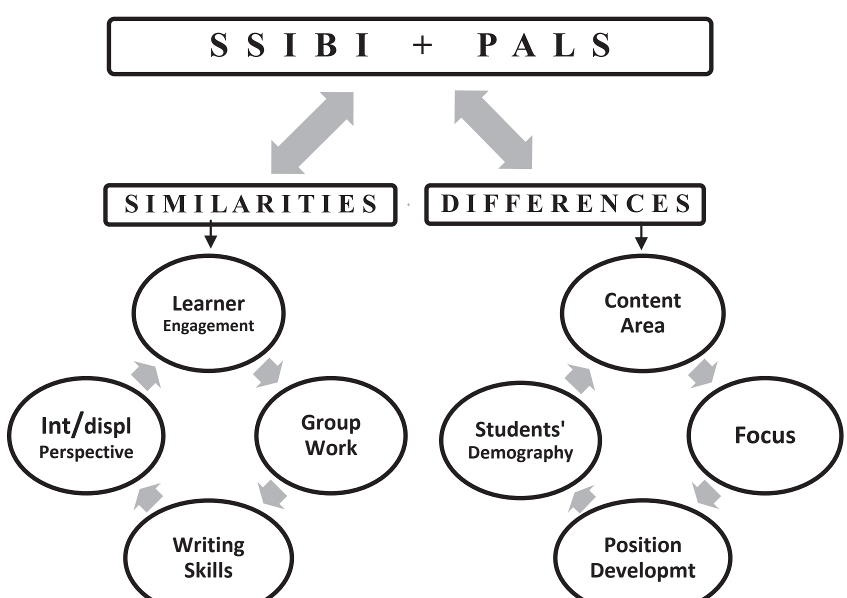


Figure 1. *The conceptual framework of the relationships*

Development of a position

In PALS, students are not encouraged to argue or debate among themselves, rather, they are assisted to help in the removal of misconceptions and in the improvement of some skills or experiences in a given task. This constrasts with SSIBI where students are encouraged and deliberately allowed to debate and argue among themselves in defence of their developed position on a particular socioscientific issue. In PALS, students do not develop a position because the learning contents guides the discussions from beginning to the end and where there is argument, it might be as a result of misconception but not deliberately encouraged. Once the misconception is removed, the argument is gone.

Learners' demography

Learners' demography entails their age, sex, level of education, religion, urban or rural and socio-cultural background. All these determine the possibility of integrating SSIBI, but in PALS demography has no influence on either participant. In other words, "it happens" in "lower classes" while sex, religion, socio-cultural background as well as whether urban or rural learners do not determine who can be the tutor or the tutee. This is unlike in SSIBI where students' demography can play a significant role in their opinion and exploration of the controversy and would therefore be strictly guided by that. Hence, discussions during presentations and debate or argumentation would be highly influenced by demography.

Besides, PALS is carried out irrespective of the level of education meaning that it happens even at the lower level of education as low as primary V and VI (key stage 5 and 6). But SSIBI require higher level thinking order and so is possible only at a higher educational level, possibly from senior secondary level and above (key stage 9 and above).

CONCLUSIONS

Scientific literacy for successful living in the 21st century is one of the priorities of science education (Rennie and Goodrum, 2007; Tyler 2007), and schools are believed to be the main avenues for teaching knowledge, skills, ideas, attitudes, experiences and processes of science and other disciplines. But Klosterman and Sadler (in press) contended that learners usually lost interest and motivation in school sciences and as a result hardly can they make a connection between knowledgc taught to them in the classroom and their everyday life. They also opined that science and technology have a great influence on the everyday living of the people of modern society and the relevance of science to students cannot be overemphasised in providing the means to resolve life problems. It can be seen here that in both the similarities and differences of the SSIBI and PALS as instructional strategie that both models are significant in school science instruction. It was widely agreed that school science is an activity-based subject and teacher-dominated lessons proved ineffective in the acquisition of desired knowledge, skills, experiences, attitudes and ideas for the learners who are hoped to be the future scientists and technologists for sustainable development. Therefore, the approach to be used for science instruction is the one that is geared towards holding learners' interest, motivating learners and making science a meaningful part of everyday activity for successful living. This can happen only if the students are fully involved in the activities of teaching and learning. This involvement must stimulate their interest, improve higher order thinking skills and at the same time increase understanding of the nature of science (Klosterman and Sadler, 2012, Rundgren 2010) and technology (Klosterman and Sadler, 2010; Latourelle, Poplawsky, Shmaefsky and Musante, 2012; Reis and Galvão, 2009). SSIBI and PALS are instructionally significant in involving learners in the teaching and learning process where students can make meaningful connections between what they learn in the school and their life. This includes both socioscientific issues and other science topics that are very significant to the students'elives. Consequently, it is strongly recommended that science teachers at all levels of educatios should use their skills and experience in science instruction to identify socioscientific issues in their science subjects so that the best instructional approach can be used. Learners' involvement should also be given a priority so that some of the young learners will become scientists and that scientific literacy can be popularised among the citizens for successful living.

BIBLIOGRAPHY

Aleksashina, I. Organización de la actividad de los estudiantes en la clases de química Leningrado, Instituto Científico de Educación general de Adultos, 1987, in Russian

Bandura, A. Organisational Application of Social Cognitive Theory. Australian Journal of Management, 13 (2), pp. 275-302, 1988.

Council for Exceptional Children – CEC –.Peer assisted learning strategy. Accessed on 30th, May 2012 from: www.cec.sped.org/AM/Template web page, 2011.

Dabwosky, B. The history of peer tutoring. Professional learning publication of the Syracus University writing programme, 2000.

Eastwood, J. L., Sadler, D. T., Sherwood, R. D. & Schlegel, W. M. Students' participation in an interdisciplinary socioscientific issues-based undergraduate human biology major and their understanding of scientific inquiry. Research in science education. Springer. 2012.

Eggart, S. & Bögeholz S. Students use of decision making strategies with regard to Socioscientific issues: an application of the Rasch Partial Credit Model. Science Eduaction. Wiley periodicals, Inc. pp.230-258, 2009.

Ehly, S. W. & Larsen, S. C. Peer tutoring for individualised instruction. Allyn and Bacon Amazon.com pp.1-55, 1980.

Hammerich, P. Confronting students' conception of nature of science with comparative controversy. In W. McComas (Ed). The nature of science in science education. Rationale and strategies, pp. 127-136, 2000. Dordretch: Klower Academic Publishers

Keith, T. & Stewart, E. Peer group tutoring of students. Mahwah, NJ: Erbaum Associates, 1998.

Klosterman, M. & Sadler, T. D. (in press). Information literacy for science education. Evaluating Web-based materials for scientific issues. *Science Scope*.

Latourelle, S. M., Poplawsky, A., Shmaefsky, B. & Musante, S. Using socioscientific issues-based instruction. Pedagogy in Action: Library, NY. 2012.

Luszczynska, A. & Schwarzer, R. Social cognitive theory. In Conner, M. & Norman, P. (Eds), predicting health behaviour: 2nd ed. Rev., pp 127-129, Buckingham, England: Open University Press, 2005.

Mattatal. C. A. Peer assisted learning strategies: the potential and promise of peer mediated learning for struggling readers in elementary school classrooms. Canadian society for the study of education XXXVII annual conference, pp. 1-16, May 2009.

McLeod, S. A. Simply Psychology; Bandura social learning theory. Accessed on 30th, May 2012 from: http://www.simplypsychology.org/bandura/html web page,2011.

Nuanchalerm, P. & Kwanthong, B. Teaching global warming through socioscientific Issues based instruction. *Asian Social Science*, 6 (8), pp. 1-10, 2010.

Oekes, H. Peer Assisted Learning in the Sciences. Accessed on November 20th, 2012 From: www.bates.edu/learning-commons/pals web page, 2012.

Okilwa, N. S. & Shelby, L. The effects of peer tutoring on academic performance of Students with disabilities in grade 6 through 12. A synthesis of the literature, remedial and special education: 2010. http://rse.sagepub.com/

Orlik, Y. Chemistry: Active Methods of Teaching and Learning. Iberoamerica Publ., Mexico, 2002, 358 pp. Chapter 10. Modern class organisation and extra class work in Chemistry.

PSEA. Research based strategies for special needs students, peer assisted learning strategies, PSEA education services division. Professional Learning Exchange Advisory, (2008).

Reis, P. & Galvão, C. Teaching controversial socio-scientific issues in biology and Geography Classes: a case study. *Electronic Journal of Science Education*. 13 (1), pp 1-11, 2009. http://ejse.southwestern.edu.

Rennie, L. J. & Goodrum, D. Australian school science education: National Action Plan 2008 - 2012, Vol 2. Background research and mapping. Canberra: Australian Government Department of Education, Science and Training, 2007.

Rosen, J. E., Murray, N. J. & Moreland, S. Sexuality education in schools: the International experience and implication for Nigeria: Policy working Paper series No 12, 2004.

Rundgren, S. N. C. How does background affect attitudes to socioscientific issues in Taiwan? *Public Understanding of science*, 20 (6), pp. 722-732, 2010.

Sadler, T. D. Informal reasoning regarding socioscientific issues: a critical Review of research. *Journal of Research in Science Teaching*, 41, pp. 513-536, 2004.

Sadler, T. D. A socio-cultural perspective on scientific literacy and science Learning. In Akerson V. L. (ed). Interdisciplinary language arts and science instruction on elementary classroom. Mahwah, 2007. NJ: Lawrence Erlbaum.

Sadler, T. D. Situated learning in science education: socioscientific issues as context for practice. Studies in Science Education, 45 (1), pp. 1-42, 2009.

Sadler, T. D. Socioscientific issues in science education: labels, reasoning and transfer: *Cult stud of science education*, 4, pp. 697-703, 2008.

Sadler, T. D., Barab, S. A. & Scott, B. What do students gain by engaging in socioscientific inquiry. Research in Science Education, 37, pp. 371-391, 2007.

Sadler, T. D. & Zeilder, D. L. Patterns of informal reasoning in the context of socioscientific Decision making. *Journal of Research in Science Teaching*. 42 (1), pp. 112-138, 2005a.

Scott, C. Outline peer tutoring comes of age. Accessed on April 2nd, 2012 web page from: www.socrato.com/online-peer-tutoring-comes-of-age/-41k-, 2011.

Scruggs, T., Mastropieri, M. & Berkeley, S. Peer tutoring strategy: the Gale group. Accessed on May 2nd, 2012 web page from: www.educatio.com/reference/article/peer-totoring

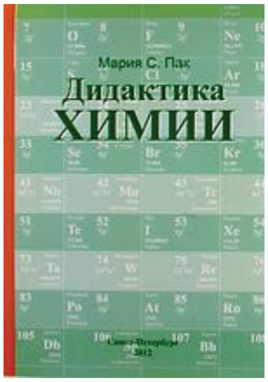
Tomas, L. Merging facts with fiction: developing students' scientific literacy through story writing on a socioscientific issue. *Science Educator*, 9 (5), pp. 1-5, 2009.

Young, K. Learning centre inspire new tutorial model. CCV Now: the news magazine for the community college of Vermont, accessed on May 2nd, 2012 web page from: now.ccv.edu/index-php/news/130-learning-center-inspires-new-tutoring-model-23k

Received 16-07- 2012/ Approved 29-04-2013

Book reviews

M. S. Pak. Methodology of teaching chemistry (Дидактика химии: учебник для студентов вузов)**. Trio. Moscow, 2012, in Russian.**



Improvement of professional students' training in pedagogical universities is one of the most important tasks for modern Russian education. Socio-economic changes taking place in Russia contribute to the growth of the prestige of education, the increased demand for highly educated, competent specialists, capable of a creative approach to the answering of any question and who will make their own decisions. This situation calls for new approaches in the preparation of the students - future chemistry teachers. We need to update the goals, content and technologies of training. The importance of this problem is due to the fact that in the framework of the implementation of the Federal state standards of general education of the second generation reviewed the objectives, content, means, methods of chemical education in Russian schools. The ways of solving these issues are considered in the book of M. Pak «Didactics of chemistry.

The novelty of the textbook M. Pak «Methodology of teaching chemistry» arises from the fact that, for the first time, we have a specially designed textbook for methodical preparation of students directed towards the development of scientific thinking of future teachers in higher and secondary schools, contributing to the mastering of their interdisciplinary concepts, principles, laws and methods of chemical-and-pedagogical education. In the textbook, the results of researches of psychologists, the scientific works of the teachers, the work of the leading methodologists of chemists are taken into account.

The questions of education, upbringing and development of pupils in the process of studying chemistry in secondary and higher school are considered. The author acquaints the readers with the content of school-chemistry and its regularities. In the book, such issues as methods, means and forms of organization of educational activity of students are reflected. Materials of the educational benefits allow the student and the teacher get acquainted with the changes that occur in the present time to the theory and methods of teaching chemistry, as well as with modern approaches, methods and practical experience. In the book, there are various tasks for the self-assessment and independent work by students, necessary for the development of professional skills.

This material helps the future teacher of chemistry to specify the learning objectives and determine the ways of their implementation and to select the content of the material on the subject in accordance with its principles. They are also helped to apply the most effective methods, means and forms of education, to develop the cognitive tasks of different kinds, which carry out the control of knowledge and skills of students and apply modern technologies of teaching chemistry. Of great importance especially for teachers, is the material that reveals the methodology of chemical education. It is very important for the comprehension of modern methods of teaching and for chemistry teacher to get acquainted with new conceptual approaches during their training.

The training manual is addressed to teachers, dealing with the urgent issues of the modern chemical education, and University students studying the methodological discipline in the different systems of higher professional education with the profile of «Chemical education» and may be useful for preparation for the lectures, seminars, laboratory and practical studies.

At the present time there are some works (I. Grebenev, A. Darinsky, O.S.. Zaitsev, N. Kuznetsova, I. Sarancev and others), which are devoted to the problem of correlating didactics of chemistry and methods of teaching chemistry. Many scientists consider didactic bases as the general framework for a technique of teaching chemistry, and the methodological framework as a private method. Despite different opinions, M. Pak substantiates the importance of didactic bases in the methodical preparation of students. The author shows that the solution of practical problems of chemical education is impossible without theoretical knowledge. Any teacher should possess the common methods of teaching. It can be noted that didactics, on the one hand, is an independent unit of the methodological training, and on the other, integrated with a private method, while remaining section of pedagogy. Disclosure of didactics of chemistry in the book of M. Pak is based on the integrative methodology, the ideas of the systemic integrity (training, education and development), the complexity of the application of educational tools, intra - and interdisciplinary integration, unity of theory and practice, as well as the directivity of chemical education (humanistic, vocational, practical, research, ethical, etc.).

The analysis of the textbook allows you to appreciate its functions: informational, methodological, training, controlling development. Of course, the content of the training manual is focused on educational practice. The textbook proposes material, which allows teachers to organize the student's independent work efficiently. Materials in the textbook contain both theoretical issues and methodological recommendations.

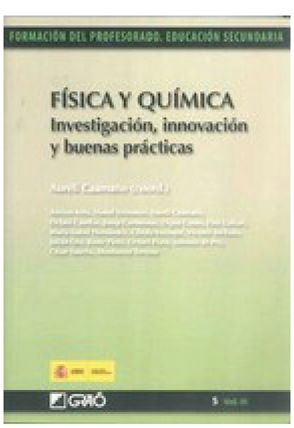
The content of the training manual is built on the principle of continuity with the subsequent levels of higher pedagogical education: master's degree and postgraduate course. The textbook is recommended for use in the process of theoretical and practical training of students in a bachelor of education, and then in a masters of education, as well as in the system of raising the professional skills of teachers.

The book, undoubtedly, will be reissued and I would like to wish to the contents of tasks for the self-assessment included not only questions and the answers, but also the tasks on critical and creative thinking.

This tutorial of M. Pak is useful not only to students and teachers of pedagogical universities, but also for the teachers in schools and other educational institutions.

M, Toletova, A. Levkin
Russian State Pedagogical University
/The Herzen University/,St. Petersburg., Russia

A. Caamaño (coord.) . Física y Química - investigación, innovación y buenas prácticas. Formación del Professorado. Educación Secundaria, Ed. Graó. Barcelona, 2011.236 pp.



Em 2011, o Ministério da Educação da Espanha publicou uma coleção de livros sobre a formação de professores e a educação secundária. Essa coleção foi dirigida por César Coll e contou com a coordenação de outros docentes das mais diversas áreas, tais como, biologia, educação física, química, física, línguas, geografia, história, tecnologia, música, matemática, literatura e orientação educativa.

Da coleção, o livro "*Formación del Professorado. Educación Secundaria: Física y Química – investigación, innovación y buenas prácticas*", coordenado por Aureli Caamaño, junta textos que buscam mostrar desde a necessidade da compreensão sobre educação de ciências, currículos de ensino, até as práticas possíveis de serem trabalhadas por professores sob uma concepção de inovação.

Ao ler o primeiro capítulo do livro, percebe-se que a falta de apoio do governo no que diz respeito ao ensino de ciências não é a realidade somente de países subdesenvolvidos ou em desenvolvimento, como Brasil, mas em países desenvolvidos também, como a Espanha.

Outro ponto analisado é o ensino de ciências para o ensino secundário. Com isso até espera-se uma crítica sobre a formação dos professores de ciências nas universidades, porém, Vicente Mellado, coloca que as experiências obtidas ao longo da formação acadêmica do futuro professor, desde sua formação primária, também influenciam na sua atuação profissional. Isso leva a pensar que qualquer mudança feita no ensino terá seus resultados positivos, porém, não instantâneos.

Uma frase que chama a atenção, muito ouvida nos corredores de instituições de ensino e provavelmente também no ambiente escolar, é colocada no livro "*Este professor sabe mucho, pero no sabe enseñarlo*". É comum encontrar professores, grandes pesquisadores nas áreas de ciências com um conhecimento enorme, inquestionável, entretanto, não conseguem transmitir aos alunos, isto é, não sabem lecionar. Sobre esse tema devem ser considerados dois pontos principais: o elevado conhecimento necessários para os professores de ciências e a didática de seu ensino.

Na sequência, o livro apresenta alguns projetos de qualidade para o ensino de física e química para o ensino secundário. São projetos criados em outros países, os quais obtiveram sucesso, e que estão sendo reproduzidos em algumas regiões da Espanha. Um elemento chave na reprodução desses projetos consiste na sua adaptação à realidade local e ao público alvo. O que os autores dessa parte do livro salientam é a utilização de recursos disponíveis, nem sempre os ideais, para a obtenção da melhor aprendizagem por parte dos alunos, bem como a avaliação contínua do projeto e sua adaptação, caso necessário.

A descrição detalhada de cada projeto de ensino de física e química possibilita uma avaliação por parte do leitor. Imediatamente esse é capaz de fazer um julgamento prévio sobre a possibilidade de aplicação, ou não, do referido projeto na sua realidade escolar.

Experimentos de química e física, de fácil execução, são descritos nos próximos capítulos do livro. Esses procuram abordar conceitos importantes com práticas que envolvem o cotidiano dos alunos, o que facilita a aprendizagem leva à satisfação do conhecer o que acontece ao seu redor.

Não deixando a ciência física e química desvinculada da realidade, o livro também aborda a utilização de softwares didáticos no ensino de ciências. Sabendo da dificuldade da realização de alguns experimentos em escolas secundárias, os softwares desempenham um papel importante. Novamente os autores mostram exemplos de aplicações e colocam endereços dos sítios ontem podem ser encontrados os softwares na rede mundial de computadores.

A utilização de terminologias e símbolos também é abordada no livro não deixando de demonstrar como podem ser trabalhados com os alunos.

O fechamento do livro ocorre com a apresentação de como realizar uma pesquisa científica, o que é ensinado aos alunos do final do ensino secundário, e com uma descrição detalhada de como o professor pode programar, realizar e avaliar as atividades de ciências.

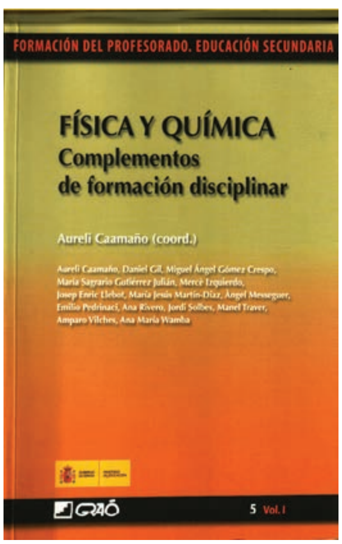
Como citado acima, não adianta ter conhecimento e não saber fazer dele a práxis. Portanto, ao finalizar a leitura do livro "*Formación del Professorado. Educación Secundaria: Física y Química – investigación, innovación y buenas prácticas*" o sentimento que fica ao leitor é que ensinar é possível, basta querer. Querer aceitar ideias, querer adaptar e querer o melhor para alcançar o objetivo de ensinar ciências. Porém, o querer envolve muito trabalho e este é recompensado com o resultado final.

Janine Botton
Instituto Latino-Americano de Ciências da Vida e da Natureza,
Universidade Federal da Integração Latino –americana,
UNILA, Brasil

A. Caamaño (coord.). Física y Química: complementos de formación disciplinar. Formación del Professorado. Educación Secundaria: N. 5. Vol. 1. Ed. Graó. Barcelona, 2011. 10 capítulos

"O primeiro pecado da humanidade foi a fé; a primeira virtude foi a dúvida."

Carl Sagan



No ensino de ciências, devido as crescentes inovações das sociedades em diversos setores da ciência, da tecnologia e seus impactos na vida cotidiana, a elaboração de livros e artigos para a formação profissional de professores é muito importante. O sistema de formação e atualização de professores da escola secundária deve propor atividades inovadoras e eficientes para atender tantos as demandas de modernização da práxis pedagógica quanto de promover o desenvolvimento de habilidades científica nos estudantes o mais cedo possível e assim maximizar a qualidade do ensino contemporâneo. Para as disciplinas de Química, Física e outras disciplinas das Ciências da Natureza os docentes da escola precisam ter oportunidades de obter informações atualizadas dos novos métodos de ensino em suas respectivas áreas, bem como ter oportunidades de atualizações interdisciplinares e multidisciplinares, um meio para isso, são as publicações de livros artigos, tais como esse.

O livro revisado trata de temas, questões e problemas chaves do ensino de Química e Física. Essas disciplinas devido a sua complexidade intrínseca, muitas vezes, apresentam grau de dificuldades para os professores e professorandos para organizar metodologias e processos de ensino e aprendizagem para as aulas. O capítulo 1 descreve o tema da natureza da ciência e construção do conhecimento científico. Os autores analisam vários conceitos da Ciência, tais como a concepção indutivista da ciência e a concepção objetiva dos conhecimentos científicos. Eles discutem o que é mais importante analisar, uma vez que a ciências é neutra e sem ideologia, pelo menos teoricamente. E também dão ênfase ao fato do trabalho científico ser um processo coletivo e ter por base os avanços da ciência passada e atual. Neste sentido, ressaltam a importância da ciência e suas interligações interdisciplinares com na cultura humana, nas tecnologias e na sociedade e outras linhas de ensino moderno de ciências.

Nos capítulos 2 e 3 disponibilizam informações muito interessantes sobre a história da Física e da Química e suas influências no ensino. Os autores mostram o enfoque histórico do processo de ensino, apresentando vários exemplos de conceptos do ensino de Química e Física e seu desenvolvimento e histórico. Por exemplo, eles analisam os conceitos de matéria (átomo, elemento químico) de campo e outros, mostrando a linha de desenvolvimento desde a antiguidade até a idade moderna. Também nestes capítulos de apresentam as descrições de metodologias e de atividades para aulas, as quais podem ser usadas por professores no processo de ensino.

Os próximos dois capítulos mostram a fronteira do conhecimento e investigação em Física e Química. Estas ciências se destacaram pelo grande progresso no século XX e os autores apresentam os pontos chaves deste processo tais como as investigações sobre Bing Bang, antimatéria, energia, clima e outras, as quais são o fundamento para o incrível aumento de inovações tecnológicas da contemporaneidade. Também analisaram a influencia de Química e da Física para a resolução de problemas de energia, saúde, ambiente e também para outras ciências modernas tal como química biológica, biotecnologia e nanotecnologias.

Capítulo 6 analisa os problemas ambientais e as questões sobre a sustentabilidade do ponto de vista das Ciências da Natureza. Os autores fazem apontamentos para os aspectos de maiores importâncias a serem ensinados nas escolas, e suas correlações com os conhecimentos que podem apresentar a solução destes problemas em todo o mundo. Defendem o ponto de vista que no ensino é preciso por atenção especial aos processos de proteção e conservação ambiental, bem como aos assuntos sociais que visam o aumento da distribuição de renda igualitária e os meios de construção de um futuro sustentável. Para atender a esses objetivos nos cursos escolares, os autores propuseram várias atividades para aulas com diferentes exemplos.

Nos capítulos 7 e 8 mostram a importância do tema de alfabetização científica e suas conexões com o ensino de ciência na escola. Para atender as demandas do currículo das ciências da natureza, Física, Química na Espanha, e as suas conexões com assuntos da vida cotidiano e sociedade, os autores discutem diversas possibilidades da práxis pedagógica do processo de alfabetização científica e sugerem enfoques lúdicos e divertidos. Também são analisados os conceitos de contextualização da ciência, e as competências necessárias a serem adquiridas no processo de ensino-aprendizagem de ciências.

Os últimos dois capítulos do livro tratam dos aspectos do curso de formação de professores para o ensino médio em Química. Nas escolas da Espanha e outros países da Europa, a construção destes cursos tem foco nos aspectos do funcionamento moderno da ciência, tecnologia e sociedade. Enfatizando a importância dos conhecimentos de Física para a formação futura de jovens e para a vida profissional, nos cursos de formação de professores de Física devem analisar o processo de abandono escolar vinculado as dificuldades de aprendizagens nesta disciplina. Os autores trazem exemplos de como organizar os cursos de ciências nesta etapa escolar utilizando recursos e informações da atualidade. E também mostram diferentes variantes de como expor os conteúdos, realizar as avaliações dos conhecimentos e habilidades adquiridos. Demonstram que ensino de ciências pode ser organizado em torno de problemas reais da vida e da natureza, com todas as suas conexões interdisciplinares.

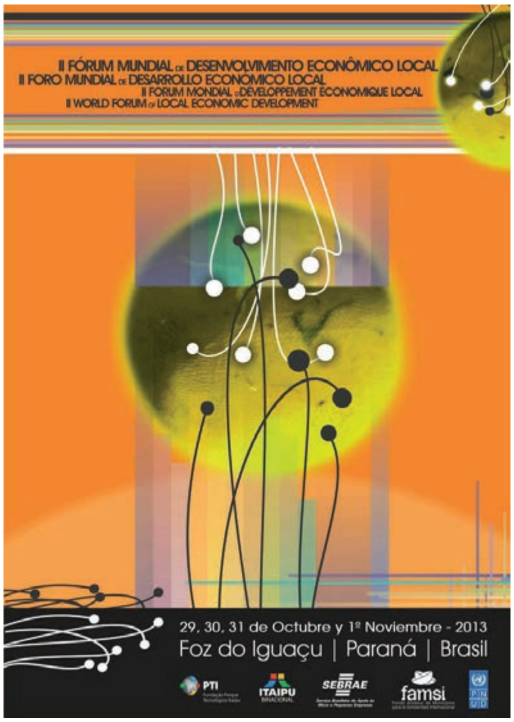
Portanto, o livro analisado é uma obra coerente com as demandas de atualização e formação de professores para o ensino de ciências. É exemplo bom e útil e pode ser utilizado tanto por estudantes das licenciaturas como por os professores das escolas, devido a sua extensiva preocupação com o rigor científico. Os educadores dos vários países podem encontrar ideias modernas para atualizar seus métodos de ensino de ciências e potencializar o seu desenvolvimento profissional, bem como de seus alunos, futuros profissionais de qualquer área de atuação a qual escolherem.

Tanise Knakievicz,
Instituto Latino-Americano de Ciências da Vida e da Natureza,
Universidade Federal da Integração Latino –americana, UNILA, Brasil

2do Foro Mundial de Desarrollo Económico Local

II Fórum Mundial de Desenvolvimento Econômico Local

Fechas: 29 de octubre a 1 de noviembre de 2013
Lugar: ITAIPU, Foz do Iguaçu, Paraná, Brasil



ORGANIZADORES

- **ITAIPU Binacional - Parque Tecnológico de ITAIPU**
- **Servicio Brasileño de Apoyo a las Micro y Pequeñas Empresas (SEBRAE)**
- **Fondo Andaluz de Municipios para la Solidaridad internacional (FAMSI) / Ciudades y Gobiernos Locales Unidos (CGLU)**
- **Programa de las Naciones Unidas para el Desarrollo (PNUD)** a través de la **Iniciativa ART**

El Segundo Foro Mundial de Desarrollo Económico Local es parte de un proceso que se inició con los preparativos del Primer Foro Mundial de Agencias de Desarrollo Local "*Territorio, Economía y Gobernanza Local: nuevas miradas para tiempos de cambio*" que tuvo lugar en Sevilla en octubre del 2011. El I Foro reunió a 1,300 participantes provenientes de 47 países para intercambiar prácticas e instrumentos territoriales para el desarrollo económico local y explorar su relación con estrategias nacionales de desarrollo local y con el debate global sobre desarrollo humano sostenible. Cómo conjugar este debate con prácticas e instrumentos operativos para superar la brecha entre conceptualización y su aplicación en el terreno es un desafío que cobra cada vez mayor importancia y atención, tal y como lo demuestran eventos globales como el Foro Social Mundial (enero 2012), la Conferencia de las Naciones Unidas sobre el Desarrollo Sostenible, Río+20 (junio 2012), y Africités (diciembre 2012), entre otros.

El objetivo principal del II Foro Mundial de Desarrollo Económico Local es de facilitar el diálogo y el intercambio entre actores locales, nacionales e internacionales sobre la eficacia e impacto del desarrollo económico local frente los grandes desafíos de la época actual, a partir de las prácticas existentes. Más específicamente, los objetivos del II Foro Mundial de Desarrollo Económico Local son:

– Facilitar un diálogo político internacional sobre Desarrollo Económico Local incluyendo a los actores públicos y privados.

– Promover la construcción de políticas públicas sobre Desarrollo Económico Local.

– Demostrar la relevancia del territorio y del Desarrollo Económico Local para un desarrollo integral, incluyendo los pilares económicos sociales y medioambientales.

– Presentar la necesidad de instrumentos de implementación de estrategias y planes de desarrollo económico local tales como las Agencias de Desarrollo Económico Local y las Agencias de Desarrollo Regional.

El Segundo Foro Mundial de Desarrollo Económico Local es parte de un proceso que se inició con los preparativos del Primer Foro Mundial de Agencias de Desarrollo Local "*Territorio, Economía y Gobernanza Local: nuevas miradas para tiempos de cambio*" que tuvo lugar en Sevilla en octubre del 2011. El I Foro reunió a 1,300 participantes provenientes de 47 países para intercambiar prácticas e instrumentos territoriales para el desarrollo económico local y explorar su relación con estrategias nacionales de desarrollo local y con el debate global sobre desarrollo humano sostenible. Cómo conjugar este debate con prácticas e instrumentos operativos para superar la brecha entre conceptualización y su aplicación en el terreno es un desafío que cobra cada vez mayor importancia y atención, tal y como lo demuestran eventos globales como el Foro Social Mundial (enero 2012), la Conferencia de las Naciones Unidas sobre el Desarrollo Sostenible, Río+20 (junio 2012), y Africités (diciembre 2012), entre otros.

PARTICIPANTES

Técnicos y políticos, sector privado, actores locales y representantes de distintos niveles de gobierno, de instituciones de promoción y apoyo al desarrollo local y organismos internacionales procedentes de los 5 continentes, con un equilibrio territorial, social y de género.

Fechas: 29 de octubre a 1 de noviembre de 2013

Informaciones: http://www.foromundialdel.org/, www.pti.org.br, Email: santiago@pti.org.br

Index - volume 14, 2013

REVISITING THE CHEMICAL HISTORY OF A CANDLE: SOME REFLECTIONS FOR CHEMISTRY TEACHERS BASED ON A CASE STUDY
Revisitando La historia química de una vela: algunas reflexiones para profesores de química respaldadas por un estudio de caso
Baldinato J., Nagy J., Alves Porto P. (Brazil) 60

DESIGNING A CHEMISTRY EDUCATIONAL GAME AND EXAMINING REFLECTIONS ABOUT IT
El diseño de un juego educacional de química y su análisis
Bayir E., Deniz C. (Turkey) 92

COURSE 'ICT TOOLS IN SCIENCE EDUCATION' – WHAT AND HOW TO TEACH
Curso "Herramientas TIC en la educación científica '- qué y cómo enseñar
Bernard P. , Bros P. (Poland) 16

O ENSINO DE CIÊNCIAS PARA CRIANÇAS DE 5-6 ANOS.
Teaching science for children 5-6 years old.
Blasbalg M.E. , Arroio A. (Brasil) ....40 SI

Botton J. ª Caamaño coord. Física y Química – investigación, innovación y buenas prácticas. Formación del Professorado. Educación Secundaria: Grao, 2011. Book review....101

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
Bosch B., Mañas F., Gentile N., Gorla N., Aiassa D. /Argentina/ 36

ART AND SCIENCE: IMPROVING SCIENCE TEACHERS´ INTERDISCIPLINARY COMPETENCES
Arte y ciencia: mejorando las competencias interdisciplinarias de los profesores de ciencias
Cachapuz A. (Portugal) ....5 SI

PROCURANDO A QUALIDADE DA EDUCAÇÃO CIENTÍFICA
Cachapuz A., Orlik Y. ....3 SI

ENSINO DE QUÍMICA E SURDEZ: ANÁLISE DA PRODUÇÃO IMAGÉTICA SOBRE TRANSGÊNICOS
Teaching of chemistry and deafness: analysis of production of visual representations about transgenic
Canavarro Benite A., Machado Benite C. (Brasil) ....37 SI

CHALLENGES IN SCIENCE EDUCATION....55

FROM SER TO STL: TRANSLATING SCIENCE EDUCATION RESEARCH INTO SCIENCE TEACHING AND LEARNING
De la investigación hacia la enseñanza y aprendizaje : transferir la investigación en educación científica a la enseñanza y aprendizaje de ciencias
Childs P. (Ireland) 56

CONDITIONERS OF TEACHING PRACTICE: REPORTS OF A CHEMISTRY TEACHER IN BASIC PRIMARY EDUCATION IN BRAZIL
Acondicionadores de la práctica docente: informes de una profesora de química en la educación primaria básica en Brasil
Clemente Urata T., Eterno da Silveir H. (Brazil) .... 44 SI

REFLEXÃO SOBRE A AÇÃO NA LICENCIATURA EM QUÍMICA: O ESTÁGIO SUPERVISIONADO COMO ESPAÇO FORMATIVO
Reflection on the action: supervised preservice teachers' practice as formative space.
da Costa Garcez E., Carneiro Gonçalves F., Tito Alves L., Flora Barbosa Soares M. ,
Araújo da Silva Mesquita N. (Brasil)....52 SI

UMA ABORDAGEM EXPERIMENTAL PROBLEMATIZADORA PARA O ENSINO DE COMBUSTÃO
An experimental problematizing approach to combustion teaching
de Barros Arsie E., Caroline Morato Fabricio C., Maciel Guimarães O. (Brasil) ....48 SI

DISEASE DETECTIVES AT WORK: A LESSON ON DISEASE TRANSMISSION FOR SECONDARY SCHOOL STUDENTS
Detectives de enfermedades en el trabajo: una clase sobre la transmisión de la enfermedad para los estudiantes de escuela secundaria
Dawson M. (USA) 85

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
Di Risio C., Bruno J., Ghini A., Guerrien D., Veleiro A., Rusler V. (Argentina)....29

USO DE SIMULAÇÕES COMO UMA DINÂMICA DIFERENTE PARA QUEM APRENDE E PARA QUEM ENSINA: UM ESTUDO DE CASO
Using simulations as a different dynamic to learners and teachers: a case study
Fejes M., Pinheiro Sales M.G., Infante-Malachias M.E. (Brasil)....8 SI

JUEGOS EDUCATIVOS Y APRENDIZAJE DE LA TABLA PERIÓDICA: ESTUDIO DE CASOS
Educational games and learning about the Periodic Table: case studies
Franco Mariscal A.J., Oliva Martínez J.M. (España)....93

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
Garcia L., Valeiras N. (Argentina) 42

ASSESSMENT OF A VISIT TO AN OPTICS LABORATORY DURING UNIVERSITY SCIENCE WEEK.
Evaluación de la visita a un laboratorio de óptica en la semana de la ciencia
García J.A., Perales F. J., Gómez-Robledo L., Romero J. (Spain) 78

INDÍCIOS DO MODELO INTEGRATIVO NO DESENVOLVIMENTO DO PCK EM LICENCIANDOS EM QUÍMICA DURANTE O ESTÁGIO SUPERVISIONADO
Evidence for integrative model during PCK development in chemistry student teachers during pre-service training
Gomes Elias Mariano Pereira P., Fernandez C. (Brasil)....74

AS REPRESENTAÇÕES MENTAIS DE PROFESSORES DE QUÍMICA EM FORMAÇÃO CONTINUADA E INICIAL: LIMITES E APROXIMAÇÕES.
Mental representations of chemistry teachers in initial and continuing education: bounds and approximations.
Gomes Catunda de Vasconcelos F. C., Valéria Campos dos Santos V., Arroio A. (Brasil)........ 16 SI

INVESTIGAR LA EXPLICACIÓN DE LOS EDUCANDOS EN CLASES DE CIENCIAS: LAS BASES CULTURALES Y BIOLÓGICAS.
Research the explanation of students in science classes: the biological and cultural basis.
Gomes da Silva H., Infante-Malachias M.E. (Brasil) 82

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
Guisasola J. (Spain), Garzón I. (Colombia), ZuzaK. (Spain) 4

TEACHING AND LEARNING OUT-OF-SCHOOL
Gisasola J. 3

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
Hargis J. (UAE) , Soto M. (USA) 45

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
Hayes L., Phair J., McCormac C., Marti Villalba M. , Papakonstantinou P., Davis J. (UK) 12

Index special issue, 2012 50

Jan Rajmund Pasko - 50 years of teaching and 45 years of scientific work 47

E-LEARNING THROUGH THE EYES OF THE CZECH STUDENTS
Aprendizaje electrónico desde el punto de vista de los estudiantes universitarios
Klement M. (Czech Republic) 66

Knakievicz T. A. Caamaño (coord.) . Física y Química: complementos de formación disciplinar. Formación del Professorado. Educación Secundaria: N. 5. Vol. 1. Ed. Graó. Barcelona, 2011. 10 capítulos Book review....102

Knakievicz T. MATIOLI, Sergio Russo; CAMPOS, Flora Maria de (Ed.). Biologia Molecular e Evolução. Ribeirão Preto; SP; Holos, Editora e Sociedade Brasileira de Genética, Brasil . 2012, 22 capítulos. Book review. ....55 SI

ENSINO ORIENTADO PARA A APRENDIZAGEM BASEADA NA RESOLUÇÃO DE PROBLEMAS: PERSPETIVAS DE PROFESSORES DE CIÊNCIAS E GEOGRAFIA
Problem-based learning: science and geography teachers' perspectives
Leite L., Dourado L., Morgado S., Meireles A., Azevedo C., Alves C., Fernandes C., Silva E., Cabral E., Pinto E., Osório J., Vale M. , Ribeiro M.T. (Portugal).... 28 SI

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
Martínez-Borreguero G., Naranjo-Correa F., Pérez-Rodrígueza A., Suero-López1 M., Pardo-Fernández P. (Spain) 25

EDUCAÇÃO EM CIÊNCIAS NO ENSINO SECUNDÁRIO GERAL EM TIMOR-LESTE: DA INVESTIGAÇÃO À COOPERAÇÃO
Science education in general secondary school in East-Timor: from research to cooperation
Martins I. (Portugal)....20 SI

INSTRUCTIONAL RELATIONSHIP OF SOCIOSCIENTIFIC ISSUES-BASED INSTRUCTION AND PEER-ASSISTED LEARNING STRATEGY : AN IMPLICATION FOR SCIENCE INSTRUCTION
Relación educativa de asuntos socio-cientificos de ensenanaza y las estrategias asistidas de aprendizaje: las implicaciones para la enseñanza de ciencias
Mikhail Yahaya J., Nurulazam MD Zain A., A/P Karpudewan M.(Malaysia) 98

Morentin M., Guisasola J. *Centros de ciencia y visitas escolares.* Editorial Académica Española, Academic Publishing GmbH&Co KG, Alemania, 2012, 219 pp. Book review 49

Nodzynska M., Stawoska I., Ciesla P. International Conference on Research in Didactics of the Sciences.....48

NOISE AND PERCEIVED DISCOMFORT IN GREEK SCHOOL CHILDREN
Ruido y molestias percibidas entre niños griegos en la escuela
Papanikolaou M., Roussi C., Skenteris N., Katsioulis A., Piperakis S. (Greece) 40

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
Penereiro J.C., Lombardo Ferreira D. H. (Brazil) 8

ANALYSIS OF THE ASTRONOMICAL CONCEPTS PRESENTED BY TEACHERS OF SOME BRAZILIAN STATE SCHOOLS
Análisis de los conceptos astronómicos presentados por maestros de algunas escuelas estatales de Brasil
Rincon Voelzke M., Pereira Gonzaga E. (Brazil) 23

DRAWINGS, WORDS AND BUTTERFLIES IN CHILDHOOD EDUCATION: PLAYING WITH IDEAS IN THE PROCESS OF SIGNIFICATION OF LIVING BEINGS
Diseños, palabras y mariposas en la educación infantil: juego con las ideas en el proceso de significados sobre los seres vivos
Rodrigues Chaves Dominguez C., Frateschi Trivelato S.L. (Brazil) 88

APLICAÇÕES DA ROBÓTICA NO ENSINO DE FÍSICA: ANÁLISE DE ATIVIDADES NUMA PERSPECTIVA PRAXEOLÓGIA
Applications of robotics in the teaching of physics: activities analyzes in a praxiological perspective
Schivani M., Brockington G., Pietrocola M. (Brasil) ....32 SI

THE PROGRESSIVE DEVELOPMENT OF SKILLS FOR ADVANCED LEVEL CHEMISTRY STUDENTS
El desarrollo progresivo de los conocimientos para los estudiantes de química del nivel avanzado
Szalay L. (Hungary), Gadd K. (UK), Riedel M. (Hungary) 19

MAPEAMENTO CONCEITUAL E O USO DE CONCEITO OBRIGATÓRIO PARA FAZER AVALIAÇÃO DIAGNÓSTICA DOS CONHECIMENTOS DOS ALUNOS
Concept mapping and the use of compulsory concept to make diagnostic assessment of students' knowledge
Tolentino Cicuto C.A., Miranda Correia P.R. (Brasil). ....23 SI

Toletova M., Levkin A. M. S. Pak. Methodology of teaching chemistry (Дидактика химии: учебник дяя студентов вузов). Trio. Moscow, 2012, in Russian. Book review. 101

PROBLEM BASED LEARNING ENVIRONMENTAL SCENARIOS: AN ANALYSIS OF SCIENCE STUDENTS AND TEACHERS QUESTIONING
Aprendizaje basado en problemas en escenarios ambientales: un análisis de interrogación de estudiantes de ciencias y profesores
Torres, J., Preto, C., Vasconcelos, C (Portugal) 71

AVALIAÇÃO DO CURRÍCULO PORTUGUÊS DE CIÊNCIAS FÍSICAS E NATURAIS: O QUE PENSAM OS PROFESSORES?
Evaluation of the Portuguese Curriculum of Physics and Natural Sciences: What do teachers think?
Torres, J., Vasconcelos, C. (Portugal). ....12 SI

ENSENÃNZA DE LA DERIVA CONTINENTAL: CONTRIBUCIONES EPISTEMOLÓGICAS E HISTÓRICAS
Teaching continental drift: epistemological and historical contributions
Vasconcelos C., Almeida A., Américo Barros J. (Portugal) 32

SI- special issue, vol. 14, 2013

FORMATO DE SUSCRIPCIÓN

REVISTA DE EDUCACIÓN EN CIENCIAS
Journal of Science Education

Suscripción volumen 14, 2013 (2 números en CD)
Suscripción por año (2 números)

El precio es 64 US$ para N. América y Europa (correo incluido); 53 US$ para otros países (correo incluido)

Disponibles también los vol. 1, 2000, vol. 2, 2001, vol. 3, 2002, vol. 4, 2003, vol. 5, 2004, vol . 6, 2005, vol. 7, 2006, vol. 8, 2007, vol. 9, 2008, vol. 10, 2009, vol. 11, 2010 , vol. 12, 2011, vol. 13, 2012 (N 1 y N 2 de cada volumen).

Revista Virtual (On Line). Todos los textos de los artículos de los volúmenes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 en Internet. Suscripción: en Colombia: $ 98 000, en otros países: 120 US$.

a. para persona natural: $ 25.000.oo pesos colombianos
b. para institución: $ 43 000.oo pesos colombianos.

Pago en Colombia:

consignar en la cuenta corriente número 16544886391 de BANCOLOMBIA, Revista de Educación de las Ciencias.

Pago para suscriptores fuera de Colombia:

A. Hacer transferencia bancaria o giro bancario de la suma correspondiente BANK INFORMATION: Banco do Brasil, Foz de Iguacu, Estado Parana, Brazil, Agencia 3270-0 cuenta corr. 21686-0, name: Y. Orlik, JSE
Swift / ABA: BB New York BRASUS33 BB Curitiba (Brasil), BRASBRRJSBO
IBAN 001327000000216860
B. Hacer el giro por Western Union, WU, a nombre de Y. Orlik, Director JSE, Brasil.
Favor enviar copia de comprobante de pago a la dirección: Revista de Educación en Ciencias,
e-mail: oen85@yahoo.com, http://www.accefyn.org.co/rec