ISSN 0124-5481

Journal of Science Education

REVISTA DE EDUCACIÓN EN Ciencias

Vol. 16 n° 2, 2015

Improving education: reading books and science education p.41

Inquiry based experimental applications in the chemistry laboratory p.52

Investigación • Internet • Computadores

Métodos activos • Innovaciones • Creatividad

Desarrollo de capacidades

UNILA Universidade Federal da Integração Latino-Americana

ISSN 0124-5481

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
Publindex, Colombia
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

On the cover:
the images are from
www.whytoread.com
and https://warosu.org/lit/thread/3562718#p3562806

Sandro Botticelli,
1444-1510
MADONNA OF THE BOOK

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 16, 2015

CONTENTS

Improving education: reading books and science education

The readers can see here the image of bronze monument to Book in one of the central places in Beijing, China. This image is here, because the theme of this text is books and reading and its influence to education and science education achievements.

Abilities in reading and a culture of reading books in young students and adults is a key factor among those which have strong influence on the quality of science education. We speak here mostly about reading books for pleasure, because students at all levels have obligatory reading (textbooks, computer and internet texts and so on) in school and university. It should be stressed that actual form of books need not be in the traditional format on paper since many modern books and texts can now be accessed electronically (.pdf, .doc, .djvu and others) .

Reading has long been the most important activity for increasing the level of education and culture of young people and adults. Readers can find innumerable aphorisms about that, for example,

- *There are many little ways to enlarge your child's world. Love of books is the best of all. (Jacqueline Kennedy Onassis)*
- *A book must be an ice-axe to break the seas frozen inside our soul. (Franz Kafka)*
- *The books are as important or more than bread. If I were hungry I would ask, rather than a whole loaf, half a loaf and a book. (Federico García Lorca)*
- *Everything which is good in me should be credited to books. (Maxim Gorky).*

Unfortunately at the present time in all countries decreasing reading for pleasure is apparent in all groups of population. For example, it is known that the reading rates decline as students get older, but the numbers have also dropped off significantly in the past 30 years. For example, in 1984, 8% of 13-year-olds and 9% of 17-year-olds in UK said they "never" or "hardly ever" read for pleasure. In 2014, that number had almost tripled, to 22% and 27%. (Alter, 2014). The situation is the same in Brazil, Chile and other countries in Latin America. In South Africa: over 50% of families own no books for recreational or leisure time reading and many communities have no access to libraries (Functional illiteracy and the case for reading, 2013).

The PISA exams also provide many data about the declining of reading and literacy achievement in almost all countries. Researchers say too that there is another problem – school and university teachers do not necessarily read the books, articles and other texts needed for classroom preparation and improving the knowledge and abilities of their students (Orlik, 2005).

There are various causes for this decreasing of reading. One of them is that young people and adults actually have strong preference for other social activities: watching TV and movies, shopping, phone and internet social networks and movies, playing video games and so on. Researchers say that several of these activities have very negative influence on school performance and the development of human mind. For example, violent video games have the particular influence, because they lead to desensitization, aggressive behavior and gender inequity development of visual-spatial skills (Greenfield, 2009). Other research says that Americans averaged almost 5 hours of TV viewing per day in 2009 and that excludes DVDs and other rented viewing material**.** It is well known too that watching TV by young people and adults for many hours/per day with usual programs of low quality in many countries (like soap-operas) not only produces many health and obesity problems, but substantially decreases human brain capacities.

Another important cause of this phenomenon is inadequate use of modern technology in education and life, including computers and the internet. For example, schools seem to make more effort introduce students to the use of visual media, by asking them to prepare Power Point presentations, and so on. Thus, students spend more time with visual media and less time with print (screen or printed books and texts). By this "modern" manner, students will process information better. But it is necessary take into account here, that most visual media are real-time media and they do not allow time for reflection, analysis or imagination (equally like TV or video games). So, the technology does not always play a positive role in education, because the skills of reading are being lost. For example, specialists say that students who were given access to the Internet during class and were encouraged to use it during lectures did not process what the speaker said as well as students who did not have Internet access. When they were tested after lectures, those who did not have Internet access performed better than those who did. Students today have more visual literacy and less print literacy and many students do not read for pleasure and have not done so for decades. (Greenfield, 2009).

Another difficult problem exists in many countries - a functional illiteracy. According to UNESCO "a person is functionally literate who can engage in all those activities in which literacy is required for effective functioning of his group and community and also for enabling him to continue to use reading, writing and calculations for his own and the community's development." (Europe together against functional illiteracy, 2012). However, a functionally illiterate person can not understand the contents of the reading text or can not make a very simple analysis (or answer simple questions about) a written message.

Statistics say that 44 million adults in the U.S. can't read well enough to read a simple story to a child and more than 20 percent of adults read at or below a fifth-grade level - far below the level needed for employment and approximately 50 percent of unemployed youth aged 16-21 are functionally illiterate, with virtually no prospects of obtaining good jobs. (Reading, Literacy & Education Statistics, 2012). According to another study conducted by the U.S. Department of Education and the National Institute of Literacy, 32 million adults in the U.S. can't read. That's 14 percent of the population and 19 percent of high school leavers can't read. (Illiteracy Statistics, 2012). Among Americans 16 years and older, 19% had read no books over the previous 12 months and 25% had read 1-3 books over a whole year. That is almost 45% of the population who read almost nothing (Functional illiteracy and the case for reading, 2013).

The same situation applies in other regions. About half Chilean citizens can not understand reading. In Australia - almost half the country - 47 per cent - can't read well enough to follow a recipe or understand instructions on medication. (Van de Wetering, 2012). In UK around a fifth of pupils leave school functionally illiterate and functionally innumerate (Europe together against functional illiteracy, 2012)

The examples indicate serious educational problems exist and the base of almost all of them is lack of reading books.

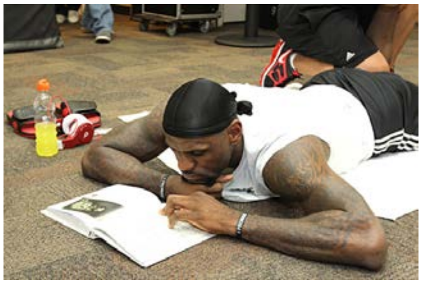
On the positive side researchers identify several key benefits deriving from reading for pleasure: reading attainment and writing ability; text comprehension and grammar; breadth of vocabulary; positive reading attitudes; greater self-confidence as a reader; pleasure in reading in later life and a better understanding of other cultures. (Research evidence on reading for pleasure, 2012). Studies show that reading develops imagination, induction, reflection and critical thinking, as well as vocabulary. Additionally it is the key to developing high order cognitive skills. Interesting cases for quality reading can be found at **(**Functional illiteracy and the case for reading, 2013) and include**:**

- Children who enjoy reading tend to have higher IQ and EQ levels.
- Regular readers have better language and conversational skills. They are also better at understanding and expressing nuance due to an expanded vocabulary and understanding of semantics.
- Reading improves ability to interpret information, which leads to better and more informed decision making skills.
- Varied reading promotes a holistic as opposed to insular world view, due to development of a wider and deeper paradigm. That means less xenophobia, racism and bigotry.
- The more reading the higher the level of immersion and reflection, which facilitate more effective learning processes, cognitive skills and critical thought.
- Reading extensively supports creative problem solving in business and other areas.
- It also increases emotional intelligence, which enhances the ability to create positive relationships (a better and deeper understanding of the human matrix).

According to what is written above we can stress that educational communities, Ministries of Education, teachers, parents and other social forces should increase efforts to promote the reading of books for pleasure. There are some examples of this education policy in various regions. In modern China there have been important achievements not only in economic and social development, but also in science education (Jingying Wang , Orlik, 2012). It is interesting that recently Chinese Premier Li Keqiang spoke at a press conference after the closing meeting of the third session of China's 12th National People's Congress about books and reading. He said: "*Books and reading can be said to be the main carrier of human civilization heritage, in my personal experience, the use of leisure time for reading is a pleasure, but also provides value that lasts a lifetime. I hope that for all the people of our country reading can form an atmosphere everywhere. The amount of reading can be increased year by year, it makes our social progress, improves our civilization to a very important degree. Reading is a way of life and combined with the work, will not only increase the innovative power for development, but will enhance the moral force in society*". In Latin America, Cuba and Venezuela help Bolivia to fight functional illiteracy by collecting books and promoting reading in all groups of the population (Cuba y Venezuela ayudan a Bolivia, 2013). Similar actions exist in Chile and other countries of this region.

Based on information shown above it is possible to propose several steps to improve the present educational situation with books and reading for students and adults:

- Parents need to spend more time reading books to kids and school children. It could be recommended to keep 1hour diary of familiar reading books (for about 360 days/year). During this activity parents, grand-parents, children read book aloud with short discussion of the meaning after that. It is very important too to organize in each family with school children some time each day (1 hour) for reading books for pleasure, for small children this time should be



controlled by parents.

- Parents should organize a special visits to urban library (1 dais/per week) with their children .
- It is recommended too that similar visits of parents with children are made to virtual libraries for reading books in electronic formats and choose to download them in their mother language. Some known libraries are: https://www.gutenberg.org/, http://en.childrenslibrary.org/, http://www.cervantesvirtual.com/, lib.ru and mirknig.com (in Russian) and so on.
- In school each class of all subjects should end with 5-10 minutes reading of appropriate interesting books. For science is easy to use classical popular science literature , such as Jules Verne. *Twenty Thousand Leagues Under the Sea,* I. Asimov. *A Short History of Biology and A Short History of Chemistry*, C. Sagan. *Cosmos*, *Surely You're Joking, Mr. Feynman!* , Y. Perelman. *Algebra Can Be Fun and Physics Can Be Fun*, A. Oparin. *The Origin of Life* and so on. Each country has its own series of books of popular science that would be suitable, like, for example, the Foundation of Economic Culture, FCE, Mexico (http://www.fondodeculturaeconomica.com/).
- Programs should be organized for delivering books in electronic format for notebook computers, Android tablets, i-Phones and mobile phones to spread reading for pleasure for young people and adults in various situations: at home, in transport, in the stadium and in other different life circumstances, see the image above.

  (the image is from https://warosu.org/lit/thread/3562718#p3562806)
- National TV systems should organize daily programs for advertising reading activities for children and adults.

There are, of course, other strategies that could be tried and evaluated to try to enhance the status of and engagement in reading to improve education, science education and quality of life for our citizens.

BIBLIOGRAPHY

C. Alter. Study: The Number of Teens Reading for Fun Keeps Declining, 2014. http://time.com/94794/common-sense-media-reading-report-never-read/

Cuba y Venezuela ayudan a Bolivia a combatir el analfabetismo funcional, 2013, http://www.noticias24.com/internacionales/noticia/64042/cuba-y-venezuela-ayudan-a-bolivia-a-combatir-el-analfabetismo-funcional/

Europe together against functional illiteracy - facts, information and solutions, 2012. (http://www.grundbildung-und-beruf.info/et_dynamic/page_files/267_datei.pdf?1334836254)

Functional illiteracy and the case for reading, 2013, http://reprobate.co.za/functional-illiteracy-and-the-case-for-reading/

N. Goulart. Hábito de leitura cai no Brasil, revela pesquisa. 2012. http://veja.abril.com.br/noticia/educacao/habito-de-leitura-no-brasil-cai-ate-entre-criancas

P. Greenfield. Technology and informal education: What is taught, what is learned. *Science,* 323, pp. 69–71, 2009.

Illiteracy Statistics, 2012 http://www.statisticbrain.com/number-of-american-adults-who-cant-read/

Jingying Wang , Orlik Y. The development of science education in PR China. *Journal of Science Education* , N 1, vol. 13, pp. 4-8, 2012.

S. Norris, L. Phillips. How literacy in its fundamental sense is central to scientific literacy. *Science Education.* Volume 87, Issue 2, pp224–240, 2003.

Y. Orlik. Actualización y lectura, herramientas para los profesores de ciencias. *Universitas Scientiarum.* Vol. 9, Special issue, 5-6, 2005.

Reading, Literacy & Education Statistics, 2012,

http://www.readfaster.com/education_stats.asp

Research evidence on reading for pleasure. Department of Education, UK, 2012.

J. van de Wetering Almost half the country is functionally illiterate. 2012. http://www.abc.net.au/local/videos/2012/09/07/3585457.htm

Yuri Orlik

Embracing the critical pedagogical issues in higher education: strategic implementation of appropriate, relevant technology

Asuntos pedagógicos críticos en la educación superior: implementación estratégica de tecnología apropiada y relevante

Jace Hargis, Melissa Soto

Faculty Development, Assessment and Research
Chaminade University, Honolulu , San Diego State University, USA

Abstract

This paper describes some of the critical issues facing higher education today and encourages an attitude of embracing those challenges. The authors connect the attributes of what the best teachers do to using meaningful, appropriate technology, as well as integrating expert predictions. Issues discussed include preparing learners for uninvented careers, MOOCs and nano-degrees, digital content creation, play with purpose maker economy, fabrication labs to create accessible electronic learning objects, big data learning analytics, wearable technology, the quantifiable self, the internet of things, and mobile learning. A specific example of mobile learning as an umbrella framework will be shared with lessons learned and scholarly research findings.

Key words*: Mobile Learning, MOOCs, eLearning Objects, OER, learning analytics, ePortfolios*

Resumen

Este texto describe temas críticos que enfrenta la educación superior hoy y alienta una actitud de analizar esos desafíos. Los autores muestran los ejemplos de actuación de los mejores profesores para usar la tecnología educativa apropiada y los datos de los expertos. Los temas discutidos incluyen métodos de preparación de los alumnos para carreras universitarias y los ejemplos de aplicación de la tecnología educativa en clases, uso y creación de objetos virtuales de aprendizaje electrónicos, la utilización de la tecnología portátil, la Internet y el aprendizaje móvil. Un ejemplo específico del aprendizaje móvil está discutido con resultados de las investigaciones científicas.

Palabras clave: *el aprendizaje móvil, MOOCs, objetos de aprendizaje electrónicos, OER, analíticas de aprendizaje, portafolios electrónicos*

INTRODUCTION

In Ken Bain's (2004) book, What the Best Colleges Teachers Do, he summarizes twenty-five years of research on key attributes, which good teachers exhibit. In summary, good college teachers

- know how we learn and process information;
- prepare to teach as a serious intellectual endeavor as demanding and important as scholarship;
- conduct class where diverse learners can explore, analyze and synthesize to construct own meaning; and
- check their own progress with a systematic program to assess and modify.

We share this information early in this paper, as we both believe these are critical to teaching and they have an essential role in the issues of higher education today and tomorrow. We also strongly believe that what makes a good teacher applies to whether instructional technology is used often, occasionally or not at all. Many of the issues in higher education, which we will suggest involve the use of technology. Of course, technology is not the panacea for good teaching, perhaps at times, it may distract or confuse learners. However, it would seem irresponsible of concerned educators not to at least explore the possibilities of technology and then determine its merit, based on foundational research methods, which we have employed and used for determining the effectiveness of our instructional approaches in the past.

Background for Issues in Higher Education

A major resource for identifying potential issues in higher education is the New Media Consortium (NMC)/Educause Annual Horizon report (Johnson et al., 2013). The Horizon report "is a collaborative effort between the NMC and Educause designed to identify and describe emerging technologies likely to have an impact on learning, teaching, and creative inquiry in education" (Johnson et al., 2013). It may be useful to compare the 2013 and 2014 predictions to identify trends and continually monitor the changes from one year to the next. These predictions are organized by time periods of one, two to three, and four to five years. The 2013 year one prediction included Massive Open Online Courses (MOOCs) and mobile learning; years 2-3 included learning analytics and gamification; and years 4-5 were 3D printing and wearable technology. The 2014 predictions for year one included flipped learning and learning analytics; years 2-3 were 3D printing and gamification, and for years 4-5 were quantifiable self and virtual assistants.

Many potential and exciting issues exist in higher education today. Using the past two years of The Horizon reports' predictions as a guide, we identified eleven issues, which have been discussed in the education literature. They include preparing learners for uninvented careers, MOOCs and nano-degrees, digital content creation, play with purpose maker economy, fabrication labs to create accessible electronic Learning Objects (eLOs), big data learning analytics, wearable technology, the quantifiable self, the internet of things (IoT), and mobile learning. These issues will be discussed in detail in the following sections.

Preparing for "Uninvented Careers"

Faculty members are typically experts in their discipline, and perhaps many of them have experience as graduate teaching assistants and/or many years developing their teaching skills. However, the relatively recent movement of the 'uninvented careers' now creates a challenge on how to help students prepare for a career. Some of the newly created careers include cyber-security specialists, mobile application developers, social media managers, stem cell researchers, robotics technicians, and simulation engineers. It would seem that the nonlinear, non-predictive trend of careers might continue, and therefore, the challenge of how to prepare students years before their careers will persist. One idea is to ensure students are provided time to incorporate process-drive and twenty-first century skills into their curriculum. Twenty-first century skills typically include collaboration, communication, creativity and critical thinking (Partnership for 21st Century Skills, 2014). These skills have been widely sought by employers for years, and the demand has escalated in recent years. Besides teaching learners how to learn, these skills encourage learners to become more self-regulated in their learning. So, instead of sharing facts and dates with students, more emphasis is on project-based learning and inquiry approaches to exploring possible solutions. Inquiry-based learning (IBL) and its derivative method typically include a process that includes questioning, predicting, investigating, exploring, data gathering, reflecting, and making conceptual connections. Many worthwhile models could be suggested to implement IBL. One approach is called Design Thinking (DT) (www.ideo.com/work/toolkit-for-educators). Neumaier (2009) defines DT as the "process of working through problems while operating in the space between knowing and doing, prototyping new solutions that arise from the use of four key strengths: empathy, intuition, imagination and idealism." There are several derivations of DT, all of which are components of traditional IBL, such as discovery, interpretation, research, ideation, experimentation, and evaluation. Design Thinking is often used when addressing "wicked problems," situations where neither the problem or solution is known (Camillus, 2008). Wicked problems correlate well with current beliefs on educational systems, where perhaps we are attempting to educate learners for problems and careers that do not currently exist (cloud-server specialist, big-data architect, data scientist, waste data managers, 3D Food Print Engineers, and Smart Dust programmers).

MOOCs and "Nano-degrees"

A MOOC or Massively Open Online Course is a free online course available to anyone with an internet connection. In late 2012, the New York Times called 2013 as the year of the MOOCs (Pappano, 2012). As one might imagine, MOOCs have been heralded as the answer to higher education and contradicted as an over-hyped fad. Perhaps a major reason why MOOCs have remained in conversations are the types of institutions offering courses, which include Stanford (Coursera and Udacity), MIT, and Harvard University (EdX). Strengths of MOOCs include their potential to deliver rich, mobile scalable content; a broader open access, more interaction and therefore, the chance that more people may perceive education as a human right; an interactive disruption of linear, low-level education; and a heightened involvement for crowd-sourced, democratized reform (Spinner, 2013). The challenges of MOOCs include a lack of perceived educational value; the chance of inconsistent quality; yet to be seen movement from traditional instruction to engaging, highly interactive learning; talking head videos, which may only move the real issue around; uncertain, traditional leaders preventing forward movement; and a lack of appropriate rewards and recognition.

Nano-degrees have recently extended the idea of a MOOC. Nano-degrees have been developed by Udacity and AT&T, which provide learners an online opportunity to earn a certificate of learning in 6-12 months working between 10 and 20 hours/week (Blase, 2014). The cost is bundled at $200/ month. Currently, the type of programs are limited to basic programming skills and data analysis. It seems that few people believe that nano-degrees are the ultimate answer. However, many others see this movement as a sign of a MOOC evolution, which at some point, could provide a more acceptable learning tool.

Digital Content Creation

As education begins to use more digital tools and information, the need to create an efficient collaborative learning digital content creation(DCC) platform is essential. Ideally, an efficient DCC would allow educators to create digital learning materials using suggested prompts, which align to best-practices instructional design, open-source, copyright free diagrams, simulations and apps, and a very easy way to upload, review, enhance and reuse. As teaching and learning continues to evolve to include mobile learning tools, there is a desperate need for correlating high quality learning materials. While some educators are developing materials for their own use, many of the highly interactive learning objects tend to be out of reach. Ideally, what is needed is a DCC platform, which would allow connected educators to access all published materials in a way that is similar to an open source software environment. The on-line nature of the platform would allow educators to collaborate within a department, an institution or across the world to create and develop relevant gold class learning content. The opportunity for high quality DCC is timely due to the convergence of the proliferation of mobile learning devices in education and the need in education for quality digital learning content to support a new pedagogy.

Educators can integrate their professional development by logging their reflective statements within the DCC system and apply their learning to the development or improvement of course materials. Ideally at least five main elements would make up the DCC system: create, share, teach, reflect and learn. Each of these will be discussed below.

Create is the area where users can rapidly develop digital learning materials without any programming skills, using built in templates. It would offer the ability to include existing content in any form (Word, PowerPoint, Pages, Keynote, PDFs, audio, video files, etc.). It is envisaged that the system would also cater for Adobe Flash, simulations, scenarios, built-in interactions, animations, HTML, Java and other popular media to create highly engaging content. Users can assemble courses from all types of content including natively authored, integrated and third party materials. Course creators should be able to develop assessments using easy to use built-in tools. Results are tracked using the analytics tool. The system would automatically notify owners of changes to their content and tracks progress and updates of flagged content.

The Share function is where teaching and learning resources would be posted for open sharing and/or further developed by other members of the learning community. The tool provides collaborative development environment of teaching and learning resources by allowing community members to work individually or in groups. This crowd-sourced approach allows for both autonomy, as well as a collective artifact, which can be used in multiple forms and purpose. Educators, researchers and students are able to share ideas, best practices, innovations, tips as well as ask questions to create socially driven learning content and methods. This approach also provides a central point to create courses for all institutions to share plans, ideas and resources, so everyone draws on the same source. The ideal platform should be able to share content ideas using Wikis, surveys, on-line chat and web meetings; edit and update research data upload by users into a database pool; integrate with popular social media sources to import and export content such as FaceBook, LinkedIn, Twitter, Pinterest, etc.; integrate within the Local Learning Management System to import and export content; create authoring versions of content and user signing; and find and share content through file tags.

The Teach area will facilitate learning in an individualized way, by increasing student engagement though the flexibility of multiple channels including the web, instructor guides, classroom materials, off-line on the desktop, iPad, smart phone, performance support and printed documents. The area will be able to export in multiple formats including iBooks, Pages, Keynote, Word, PowerPoint, FrameMaker, HTML, widgets and direct to PDF to support online, classroom and mobile learning.

Reflection is a key part of maintaining our metacognitive viewpoint on how we teach and learn. As part of the ecosystem, members would have access to professional development (PD) tools that they can fully use opportunities the system offers. The PD tools would include FrameMaker and other Adobe products, HTML, Java and would increase as the faculty crowd-sourced their needs. Additionally, a Scholarship of Teaching and Learning support tool could be made available to assist those teacher-scholars, who wish to research their teaching methods.

The Learn process is embedded in the creating, sharing, delivering and reviewing teaching and learning materials promoting continual personal development and thus the quality of those materials and effectiveness of delivery. Faculty Development is both a comprehensive term that covers a wide range of activities ultimately designed to improve student learning, and a less broad term that describes a purposeful attempt to help faculty improve their competence as teachers and scholars (Eble, & McKeachie, 1985).

Play with Purpose Maker Economy

The term "play" is typically interpreted as fun and perhaps not sufficiently serious for learning. However, the ability to encourage learners to "play" has been shown to be a desirable component of learning, as it provides opportunity to enhance the learner's intrinsic motivation. Lin, McKeachie, and Kim (2001) found that college students with average extrinsic motivation and high intrinsic motivation achieved better grades. The idea of playing with purpose creates outcomes-driven learners, who embrace low risk, and a modified level of acceptance for failed events, which occur often with play. With the rapid integration of game oriented application, we see many users embrace and enjoy momentary failed events, as they receive additional 'players' and/or options to continue the play (learning). A specific and somewhat now dated example is the game application (app), Angry Birds. In this app, the learner can manipulate the 'bird' to direct its flight into 'pigs,' which are strategically hidden behind virtual walls of wood or concrete. The goal is to know how to arch the bird's flight path and hit the wall, which will cause the most virtual damage. Cognitive science research provides rationale for the success of this type of learning (Mauro, 2011). In summary, the research connects the game to several foundational attributes for learning. The game is simple, yet engaging, provides timely feedback, reinforces short term memory management, provides multiple opportunities for inquiry, addresses the look and sound, which engages the sensory step of information processing and it measures and shares our progress. The challenge is to create a "playful" learning environment, which contains a real purpose and the purpose needs to be connected to a desired learning outcome. This does not happen by accident and requires thoughtful, well-planned professional development in instructional design and learning theories.

I mentioned the term 'failed events' intentionally, avoiding the word 'failure.' A failed event is a moment, although failure could be a sustaining label. With play, learning is enhanced by high frequency, low risk failed events. It is through these failed events that our cognitive ability is able to make sense of the concepts. Piaget believed to genuinely learn or "through which awareness of the outside world is internalized," we need to encounter a disequilibrium phase, which may be when we come across an idea that we are unfamiliar with or a question we do not know the answer (Atherton, 2013). It is at this point that we either accommodate, adapting new information to conform to current mental paradigms; or assimilate, incorporating the idea without modification. Embracing the idea of frequent 'failed events' allows the learner to both become an expert in re-equilibrating, and empowers them to engage in novel situations, knowing they possess a process to address new ideas.

Another benefit of the play with purpose mentality is the ability to focus on a maker economy, democratizing the benefits of learning (Anderson, 2012). Allowing learners to "make" representations of what they have learned both creates a different type of learning environment and allows diverse learners to provide evidence of learning outcomes. The challenge for this approach is helping teachers be able to accurately and consistently assess, which can be done through rubric's. If high stakes assessment is required, the rubrics can be reviewed, modified and ultimately categorized with an inter-rater reliability coefficient. One of the most powerful methods to help learners become "makers" is to create a maker or fabrication lab, that contains tools, such as 3D printers, sheet metal and laser cutters, routers, maker-bots, precision milling tooling, capacitors, micro-controllers, transducers, etc.

Fabrication Lab to Create Accessible Electronic Learning Objects

As mentioned earlier, a fabrication or fab lab typically contains equipment, computers, circuit boards, tools, interchangeable parts, so the user can make and modify things (Watson, 2011). A fab lab is ideal for providing the tools for learners to create readily accessible electronic Learning Objects (eLOs). Besides creating physical objects in a fab lab, another idea is to ask students to represent their learning by creating eLOs. Historically learning objects were a collection of content items, practice opportunities, activities, and assessments that were combined in an intentional way to help the learner navigate through a concept. The objects were built based on a foundation learning theory, for instance in a constructivist, nonlinear, or objectivist, linear format. They were modular and provided educators and learners the flexibility to be used in different ways. A typical object might contain an introductory text, followed by a worksheet with instructions for the learner to do something, and then finally an assessment or examination, which would provide a check of how much the student learned. Translating these objects into an electronic format enhances their ability to be easily modified. A typical eLO might include:

Video introduction of a problem, which could simply be a video of various forms of running water and an associated driving question of "what is in our water?";

List of hyperlinks to city municipalities on their drinking water analysis;

Google Scholar list of pertinent research papers;

Podcast/vodcast/blog of experts in the area discussing water quality issues;

Tablet app, which allows the learner to play a game to more fully understand the consequences of contaminated drinking water;

Challenge for the learner to create rich media on the topic, attending to suggested prompts, which align to a rubric and course learning outcomes; and

Portal to submit their authentic media assessments, review and evaluate other artifacts from around the world.

In addition, the data collected from learner responses to the eLOs can be shared and collected, both locally for individual students, as well as class, school or globally in an aggregate form to propose possible remediation steps for the instructor. The power of more data allows programs to more accurately determine how learners are making decisions. From this data, algorithms can be created, which can more accurately identify gaps in understanding and provide alternative eLOs to assist students who are struggling.

Big Data Learning Analytics

Big data has been used in business in many years to help determine inventory, marketing trends, consumer buying habits and more. Recently, education has begun to question how big data could assist teaching and learning. Ideally, if we could identify an efficient method to collect authentic assessment data (which is different from low level linear forced-choice tests), such as media-rich representations of what students have learned, we could develop a learning analytic, which would provide useful and timely information to the learner, teacher and parent. Powell and MacNeil (2012) have found that learning analytics' may vary

"for individual learners to reflect on their achievements and patterns of behavior in relation to others;

as predictors of students requiring extra support and attention;

to help teachers and support staff plan supporting interventions with individuals and groups;

for functional groups such as course team seeking to improve current courses or develop new curriculum offerings; and

for institutional administrators making decisions on matters such as marketing and recruitment or efficiency and effectiveness measures."

Soto and Hargis (2014) have researched one unique learning analytic approach addressing formative assessment while using a screencasting application on an iPad. In this approach, the authors used the ExplainEverything screencast app that allows the user to "write" on an iPad and speak about what they are writing. A screencast is a digital recording of the images and text displayed on the screen as well as any audio input. Using the app, collecting and analyzing the qualitative data with a rubric allowed them to gain a greater sense of what the students were thinking as well as when they were thinking particular thoughts. This type of electronic learning analytics was difficult, if not impossible to obtain, especially in such an efficient way previously. The amount of rich data generated by students it is necessary to identify ways to efficiently comb though all the nuances of their explanations to make informed decisions and target instruction.

Wearable Technology, Quantifiable Self, Internet of Things

For those, who believe issues such as wearable technology, quantifiable self, and the internet of things are too far off to be discussed, it seems an understatement to say how quickly technology has become part of our education and lives. Along with the well known Google Glass, other wearable technologies on the horizon include remote patient monitoring for exercise, blood pressure, diabetes, insulin and cortisol levels, and posture. Afshar (2014) shares examples of how Google Glass wearable technology is currently being used in colleges include:

- Students to document classroom activities, or during informal learning;
- Making instructional films;
- Record practice videos, while solving a math problem, to record the process and provide voice over;
- Encourage remote group work;
- Teachers record their teaching process;
- Identifying buildings on-campus map;
- Closeup view of lab demonstrations;
- Screencasting from the perspective of the lecturer; and
- Gathering blood pressure, heart beat and temperature data as part of the quantifiable self.

The quantifiable self is a way to monitor our health and well-being by using technology to gather data on everything we do. This may include what we eat, drink, breath, how much we exercise, mental, emotional and social performance. Historically this type of information was only available during physical examinations and even then only as a snapshot of our health at the time. If health issues existed, the physician may have struggled with diagnostics since the symptoms were not present during the examination. Strategies might include trial and error medication and/or trying to provoke the symptom to occur, which could be painful or dangerous. The ability to collect health information real time and forward automatically through wireless technology to a local system, and/or a physician would allow for more targeted diagnostics. Perhaps a "Big Brother" science fiction, but one day we may wish to collect quantifiable self data on our learners. This data could help us determine how and when a student learns best, providing more personalized learning experience, detecting learning issues, and determining the behavior variables that are the significant indicators of student performance.

The Internet of Things(IoT) is a loose definition of anything connected to the internet. Historically, only computers were connected, but now, through small chips, we can connect practically anything. Examples include our pets, manufacturing inventory, heart monitoring implants, automobiles and smart thermostats, lighting and home security. Gartner (2013) indicates that by 2020, 26 billion devices will be connected to the IoT. With so many devices connected to IoT, there are bound to be ways for education to capitalize on the benefits, which IoT can offer. Selinger, Sepulveda, and Buchan (2013) have described many of the potential uses in their work, Education and the Internet of Everything: How Ubiquitous Connectedness can Help Transform Pedagogy. In this paper, they describe the implications for IoT in education, as well as what they term the four pillars of IoT: People, Process, Data, and Things. They suggest that with the increase in mobile tablets and learning in the classroom, there will be a natural connection between mobility and the ability to access large amounts of information through the internet.

Mobile Learning

One example, which may both embody the current issues in higher education as well as act as an umbrella category is mobile learning. Mobile learning can be seen as a derivative and a springboard for many of the critical issues of higher education discussed previously. Mobile learning (ML) can create a learning anytime, anywhere model, which would provide more opportunities and time for PD, such as while traveling, waiting, or preparing. Many of the uninvented careers will most likely include and/or be performed using a mobile platform. MOOCs are more easily accessible using a mobile device; digital content creation can be developed and accessed; maker and fabrication labs would create apps for mobile devices; identifying how learners engage while using mobile devices could provide big data for subsequent learning analytic analysis, and of course the decrease in size of mobile devices makes them much more capable for wearing and then using the data to quantify or make sense of one's health. The idea of mobile learning may not be the critical issue for higher education today, but how and when it is implemented, sustained, assessed and valued are certainly key questions to discuss.

To further demonstrate the potential impact of mobile learning on many of the critical issues, we will share the following example from the United Arab Emirates (UAE) (Hargis, Cavanaugh, Kamali, & Soto, 2013). In April of 2012, the Chancellor of the UAE federal higher education commissioned the higher leaders to aggressively implement an iPad mobile learning for the incoming 14,000 students. The primary goal of the program was to increase student engagement and subsequent success in learning. The expectations were everyone would have open and efficient access to content and learning experiences with a single portable engaging device.

The initiative followed Mishra and Koehler (2006) TPCK model, which included technology, content and pedagogy knowledge and the SAMR model of Substitution, Augmentation, Modification, Redefinition (Puentedura, 2006). The lead author's role was to lead the national pedagogy team. His initial action was to create a systematic professional development (PD) model, which could be easily acted upon and scalable throughout the country. He developed a four step iPD model, iChampion, iCelebrate, iCommunicate, and iSoTL or Scholarship of Teaching and Learning.

The iChampions were an eager group of focused faculty who worked in the capacity of a faculty developer for their campus. We did this by selecting thirty faculty from around the country to work on the pedagogy and faculty development task, iChampions worked with Apple on learning and then training others on specific programs, such as iBooks, iBook Author, iTunesU, and iPad apps. This team met regularly for educational programs on the iPad, and perhaps on how they could return to their campus and develop, encourage, motivate their faculty on integrating mobile learning into their classroom.

The iCelebrate step involved creating a mechanism to share the efforts that were quickly being created by faculty (Cavanaugh, Hargis, Munns, & Kamali, 2013). iCelebrate was a 'non-conference' event that we held three times in the first year of implementation. For the first iCelebrate in June 2012, faculty came to our campus and shared one concrete app that they could use in September, the start of the new academic year. The format was a 15 minute 'quick-chat' in a large Library common space and the presenter used an Apple TV for ease of presenting and switching presenters as well as audience engagement. This first iCelebrate featured 40 presenters and 400 faculty participants. Later faculty commented on how successful and needed this kickoff session was as well as timely. We began the term with additional sessions and then held an iCelebrate 2 in December 2012, which contained 80 presenters and 650 faculty attending voluntarily with no rewards offered. Ultimately, one year later, June 2013, we held the iCelebrate Finale, which experienced similar success and we are now analyzing the data for a final publication.

Communication was key, especially in the beginning. We created a way to communicate quickly and efficiently by using an open website, http://www.ipads.ae where faculty shared ideas and the lead author blogged on relevant resources and faculty development. The most powerful function of this site was our ability to crowd source the apps that we would include on the student iPads. Faculty suggested an app and others voted on them. This increased engagement and accountability, as we selected the top 20 apps to be placed on every students' iPad.

The SoTL step provided information and guidance to faculty who wished to gather data and write on the effectiveness of the program. Overall, this initiative was a showcase success, which has added significantly to the literature base and mobile teaching and learning. We were fortunate to collect a large amount of data on the implementation, process, and how students and instructors transitioned their teaching and learning by using mobile learning tools. Subsequently, we were able to publish several scholarly articles as one of the early adopters of large scale uses for mobile learning. Some of the scholarly findings include:

Increased access to learning material, engagement between students and teachers, and collaboration within and beyond the learning community;

A "play with purpose" attitude, which resulted in a new mentality to embracing low risk 'failed events';

The creation of rich-media and electronic Learning Objects, some which were used as formative assessments; and

Assessing twenty-first century skills, such as collaboration, communication, creativity and critical thinking through Project-based learning and ePortfolios.

The following text summarizes our key findings from Cavanaugh, Hargis, Kamali, and Soto (2013) on using two distinct professional development (PD) models for mobile learning implementation. The main theoretical model used was Koehler and Mishra (2009) TPACK or Technology, Pedagogy, and Content Knowledge PD model of tracking progress. An analysis of descriptions of teaching practices at the first iCelebrate and the second iCelebrate, six months later was used to compare the abstracts for the events using an alpha of 0.05. We compared five indicators from the TPACK model including the SAMR levels of technology integration. Statistically, we found no significant difference ($p=.069$) between the technology, although there was a significant ($p=.0015$) difference in the content. We found no significant difference ($p=.129$) for the pedagogy. For technology integration into content teaching, there was no significant difference ($p=.379$) in level of substitution versus other levels, although substitution increased to higher levels; with a corresponding decrease that focused only on substitution. For the level of technology adoption, there was a significant difference ($p=.008$) with a shift to higher levels of integration.

CONCLUSIONS

One of the ideal next steps would be to create a holistic mobile learning ecosystem. The system would allow teachers to create and systematically share between other educators as well as students. There are many vendors, which could create a system, and in a perfect world, one where eLO's would be interchangeable. We will share one which is currently developed in use. The Apple system includes:

iTunes, used to create and listen to podcasts and audiobooks;

App Store, used to create, download and use applications;

iBook Author, used to create eBooks;

iBooks, used to download and interact with eBooks;

iMovie, used to create movies for stand alone content, and/or to embed in iBooks;

iTunesU, used to create and organize online courses, while attending to good instructional design practices.

We have shared several critical issues facing higher education today. The issues include time for professional development, uninvented careers, MOOCs, digital content creation, play with purpose maker economy, fabrication labs to create accessible electronic learning objects, big data learning analytics, wearable technology, the quantifiable self, the internet of things, and mobile learning. These are substantial issues, which will require a host of educator-scholars to explore, troubleshoot, deploy, fix, update and help convince others that these issues and others, which we have never heard of are worthwhile. Perhaps, these specific issues will not be the ones that change our current archaic education model. However, we believe that it is through the investigation of these issues that the possibility of creating another paradigm for higher education exists.

BIBLIOGRAPHY

Anderson, C. Makers: The New Industrial Revolution. New York: *Crown Business*. 2012.

Afshar, V. 14 Google Glass innovation uses in education. Retrieved on August 20, 2014 from http://www.huffingtonpost.com/vala-afshar/14-google-glass-innovativ_b_5410893.html.

Atherton J S . Learning and Teaching; Assimilation and Accommodation. Retrieved August 23, 2014 from http://www.learningandteaching.info/learning/assimacc.htm.

Bain, K. What the best college teacher do. Harvard University Press: Cambridge, MA. 2004.

Blase, B. Introducing Nanodegrees: Industry credentials for today's jobs in tech. Retrieved on August 11, 2014 from https://www.udacity.com/nanodegrees.

Camillus, J. Strategy as a wicked problem. *Harvard Business Review*, 86(5), 2008.

Cavanaugh, C., Hargis, J., Kamali, T., & Soto, M. Substitution to augmentation: Faculty adoption of iPad mobile learning in higher education. *Interactive Technology and Smart Education*, 10(2), 2013.

Cavanaugh, C., Hargis, J., Munns, S., & Kamali, T. iCelebrate teaching and learning: Sharing the iPad experience. *Journal of Teaching and Learning with Technology*, 1(2), 1-12, 2013.

Eble, K., & McKeachie, W. Improving Undergraduate Education Through Faculty Development. San Francisco: Jossey-Bass. 1985.

Gartner . Gartner says the Internet of Things installed base will grow to 26 billion units By 2020. Retrieved August 15, 2014 from http://www.gartner.com/newsroom/id/2636073.

Hargis, J., Cavanaugh, C., Kamali, T., & Soto, M. A federal higher education iPad mobile learning initiative: Triangulation of data to determine early effectiveness. *Journal of Innovation in Higher Education*, 39(1), 2013.

Johnson, L., Adams Becker, S., Cummins, M., Estrada V., Freeman, A., & Ludgate, H. NMC Horizon Report: 2013 K-12 Edition. Austin, Texas: The New Media Consortium.

Koehler, M., & Mishra, P. What is technological pedagogical content knowledge (TPACK)? 500 Contemporary Issues in Technology and Teacher Education, 9, 60–70, 2009.

Lin, Y., McKeachie, W., & Kim, Y. College student intrinsic and/or extrinsic motivation and learning. learning and individual differences, 13(3), 251-258, 2001.

Mauro, C. Why Angry Birds is so successful and popular: a cognitive teardown of the user experience. PulseUX Blog Theory, Analysis and Reviews on UX User Experience Research and Design. Retrieved August 15, 2014 from http://www.mauronewmedia.com/blog/why-angry-birds-is-so-successful-a-cognitive-teardown-of-the-user-experience/.

Neumaier, M. The Designful Company. Berkeley, CA: New Riders. 2009.

Pappano, L. The year of the MOOC. New York Times. Retrieved on August 20, 2014 from http://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html?pagewanted=all&_r=0 .

Partnership for 21st Century Skills. Framework for 21st century learning. Retrieved on January 2, 2014 from http://www.p21.org/about-us/p21-framework

Powell, S., & MacNeil, S. Institutional readiness for analytics: A briefing paper. CETIS Analytics Series. JISC Center for Educational Technology and Interoperability Standards, 1(8), 2012. http://publications.cetis.ac.uk/wp-content/uploads/2012/12/Institutional-Readiness-for-Analytics-Vol1-No8.pdf

Puentedura, R. Transformation, technology, and education. Unpublished essay. 2006. Retrieved from http://hippasus.com/resources/tte/.

Seal, C., & Hargis, J. Celebrate teaching symposium. *Mountainrise Journal*, 7(2), 2012.

Selinger, M., Sepulveda, A., & Buchan, J. Education and the internet of everything: How ubiquitous connectedness can help transform pedagogy. Retrieved August 14, 2014 at http://www.cisco.com/web/strategy/docs/education/education_internet.pdf.

Spinner, A. Analyzing MOOCs - A SWOT analysis. Retrieved on August 19, 2014 from http://andrewspinner.com/2013/02/05/analyzing-moocs-a-swot-analysis/.

Soto, M., & Hargis, J. Students ExplainEverything using iPads. ISTE Learning & Leading with Technology, 32-33, 2014.

Watson, G. The Champaign-Urbana Community Fab Lab. Interactions, 18(5), 86-87, 2011

Received 12-10-2014 /Approved 02 -05- 2015

Impressions of students on guided visits to National museum

Impresiones de los estudiantes en las visitas guiadas al Museo Nacional

[1] Guilherme Cordeiro da Graça de Oliveira, [2] Cássia Curan Turci, Marcio José E.M. Cardoso, [3] Rhoneds A.R. Perez da Paz

[1] Instituto de Química da Universidade Federal do Rio de Janeiro (IQ-UFRJ), [2] IQ-UFRJ, [3] Museu Nacional-UFRJ, Brazil, rhoneds@gmail.com, cordeiro@iq.ufrj.br, cassia@iq.ufrj.br, marcio@iq.ufrj.br

Abstract

This paper involves the planning, implementation and evaluation of guided visits to the National Museum of the Federal University of Rio de Janeiro, located in Rio de Janeiro, Brazil. The theoretical framework considers the John Falk Model of learning in museums. The visitors were students selected from the 9th year elementary school to 3rd year secondary school education. The museum`s collections were analyzed under their chemistry aspects without underestimating the artistic, historical and cultural characteristics. The main purpose of this work was to analyze, as a function of the student level of schooling, the learning, motivation and affective gains provided by visits. Questionnaires were applied before, during and after the visits and were used to characterize the students groups and evaluate the mediation method. Fisher`s exact test was the statistical procedure employed to identify significant differences in the students' behavior as a function of schooling level. The results showed that the procedure was able to provide affective and cognitive gains for all students. Also, the physical context of the National Museum promotes the development of informal classes in chemistry, especially for secondary education students.

Key words: *chemistry education, informal education, national museum*

Resumen

Este trabajo implica la planificación, implementación y evaluación de visitas guiadas al Museo Nacional de la Universidad Nacional de Río de Janeiro, ubicada en la ciudad de Río de Janeiro, Brasil. El marco teórico considera el modelo de John Falk de aprendizaje para los museos. Los visitantes eran estudiantes seleccionados desde una escuela primaria noveno año al 3º año de educación secundaria. Las colecciones del museo fueron analizadas bajo sus aspectos químicos sin infravalorar sus características artísticas, históricas y culturales. El objetivo del trabajo fue analizar el aprendizaje, la motivación y los logros afectivos proporcionados por las visitas, en función del grado de escolaridad de los estudiantes. Los cuestionarios fueron aplicados antes, durante y después de las visitas y se utilizaron para caracterizar los grupos de estudiantes y evaluar la dinámica de la mediación. Se adopto la estadística del test exacto de Fisher y se ha identificado diferencias significativas en el comportamiento de los alumnos en función del grado de escolaridad. Los resultados mostraron que la dinámica de la visita fue capaz de proporcionar logros afectivos y cognitivos a los estudiantes. Además, el contexto físico del Museo Nacional favorece el desarrollo de clases informales en química, en particular para los estudiantes de educación secundaria.

Palavras clave: *educación química, educación informal, museo nacional.*

INTRODUCTION

The Brazilian basic education system has 12 years schooling divided into elementary (9 years) and secondary (3 years) levels. The National Curricular Parameters (PCNEM) aim to establish the basic school as a conclusive stage and no longer as a simply preparatory to higher education or strictly professional training (Brazil, 1999). On the other hand, the Curricular Guidelines for basic school recommend the development of practice outside of school, pointing this procedure as motivating activity and moving the learning environment outside the classroom (Brazil, 2006).

However, the reality of the Brazilian school tradition is so far beyond that would be necessary to follow the guidelines of PCNEM. The reality brings us standardized activities, without any insertion into real contexts, placing the students in an attitude of passivity against learning. The schools are not concerned about different aspects such as professional perspectives, problems and challenges of the community, the city, the country or the world. Generally, at school, the students interact with an essentially academic knowledge through transmission of information, assuming that, memorizing them passively, they attain the desired knowledge. Relating this to chemistry teaching, it is necessary to reorganize the content currently taught, as well as the methodology employed. It is important to introduce the student to the concrete, observable and measurable facts, since the students bring to the classroom their views of the macroscopic world. Chemistry teaching should contribute to the citizen formation, allowing the development of knowledge and values that might become easier the individual interpretation experiences of the world. This seems to be one of the PCNEM goals.

Several researchers state that science education can no longer stick to strictly school setting. This statement emphasizes the role of informal education settings such as botanical gardens, ecological parks, zoos, museums, culture houses etc, where the curriculum content can be worked in a playful manner and contextualized so that students are offered opportunities to interact with their environment and social heritage (ASE, 2011).

Guided visits to museums and centers of science communication are important to popularizing of science and technology (PST). Orlik *et al.* (2007) published a comprehensive program of PST that aimed to disseminate amongst teachers and experts in education the different approaches to citizenship appropriation. Moreira (2006) and Oliveira *et al.* (2013) discuss PST as an important element of social inclusion in periphery populations of big cities in Brazil. Furthermore, Moreira (2006) presents some priority lines of action in the field of science communication and technology that were established by the Brazilian government. Navas and Marandino (2009) present a critical analysis of these government actions. Depending on the political dimension they identify actions as informational or dialogic.

The main objective of this work consists in analyzing the students' behavior and impressions during their Museum visits - their learning, motivation and affective gains. Some particularities depending on the level of schooling were also investigated. Another goal is to establish the National Museum as an informal setting, potentially motivating for guided tours as for informal classes of chemistry – with educational objectives.

MUSEUMS AS INFORMAL EDUCATION SETTINGS – LEARNING IN MUSEUMS

Several authors recognize a Science Museum as one of the main informal settings for production and improvement of knowledge (Krapas, 2001; Queiroz, 2002; Marandino, 2003, 2009; Griffin, 2004; Taylor, 2008; Spencer, 2014). However, the learning developed in these environments has particularities, which distinguish it from the learning in a formal setting. In the museum environment the idea is common that the learning is related to affective, motors and playful aspects. In addition, the visits are strongly influenced by perception, consciousness, emotion and memory of the visitor (Falcão, 2003).

In the contextual learning model (CLM), Falk and Storksdieck (2005) define learning as an effort targeted and contextualized to construct meanings in the direction of problem solving, survival or prosperity in the world; a dialogue between the individual and environment through time that relates past and current experiences. The model describes this directed dialogue as a process/product interaction that occurs in different contexts: cultural, physical and personal, each one grouping a large number of facilitators factors of learning. Table 1 describes the eleven major factors that facilitate learning, distributed in three contexts.

Table 1- Factors that influence and define the learning in a Museum (Falk and Storksdieck, 2005).

Personal Context	Motivation, expectations, previous knowledge, Interest and control.
Sociocultural Context	Mediation quality and group interactions
Physical Context	Physical orientation Exhibition environment Architecture Events and experiences outside the Museum

The personal context consists of motivations, expectations, choice and control possibilities. In this context learning is strongly influenced by prior experiences, interests and beliefs of the student. The sociocultural context is defined by social mediation in the Group and/or facilitated by others. Once individuals are products of social and cultural relations, it is believed that learning in museums is strongly influenced by the sociocultural relations that arise in these environments. We would point out the various possibilities of a visitor's interaction with others, as well as the presence of mediators, guides or any other artistic and/or educational activity, the physical context must also be taken into account. This relates to architectural lighting, agglomeration of people, quality and quantity of information presented, access to a general map of the Museum, etc.

Considering that the learning is not an instantaneous phenomenon but a cumulative process of acquisition and consolidation of meanings, the experiences that occur after the visits are also important. After the museum experience, it is believed that the visitor leaves with some knowledge that reinforces their understanding of the events that occur in nature, in the world or in society. In this way, the events that occur after the visit are also facilitators of learning since they reinforce the museum experiences.

In this work, the visits to the National Museum were planned following most of the factors described in Table 1 to provide playful and relaxed visits, developing a friendly inter-relation between mediator and visitor, in pleasant surroundings.

METHOD

Previous visits were conducted by the mediation team in order to carry out a detailed description of the National Museum collection, identifying chemical aspects that could be discussed with the students. In order to carry out effective educational work, Marandino (2009) discussed the importance of knowing the museums and their collections.

On each visit the visitors group was divided between 4 mediators. This distribution aimed to allow a maximum number of 8 students per mediator. The method of this research was explained to all students and those who agree to participate signed a consent form free. In the case of students under 18 years old this term was signed by parents or a guardian. The project that gave rise to this work had the approval of the Research Ethics Committee (CEP), issued by *Instituto de Estudos em Saúde Coletiva* (IESC) at Federal University of Rio de Janeiro in 2013/6/2, number 194614. This work presents the results and conclusions regarding 5 visits, with 118 students.

Table 2 describes the education level of the students. The students from 9th grade of elementary school, 1st, 2nd and 3rd years of secondary education are here referred as groups A, B, C and D, respectively.

Table 2 – Students Education Level

Group	Education Level	Students number
A	9th year (elementary school)	27
B	1st year (secondary education)	30
C	2nd year (secondary education)	37
D	3rd year (secondary education)	24

Table 3 describes the visits' routine. In this table and following the work, the questionnaires applied before, during and after the visits are referred as questionnaires 1,2 and 3, respectively.

Table 3 – Routine Visits

TIME	ACTIVITY
7:20 a.m.	At school – presentation of mediators and administration of questionnaire 1.
8:00 a.m.	Departure to the Museum
9:30 a.m.	Arrival to Museum – "garden tour"
10:00 a.m.	Visit – administration of questionnaire 2
12:00 p.m.	Meeting at the Museum Auditorium – administration of questionnaire 3
12:30 p.m.	Return to school

Initially, the students were gathered in a classroom and distributed among 4 mediators. The mediators are introduced and describe the routine of the visit. Questionnaire 1 is applied. This questionnaire assesses the sociocultural profile, expectations with respect to the visit and the students' impressions regarding to chemistry classes.

Arriving at the Museum, the students are invited to a garden tour. They have the opportunity of a panoramic view of the old Imperial Palace. During the tour the mediator describes the major historical and architectural aspects related to the Palace. After the tour, the visit starts with the distribution of the questionnaire 2, which is elaborated taking in account the Museum collection, covering chemical, historical, artistic and cultural aspects. The answers of this questionnaire could be found by the students in texts or in explanatory videos, during the visit. In each place related to the questions the mediator meets the Group and makes a brief explanation to facilitate the understanding and thus motivating the search for answers. The students are encouraged to seek for the answers themselves.

After the visit the students are gathered at the Auditorium where the third questionnaire is applied. This questionnaire assesses students' impressions compared to expectations. Part of the questionnaire 3 was elaborated in 5 levels Likert scale, where students demonstrate their concordance with the assertions of the questionnaire.

Statistical analysis to compare the students' responses for the questionnaires 2 and 3 was based on the two-tailed Fisher exact test, run through the Statistical Software for the Social Science-SPSS version 13.0. This test is applied when all scores from two independent random samples are mutually exclusive classes. Groups can be any two independent groups, such as experimental and control, men and women, employed and unemployed, moms and dads, etc. The discriminatory factors can be any two classifications, such as above or below an average, approved or disapproved, agreement or disagreement, right answer or wrong answer etc. Thus, every subject in each group is one of two possible scores (Siegel, 2006). In this work, the null hypothesis H_0 was tested for a 5.0 % significance level. In the literature, the Fisher exact test was employed in research work related to psychology (Scior et all., 2013), nursing (McCrow et all, 2013) and education (Davids et all, 2014; Mellanby et all., 2013).

RESULTS AND DISCUSSION

Questionnaire 1

For all investigated groups, it was observed that most students age correspond to the schooling.

Table 4 concerns the following question: Describe positive aspects of your chemistry classes.

Table 4 – Impressions of students about the positive aspects of chemistry classes.

Group	Teacher	Affinity	Knowledge acquisition
A	13 (48.1%)	7 (25.9%)	4 (14.8%)
B	8 (26.7%)	9 (30.0%)	3 (10.0%)
C	11 (29.7%)	2 (5.4%)	13 (35.1%)
D	9 (37.5%)	3 (12.5%)	7 (29.2%)

The teacher is the most cited aspect among the students from groups A and D, while group B students cited, preferably, affinity for the discipline. The Group C students cited the possibility of acquiring knowledge. Here are some testimonials assigned A1 and A2 students:

A1: "... a positive aspect is that the teacher teaches very well."

A2: "... I like the classes, I don't like the behavior of the students in the classroom."

Table 5 refers to the question: describe one or more negative aspect of your chemistry classes. The most cited aspect pointed by the students of the groups A, B and C was the difficulty with chemistry. For students at the end of the secondary level (Group D), the lack of lab was considered as the main negative aspect of chemistry lessons. This group has older students and, therefore, more experienced and aware of the importance of experimentation for teaching chemistry, Here are some testimonials from students:

A3: "I like the chemistry class, my teacher is cool. The negative is that there are no practical classes."

" A4: "I learn many interesting things but I don't use them for anything."

Table 5 – Students impressions about the negative aspects of the chemistry classes.

Group	Lack of lab	Behaviour of colleagues	Difficulties
A	3 (11.1%)	9 (33.3%)	10 (37.0%)
B	2 (6.7%)	xxx	12 (40.0%)
C	6 (16.2%)	1 (2.7%)	15 (40.5%)
D	10 (41.7%)	2 (8.3%)	xxx

It is particularly important that the A4 student starting saying that he/she learns interesting things, but don't use them for anything. This statement reveals the decontextualized character class related to the pupil reality of and a pressing need for reformulation of contents and methodology. Table 6 describes the main expectations of students regarding to the visit.

Table 6 - The main expectations of students regarding to the visit.

Group	Knowledge acquisition	Entertainment	Interesting
A	16 (55.2%)	4 (13.8%)	8 (27.6%)
B	16 (51.6%)	4 (12.9%)	6 (19.4%)
C	28 (75.7%)	4 (10.8%)	5 (13.5%)
D	18 (78.3%)	1 (4.3%)	3 (13.0%)

The expectation that the visit would enable the acquisition of new knowledge was the most cited aspect among the four investigated groups, and it was higher among the students of Group D (78.3%). For younger students (Group A), expectations that the visit was interesting and/or fun were proportionately more cited when compared to other groups. It is important to note that no responses pointed to a negative expectation with respect to the visit. In the words of the students themselves:

A5: "I think I'll learning new things.

" A6: "I really want to go, I'm anxious and nervous, I've always wanted to go to a museum."

Questionnaire 2:

For purposes of this study, five questions were selected: 1) What is the average temperature in Antarctica? 2) What is the chemical composition of the Pará de Minas meteorite? 3) Is it danger to use brass utensil for cooking food? 4) What is Natron? 5) What is the function of the Natron in mummification? The question 1 is answered in the room "fossils from the frozen continent", which contextualizes the drastic climatic changes occurring in the Antarctic due to natural causes with possible climate changes, that may occur by human action. The question 2 is answered in the room "Meteorites" where students receive information about how to differentiate a meteorite from a rock from the Earth's crust. The question 3 is answered by visiting the room "Mediterranean Culture", where several brass pieces are on display. The possibility of contextualization appears here when addressing the danger of using pans with nonstick coatings, polytetrafluoroethylene (tefal) worn or damaged. Issues 4 and 5 are treated in the room "Egyptian culture". In an explanatory text about the mummification process studies, there is the description of the Natron (common name of hydrated sodium carbonate) and its function as drying agent and disinfectant in the process.

Table 7 presents the number and percentage of right answers for each group of students, as well as the comparison between groups. Significant differences ($p < 0.050$) appeared, mainly when group A is compared to other groups. At the end of the results description some hypotheses are proposed to justify this result.

Table 7: Number, percentage of right answers and comparison among the right answers of the questionnaire 2. N_I (I = A, B, C or D) is the number of right answers in Group I. Questions are described in the text.

Groups	Questions (questionnaire 2)				
	1	2	3	4	5
A & B	NA=20 (74.1%) NB=29 (96.7%) p = 0.021	NA=23 (85.2%) NB=29 (96.7%) p = 0.179	NA=16 (59.3%) NB=23 (76.7%) p = 0.254	NA=7 (25.9 %) NB= 21 (70.0%) p = 0.001	NA=6 (22.2 %) NB=21 (70.0%) p < 0.001
A & C	NA=20 (74.1%) NC=33 (89.2%) p = 0.179	NA=23 (85.2%) NC=32 (86.5%) p = 1.000	NA=16 (59.3%) NC=29 (78.4%) p = 0.165	NA= 7 (25.9%) NC=33 (89.2%) p < 0.001	NA= 6 (22.2%) NC= 33 (89.2%) p < 0.001
A & D	NA=20 (74.1%) ND=22 (91.7%) p =0.147	NA=23 (85.2%) ND= 23 (95.8%) p = 0.354	NA= 16 (59.3%) ND= 19 (79.2%) p = 0.145	NA= 7 (25.9%) ND= 22 (91.7%) p <0.001	N_A= 6 (22.2%) N_D= 20 (83.3%) p <0.001
B & C	NB=29 (96.7%) NC=33 (89.2%) p = 0.370	NB=29 (96.7%) NC=32 (86.5%) p =0.213	NB=23 (76.7%) NC=29 (78.4%) p =0.199	NB= 21 (70.0%) NC=33 (89.2%) p =0.065	NB=21 (70.0%) NC=33 (89.2%) p =0.065

B & D	NB=29 (96.7%) ND=22 (91.7%) p =0.087	NB=29 (96.7%) ND=23 (95.8%) p =1.000	NB=23 (76.7%) ND=19 (79.2%) p =1.000	NB=21 (70.0%) ND=22 (91.7%) p =0.087	NB=21 (70.0%) ND=20 (83.3%) p =0.343
C & D	NC=33 (89.2%) ND=22 (91.7%) p =1.000	NC=32 (86.5%) ND=23(95.8%) p =0.388	NC=29 (78.4%) ND=19(79.2%) p =1.000	NC=33 (89.2%) ND=22(91.7%) p =1.000	NC=33 (89.2%) ND=20(83.3%) p =0.700

Questionnaire 3:

Questionnaire 3 was applied after the visit and sought to evaluate the affective and cognitive gains. Part of this questionnaire was elaborated as a Likert scale, where the students should assign values between 1 and 5 on a scale ranging from "strongly disagree" to "totally agree". The assertions, relating to visit, were as follows: 1) Piqued my curiosity for some aspect of chemistry or of science in general; 2) Didn't bring novelty; 3) Exceeded my expectations; 4) During the visit was difficult to find the answers to the questionnaire and 5) The exhibition/support of the mediator was clear and helped me find the answers. Table 8 presents the number, percentages of agreement and the statistical comparison between the groups respecting to sentences 1-5. For 1 and 3 sentences, concordance levels were high for all groups. This result reveals the affective and cognitive gains, stimulating curiosity regarding scientific aspects. The assertion 3 reveals that the initial expectations were exceeded for all groups of students.

Similarly, the high agreement level on assertion 5 reveals that the mediation procedure was a motivator and facilitator in the search for answers. Low levels of agreement on sentence 2 pointing in the direction that the visit was able to contribute with new insights to the students. With respect to the assertion 4 it appears that, for students of Group A (younger), it was more difficult to find the answers to the questionnaire 2. In the student´s words:

A7: "I liked most the story about Antarctica, I found it very interesting because I have never imagined that a forest could be whole frozen and end without vegetation.

A8: "What else piqued my attention was the opportunity to see things that I usually have access only through books."

Table 8: Comparison between the answers of the questionnaire 3. N_I (I = A, B, C or D) is the number of answers 4 and 5 on a scale of 1 to "totally disagree"; 2 to "Disagree in Part"; 3 to "Have no opinion"; 4 to "Agree in Part" and 5 for "Totally agree" in Group I of students. Assertions are described in the text.

Groups	Assertions (questionnaire 3)				
	1	2	3	4	5
A & B	NA=19 (70.4%) NB= 27 (90.0%) p = 0.093	NA=3 (11.1%) NB=0 (0.0%) p =0.100	NA=22 (81.4%) NB=25 (83.3%) p =1.000	NA=9 (33.3%) NB=5 (16.7%) p =0.218	NA=23 (85.2%) NB=29 (96.7%) p =0.179
A & C	NA=19 (70.4%) NC=28 (75.7%) p = 0.776	NA=3 (11.1%) NC= 4(10.8%) p =0.100	NA=22 (81.4%) NC=33 (89.2%) p =0.475	NA=9 (33.3%) NC=9 (24.3%) p =0.574	NA=23 (85.2%) NC=34 (91.9%) p =0.443
A & D	NA=19 (70.4%) ND=22 (91.7%) p =0.080	NA=3 (11.1%) ND=2 (8.3%) p =1.00	NA=22 (81.4%) ND=20 (83.3%) p =1.000	NA=9 (33.3%) ND=6 (25.0%) p =0.554	NA=23 (85.2%) ND=23 (95.8%) p =0.354
B & C	NB=27 (90.0%) NC=28 (75.7%) p =0.201	NB=0 (0.0%) NC=4 (10.8%) p =0.122	NB=25 (83.3%) NC=33 (89.2%) p =0.500	NB=5 (16.7%) NC=9 (24.3%) p =0.552	NB=29 (96.7%) NC=34 (91.9%) p =0.622
B & D	NB=27 (90.0%) ND=22 (91.7%) p =1.000	NB=0 (0.0%) ND=2 (8.3%) p =0.498	NB=25 (83.3%) ND=20 (83.3%) p =1.000	NB=5 (16.7%) ND=6 (25.0%) p =0.510	NB=29 (96.7%) ND=23 (95.8%) p =1.000
C & D	NC=28 (75.7%) ND=22 (91.7%) p =0.175	NC=4 (10.8%) ND=2 (8.3%) p =1.000	NC=33 (89.2%) ND=20 (83.3%) p =0.700	NC=9 (24.3%) ND=6 (25.0%) p =1.000	NC=34 (91.9%) ND=23 (95.8%) p =1.000

The results from questionnaires 2 and 3 show that all groups of students got affective and cognitive gains. The factors set out in CLM, and considered in the drafting of mediation visits favored the specificities of the museal environment learning. The personal context was contemplated by contextualization speech mediator relating chemical contents with the daily life of the students. The sociocultural context was awarded to promote interactions among the students and those with the mediator that generated playful and relaxed visits, developing a nice atmosphere, admittedly learning facilitator.

The Museum's physical context (particularly with respect to "Egyptian culture" hall) was more suited to secondary students. In fact, as can be seen in Table 7, significant statistical differences obtained in the questionnaire 2, relating to the Group A (students of 9^{th} year fundamental) with respect to questions 4 and 5. On the other hand, the results obtained in the questionnaire 3 showed no significant differences between the groups with respect to prints with the visit i.e. all groups of students investigated spoke positively regarding impressions concerning the procedure and the dynamics developed in mediation (Table 8). Some possible reasons for this difference in the level of hits of the Group A can be suggested. The first of these relates to the fact that students in this group are not yet familiar with the chemical concepts addressed such as inorganic salt, common names of chemical substances and dehydrating function. Another possible justification appears to analyze the callouts where the answers are found. Figure 1 presents the exhibition texts where are found the answers of questions 3, 4 and 5 of the questionnaire 2.

As can be seen, the text where one find the answers of questions 4 and 5 (Figure 1B) is considerably larger than the text where one find the answer to question 3 (Figure 1A). In view of the serious deficiencies with respect to reading and text interpretation presented by the students at the end of the fundamental level (Giambiagi, 2004; Teixeira, 2009), this significant difference in the level of hits of questionnaire 2, can be attributed also to the difficulty of reading presented by these students. Probably a conjunction between these two factors, the lack of chemical concepts and the difficulty in text reading and interpretation, were responsible for the result.

A

B

Figure 1. Callouts where the answers of questions 3 (Figure 1A) and questions 4 and 5 (Figure 1B) could be found. Approximate dimensions: Figure 1A: 40 x 50 cm; Figure 1B: 150 x 100 cm.

CONCLUSIONS

In view of the results presented, the following conclusions can be stated: (i) the procedure and the dynamics developed during the visits were able to provide affective and cognitive gains to the students; (ii) the lowest index of hits among pupils of 9th year of elementary school may be related to the fact that these students aren't yet familiar with chemical concepts discussed and also the difficulties in reading and interpretation of the callouts revealed during the visit; (iii) the National Museum, as an informal setting for Chemistry teaching, reveals itself as a promising option able to alleviate, at least in part, structural deficiencies presented in public schools; (iv) the National Museum's physical context favors the development of informal classes in chemistry, especially for secondary level students.

BIBLIOGRAPHY

Association for Science Education (2011); *Outdoor science: A coordinated approach to high-quality teaching and learning in fieldwork for science education*. Retrieved from http://www.ase.org.uk/documents/ases-oswg-report/

Brasil. Ministério da Educação, Secretaria da Educação Média e Tecnológica. *Parâmetros Curriculares Nacionais: ensino médio*. Brasília: 1999.

Brasil. Ministério da Educação, Secretaria da Educação Média e Tecnológica. *Orientações curriculares para o ensino médio: Ciências da natureza, matemática e suas tecnologias.* Brasília: 2006.

Davids, M., Chikte, U., Grimmer-Somers, K., Halperin, M., Usability testing of a mutimedia e-learning resource for electrolyte and acid-base disorders, *British Journal of Educational Technology* 45, [2], 367-381, 2014.

Falcão, D., Alves, F., Krapas, S., Colinvaux, D., Museus de Ciências, Aprendizagem e Modelos Mentais: Identificando Relações. In: Gouvêa, G.; Marandino, M.; Leal, M. (orgs.). *Educação e Museus: A Construção Social do Caráter Educativo dos Museus de Ciências.* Rio de Janeiro: FAPERJ Ed., 2003, p.185-206.

Falk, J., Storksdieck, M., Learning Science from museums, *História, Ciência e Saúde, Rio de Janeiro,* 12(supl.), 117-198, 2005.

Giambiagi, F., Reis, J., Urani, A. (Org.), *Reformas no Brasil: Balanço e Agenda*, Ed. Nova Fronteira, Rio de Janeiro, 2004, p. 481-504.

Griffin, J., Research on Students and Museums; Looking More Closely at the Students in School Groups. *Science Education*, 88, S1, S59-S70, 2004.

Krapas, S., Rebello, L., O perfil dos museus de ciências da cidade do Rio de Janeiro: a perspectiva dos profissionais. *Revista Brasileira de Pesquisa em Educação em Ciências*, 1, 68-87, 2001.

Marandino, M., Enfoques de Educação e comunicação nas bioexposições de museus de ciências, *Revista Brasileira de Pesquisa em Educação em Ciências,* 3, [1], 103-120, 2003.

Marandino, M., Museus de Ciências, Coleções e Educação: relações necessárias. *Museologia e Patrimônio,* 2, 1-12, 2009.

McGrow, J., Beattie, E., Sullivan, K., Fick, D., Development and review of vignettes representing older people with cognitive impairment, *Geriatric Nursing* 34, 128-137, 2013.

Mellanby, J., Zimdars,A., Cortina-Borja, M., Sex differences in degree performance at the Oxford University, *Learning Individual Differences* 26, 103-111, 2013.

Moreira, I., A Inclusão social e a popularização da ciência e tecnologia no Brasil, *Inclusão Social* 1, 11-16, 2006.

Navas, A. M., Marandino, M., La popularización de la ciencia y la tecnología na América Latina. El caso de Brasil. *Ciencias – revista de difusión de la facultad de ciencias de la UNAM.* 96, 52-60, 2009.

Oliveira, G.C. *et al.,* Social inclusion through access to heritage, culture and education in an informal environment. *Field Actions Science Reports,* v. 3, p. 1-9, 2013.

Orlik, Y. *et al*., *Popularización da la ciencia y la tecnología y su incorporatíon en la escuela de los países del Convenio Andrés Bello.* Bogotá, SECAB, 2007, p. 48-72.

Queiróz, G. *et al*., Construindo saberes da mediação na educação em museus de ciências: o caso dos mediadores do museu de astronomia e ciências afins, *Revista Brasileira de Pesquisa em Educação em Ciências* 2, 77-88, 2002.

Scior, K., Bradley, C., Potts, H., Woolf, K., Williams, A., What predicts performance during clinical psychology training? *British Journal of Clinical Psychology* 1-19, 2013.

Siegel, S., Castellan, N., *Estatística Não Paramétrica para Ciências do Comportamento*, Porto Alegre, Artmed, 2006, p. 125-135.

Taylor, E.; Neill, A., Museum Education: A Nonformal Perspective, *Journal of Museum Education,* Chicago, 33, [1], 23–32, 2008.

Teixeira, R., Espaços, recursos escolares e habilidades de leitura de estudantes da rede pública municipal do Rio de Janeiro, *Revista Brasileira de Educação,* 14, [41], 232-245, 2009.

Spencer, J., Sally M., Teacher Education in Informal Settings: A Key Element of Teacher Training, *Journal of Museum Education,* 39, [1], 54-66, 2014.

Received 28-02-2014 /Approved 02 -05- 2015

Inquiry based experimental applications in the chemistry laboratory

Aplicaciones basadas en la indagación en el laboratorio de química

[1] Hatice Güngör Seyhan, [2] Inci Morgil

[1] Cumhuriyet University, Sivas, [2] Hacettepe University, Ankara, Turkey, hgunsey@gmail.com

Abstract

In the study, pre-service chemistry students' performance that appears after applications in which they developed inquiry based chemistry experiments has been examined. Also examined was whether inquiry based experimental applications in chemistry laboratory have an effect on student's logical thinking skills, scientific process skills, and attitudes towards chemistry laboratory and anxieties towards chemistry laboratory. A semi-experimental design was used. 42 pre-service chemistry teachers attended the study. In the research, quantitative data obtained from tests and scales administered to students have been supported by qualitative data obtained from student interviews. Multiple regression analysis has showed that 62% of the changes in students' performance in inquiry-based experimental applications were predicted by their logical thinking skills, scientific process skills, attitudes towards chemistry laboratory and anxieties towards chemistry laboratory. Finally unstructured interviews with students about inquiry based experimental applications in the chemistry laboratory were conducted.

Key words: *chemistry laboratory, inquiry based chemistry laboratory, logical thinking skill, scientific process skill.*

Resumen

En este estudio es examinado el rendimiento de los estudiantes de licenciatura de química después de desarrollar aplicaciones basadas en la indagación de experimentos químicos. Además, se ha examinado si las aplicaciones experimentales tienen efecto en el desarrollo de las habilidades lógicas de pensamiento, habilidades científicas y las actitudes experimentales. Se utilizó un diseño semi-experimental, con la participación en este estudio de 42 estudiantes de licenciatura. Los datos cualitativos fueron recogidos a través de entrevistas con los alumnos. El análisis de regresión múltiple ha demostrado que 62% de los cambios en el rendimiento de los alumnos en aplicaciones experimentales de indagación fueron alcanzados con base en sus habilidades lógicas de pensamiento, habilidades científicas, y actitudes hacia el laboratorio de química. A los estudiantes también se les aplico entrevistas no estructuradas.

Palabras clave: *laboratorio de química, laboratorio de química basado en la indagación, habilidad lógica de pensamiento, habilidades científicas.*

INTRODUCTION

The inquiry-based teaching approach is supported on knowledge about the learning process that has emerged from research (Bransford, Brown, & Cocking, 2000; Cited by Abdi, 2014). The characteristics of inquiry-based learning are: (a) developing logical questions about students' experiences, (b) using investigation to evaluate ideas and thoughts critically, (c) using a knowledge construction process, and (d) learning science by actually engaging in it (Hume & Coll, 2010; Cited by Furtak et al., 2012). Inquiry includes also some abilities for students such as identifying questions, designing and conducting scientific investigations, formulating and revising scientific explanations, recognizing and analyzing alternative explanations, and communicating and defending scientific arguments. In addition, according to some researcher, inquiry teaching and learning poses a challenge to both teachers and students (Kracjik, Mamlok & Hug, 2000; Cited by Qinga, Jing & Yan, 2010). According to Duschl and Grandy (2008), "Teachers need to develop a shared common understanding about science inquiry teaching and learning. Without this shared understanding of scientific inquiry, teachers are unlikely to develop and enact inquiry lessons suggested by educational reform".

The inquiry-based approach provides students with an opportunity to practice how scientists really do science and to deeply understand key concepts in chemistry (Green, Elliott & Cummins, 2004; Cited by Supasorn, 2012). Inquiry experiments are thought to be an effective approach in a learning chemistry laboratory (Sanger, 2009). Inquiry experiments have more advantages than traditional experiments. These advantages provide some opportunities for students, for example, to be engaged with these experiments improves higher-order cognitive skills including analytical and critical thinking skills of students (Deters, 2005; Cited by Supasorn, 2012).

Inquiry-based learning in laboratories has been studied in various fields from chemistry (Hinde & Kovac, 2001, Hofstein, Nahum & Shore, 2001; Hofstein & Lunetta, 2003; Hofstein, 2004; Hofstein, Shore & Kipnis, 2004; Hofstein et al., 2005), to botany (Silvius & Stutzman, 1999) or applied physiology (DiPasquale, Mason & Kolkhorst, 2003). Research on effectiveness of inquiry based learning on students' learning, indicated improvement in students' understandings (Wu & Krajcik, 2006; Fortus, et al. 2004; Marx, et al. 2004; Wallace, Tsoi, Calkin, & Darley, 2003) and in their process skills (Wu & Hsieh, 2006; Tatar, 2006; Sullivan, 2008).

PURPOSE OF THE RESEARCH

In this study, 42 pre-service chemistry teachers participated to the applications and it was aimed to; i) identify their opinions obtained during brainstorming activities on "inquiry-based learning approach" performed before and after the applications, ii) determine their performances following the inquiry-based experimental applications, and iii) to find out whether their performances could be predicted by scientific process skill (SPS), logical thinking skill (LTS), attitude towards the chemistry laboratory (ATCL) and anxiety towards the chemistry laboratory (ACL) variables.

Methodology of the Research

In the study, one group post test model was used. The study was conducted by a single group due to the limitations of the number of students enrolled in the course (the study has been conducted within the context of the course: "Chemistry Experiments in Secondary Education" and the aforementioned model was preferred during the study.

Sampling

A total of forty-two student teachers studying at Hacettepe University, Faculty of Education, Department of Chemistry Education.

Data Collection Tools

Logical thinking skills test (LTST)

The test (LTST) was developed with the aim of determining students' logical thinking skills initially by Tobin and Copie (1981). It was adapted and translated into Turkish by Geban et al., (1992). The reliability coefficient of the test is 0,77.

Scientific process skills test (SPST)

Scientific process skills test (SPST) was originally developed by Okey et al. (1982). It was translated into Turkish and adapted by Geban et al. (1992). The validity of the test is rather high and its reliability is calculated as 0,82 (KR 21).

Scale of attitude towards chemistry laboratory (SATCL)

In order to determine students' attitudes towards chemistry laboratory, the Scale of Attitude towards Chemistry Laboratory (SATCL) of 18 statements was used. The reliability of these three sub dimensions was calculated via Cronbach-alpha and the results for each sub dimension were as follows: ideal laboratory environment, 0.83; interest in chemistry laboratory, 0.85; and advantages of chemistry laboratory, 0.69; whereas the total value calculated was 0.89 (Güngör Seyhan, 2008).

Scale of anxiety towards chemistry laboratory (SACL)

In order to assess students' anxiety levels towards chemistry laboratory, the Scale of Anxiety towards Chemistry Laboratory (SACL) developed by Bowen (1999) was utilized. The scale was adapted and translated into Turkish by Azizoglu and Uzuntiryaki (2006). The reliability of the scale was calculated for each dimension as follows: utilization of laboratory equipment and chemical substances 0.88, working with other students 0.87, data collection 0.86, and making effective use of time at the laboratory 0.87.

Teacher observation form (TOF)

Inquiry-based experimental applications require different evaluation methods (Hofstein, Shore & Kipnis, 2004). Teacher observation form (TOF) is a form, through which the researcher evaluates students of the group individually before and during the inquiry phase (Mamlok-Naaman et al., http://www.cpdthroughpoe.com/index.html).

Evaluation form for inquiry-based experimental application performance (EFIBEAP)

For the inquiry-based implementations in chemistry education, the evaluation form for inquiry-based experimental application performance (EFIBEAP) was used as an assessment tool. This form consists of two sections, first of which involved the addition of results obtained from the teacher observation form to scoring (Hofstein, Shore & Kipnis, 2004). The second part is the section where "experiment reports" including all phases of inquiry prepared individually by all members of the groups.

Teaching Process

At the beginning of the study, a pre test study was conducted with LTS, SPS, ATCL and ACL, which were thought to be effective on the inquiry-based experimental application performance in the chemistry laboratory. Following the pre tests, a brainstorming activity was conducted with students on "inquiry-based learning approach" as the topic of the study. All data collected from students were summarized on a logic map by the researcher and was named as the 1st Logic Map. The applications following the brainstorming activity were as follows: students were asked to form groups of three or four to prepare 3 experiment proposals on chemistry topics (corrosion of metals, electrochemistry, endo-exothermic reactions etc.) within a period of 15 days at the initial preparation phase of the inquiry-based chemistry experiments. Next, one of the experiments was chosen among the proposal in terms of its availability in the existing chemistry laboratory environmental conditions. At the second phase of the study, each group was requested to perform their experiment during the "Chemistry Experiments in Secondary Education" class for their peers. This phase formed the pre-inquiry phase of the applications. Later on came the inquiry phase. Students discussed the phases such as asking questions about experiments made, constructing hypotheses, choosing a question for further phases, proposing solution methods for the chosen inquiry question, planning an experiment, analyzing findings and reaching conclusions (Hofstein et al., 2004). The quality and quantity of all questions produced by groups relevant to the experiments they performed were checked and limited by the researcher. In order to validate their hypotheses students chose one of the solutions they had suggested and proposed an experiment to be performed. After the equipment and materials for the proposed experiment were obtained, they relocated to the chemistry laboratory to perform their experiments under the supervision of the researcher. The findings and conclusions of the experiments validating the hypothesis established by the members of the group were accepted as the indicators of successful completion of the application. In cases where the results and findings were not supportive of the hypotheses, the group members were expected to review their methods of solution proposed for the question of inquiry. In this phase, groups designed an experiment for a new method of solution, which was later, performed at the chemistry laboratory and the results wee checked by the researcher. At all phases of the study, the researcher observed the students and recorded the observations on the TOF. The researcher then requested the students to prepare individual experiment reports, which involved all phases of verbal discussions and experiments performed. The reports were evaluated by the researcher using the EFIBEAP (Hofstein, Shore & Kipnis, 2004). At the end of the study, the LTST, SPST, SATCL and SACL, which were administered to students as pretests, were repeated as posttests. The 1st Logic Map, which was prepared by the researcher as a result of the brainstorming activity at the beginning of the study, was distributed to participating students and they were asked to report misconceptions or mistakes they recognized in writing or via e-mail to the researcher. The revised version of the logic map, which involved the corrections or additions requested by the students to be made, was prepared by the researcher and it was named as the 2nd Logic Map. Students were handed out the 2nd Logic Map, which enabled them to acquire accurate and sufficient knowledge about "inquiry-based learning approach".

RESULTS OF THE RESEARCH

Results of the brainstorming activity

Students expressed their opinions in activity independently in writing or on concept or logic maps. The opinions collected from students were summarized on a logic map by the researcher and named as the "1st Logic Map". Figure 1 displays the 1st Logic Map involving students' opinions on the topic.

The 1st Logic Map was distributed to students following the applications lasted for a period of 12 weeks, which enabled to reveal the missing, insufficient or inaccurate knowledge students had and provided students with the opportunity to think on the topic in more detail. The revised opinions of students were submitted to the researcher again in writing or via concept/logic maps, certain examples of which are listed below:

Student 2: Inquiry-based learning is a student-centered approach. In this approach, students participate actively in class. Students ask the questions and find the answers through research. Their self-confidence is developed. They know how to use their time effectively.

Students 21: I think scientific process skills would develop in students within inquiry-based learning. Scientific process skills such as Making observations, classifying, making connections among topics, performing required measurements, making assumptions and reaching outcomes are among skills that students could attain within the inquiry-based learning approach.

The 1st Logic Map was revised according to such opinions obtained from students and the 2nd Logic Map was created. The 2nd Logic Map involving students' appreciated opinions on the topic are displayed in Figure 2.

Results related to the performances of pre-service teachers obtained from the inquiry-based experimental applications in the chemistry laboratory

All phases of the inquiry-based experimental applications in the chemistry laboratory were observed by the researchers. The TOF and EFIBEAP were filled in for each pre-service teacher. This EFIBEAP form consists of two sections, first of which involved the addition of results obtained from the teacher observation form to scoring (Hofstein, Shore & Kipnis, 2004). The second part is the section where "experiment reports" including all phases of inquiry prepared individually by all members of the groups. The aforementioned form involves criteria belonging to the final inquiry phase and the theoretical phase of the inquiry. Researchers calculated the total score obtained from the TOF and EFIBEAP for each group member, and a "Performance Score" was obtained for each pre-service teacher. It was found that the lowest performance score for pre-service teachers was 68, while the highest one was 93. Average performance score of pre-service teachers was found to be $X_{avr} = 79$. According to this average, it is assumed that the pre-service teachers performed well.

The statistical analysis of the LTST, SPST, SATCL and SACL pre and post test results

In comparing pre and post test results, t-test was made use of for the dependent groups. The results are displayed on Table 1.

Table 1. Results of paired samples t-test in comparing LTS, SPS, ATCL

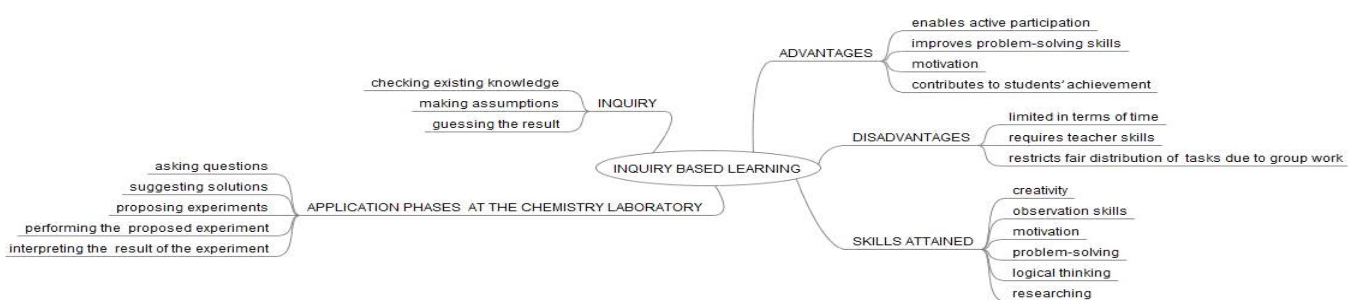


Figure 1. The 1st Logic Map prepared prior to the chemistry experiments performed according to the inquiry based learning approach

Figure 2. The 2nd Logic Map prepared after the chemistry experiments performed according to inquiry-based approach.

and ACL pre and post test results

		N	x	s	T	Sig.
LTS	Pre test	42	5,262	2,012	- 5,990	0,000
	Post test		7,164	1,308		
SPS	Pre test	42	21,262	4,633	- 8,384	0,000
	Post test		25,476	3,528		
ATCL	Pre test	42	3,841	0,606	- 3,110	0,003
	Post test		4,170	0,266		
ACL	Pre test	42	2,750	0,354	3,995	0,000
	Post test		2,548	0,380		

According to the analysis made, the logical thinking skills, scientific process skills and their attitudes towards chemistry were observed to have improved significantly. Students' anxiety towards chemistry was found to be subject to a slight decrease after the study was completed (Sig.<0,05).

Statistical analysis of the results obtained from the LTST, SPST, SATCL and SACL

In order to examine the extent, to which the overall pre and posttest results of the participating students at the LTST, SPST, SATCL and SACL, a multiple linear regression analysis was made. The results showed that the LTST, SPST, SATCL and SACL variables together explained 62% of the total variance, while the remaining 38% is explained by the variables excluded in the model due to error terms. The F= 15,057 value shows that our model is significant at all levels as a whole (R= ,787; R2= ,619; F=15,057; Sig.< ,05).

Table 2. The results of multiple linear regression analysis between LTST, SPST, SATCL and SACL and the performances of students

Model	R	R Square	Adjusted R Square
1	,787a	,619	,578

[a]Predictors: (Constant) LTS, SPS, ATCL, ACL post test

Anova[b]

Model	Sum of squares	df	Mean square	F	Sig.
1 Regression	1490,679	4	372,670	15,057	,000a
Residual	915,797	37	24,751		
Total	2406,476	41			

[a]Predictors: (Constant)) LTS, SPS, ATCL, ACL post test
[b]Dependent variable: Student performance

Coefficients[a]

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
1	B	Std. Error	Beta		
(Constant)	6,000	19,458		,308	,760
LTST	2,396	1,175	,409	2,040	,049
SPST	,120	,237	,355	2,008	,048
SATCL	11,481	5,656	,399	2,030	,050
SACL	,857	2,159	,043	,397	,694

[a]Dependent variable: Student performance

According to the standardized regression coefficient (Beta), the comparative importance sequences of the predictor variables over student performance are as follows: LTS, ATCL, SPS, ACL. The t-test results displayed that LTS, SPS and ATCL were significant predictors on the performance. ACL variable does not have a significant affect. According to regression analysis results, the regression equality regarding the prediction of student performance (the mathematical model) is as follows:

Student performance = 6.000 + 2.396 LTS + 0.120 SPS + 11.481 ATCL + 0.857 ACL

While 62% of the variance in the student performance experienced by the participating students was explained by the independent variables included in the model, with the aim of understanding the relationship between the independent variables and the direction of this relationship the correlation coefficient is calculated. Chart 3 displays the correlation results.

Table 3. The results of correlation analysis between LTST, SPST, SATCL and SACL

		LTST	SPST	SATCL	SACL
LTST	Pearson correlation	1	,363*	,856**	- ,308*
	Sig. (2-tailed)	,	,018	,000	,047
	N	42	42	42	42
SPST	Pearson correlation	,363*	1	,311*	- ,158
	Sig. (2-tailed)	,018	,	,045	,318
	N	42	42	42	42
SATCL	Pearson correlation	,856**	,311*	1	- ,306*
	Sig. (2-tailed)	,000	,045	,	,049
	N	42	42	42	42
SACL	Pearson correlation	- ,308*	- ,158	- ,306*	1
	Sig. (2-tailed)	,047	,318	,49	,
	N	42	42	42	42

* Correlation is significant at the 0,05 level (2-tailed).
** Correlation is significant at the 0,01 level (2-tailed).

Looking at Table 3 for the correlation analysis results, 1% correlation was observed between ATCL and LTS, which leads to a significant relationship at the high level of 0,856 on the positive direction the correlation coefficient calculated for the SPS and LTS was the 5% importance level between 0.70–0.30 and this led to a medium level relationship (0,363), similar to the medium level relationship observed between SPS and ATCL (0,311). According to this result, the highest correlation is between the LTS and ATCL variables. On the other hand, a relationship on the negative direction was observed between ACL, LTS, SPS and ATCL variables with a low correlation coefficient (between LTST-SACL: -0,308; between SATCL-SACL: -,306 and between SPST-SACL: -,158).

DISCUSSION

To analyze the results of the study in terms of students' logical thinking skills (LTS), various findings in the literature have been considered. Within the study, a significant improvement was observed in logical thinking skills of students participating in the study after the applications. Logical thinking skills of students, who participated in the aforementioned applications, were observed to have important effects on their performances. This finding is parallel to the previous research findings (Crawford, 2000). According to results obtained from participating students, the scientific process skills increased statistically and significantly and it was observed that scientific process skills were effective on students' performances. This finding is parallel to the previous research findings (Stout, 2001; Beishuizen et al., 2004; Tatar, 2006; Wu & Hsieh, 2006; Sullivan, 2008; Wang & Wen, 2010). A statistically significant improvement in students' attitudes towards chemistry laboratory (ATCL) was observed in participating students in the study. Additionally, students' attitudes towards chemistry laboratory would have statistically significant contributions to student performances. Various studies in the literature reported that students interacting with inquiry-based learning activities developed more positive attitudes towards science (Russell & French, 2001; Booth, 2001; Von Secker, 2002; Alouf & Bentley, 2003; Berg, Bergendahl & Lundberg, 2003; Hofstein & Lunetta, 2003; DiPasquale, Mason & Kolkhorst, 2003; Kipnis and Hofstein, 2007; Smart & Csapo, 2007). Following the inquiry-based chemistry experiment, students' anxiety towards chemistry laboratories (ACL) was observed to decrease. However, the anxiety towards chemistry laboratory was not found to be effective on students' performances within the concept of our study. During inquiry-based activities, students feel themselves more involved in this learning process and present more positive attitudes towards laboratory experiences. Some educators reported that such activities provided students with opportunities to develop independent thinking, perceiving chemical concepts and enjoy cooperative learning environments (Hofstein, Nahum & Shore, 2001; Abd-El-Khalick et al., 2004).

As a result, the study showed that following the inquiry-based activities, the anxiety towards chemistry laboratories (ACL) decreased while logical thinking skills (LTS), scientific process skills (SPS) and attitudes towards chemistry laboratory (ATCL) of students improved. Looking at the application phases of each group in terms of their inquiry-based chemistry experiment applications, all group members were observed to work in total cooperation. All members of the group worked in teams during the performance of the initial experiment according to given directions at the pre-inquiry phase and did not experience any interaction problems. At the inquiry phase of the applications, certain differences between groups emerged. Inquiry-phase involves certain activities where relevant questions are asked, a question of inquiry for research is selected, a hypothesis is constructed over this question, suggestions for solutions on this hypothesis are given, an experiment is planned to reach the required conclusion and the outcomes are interpreted. The intergroup differences were mostly observed at the activities where the relevant questions were asked and an experiment was suggested for reaching the conclusion. The most striking aspect of this was that some groups asked more quantitative and amount of questions related to inquiry in chemistry laboratories. Groups with the indicated differences were Group 2, Group 3, Group 7, Group 8 and Group 12, in which students asked many questions with quantitative aspects and suggested more than one experiment. Students in these groups suggested experiments, during which they were required to control various variables, and utilize more complex and reliable equipment or tools. The rest of the groups asked rather qualitative questions. Another conclusion of the aforementioned activities was that students with higher scores in LTST and SATCL displayed better performances as a result of the applications. Most of these students were members of the above-mentioned groups. Various studies in the literature reported that students interacting with inquiry-based learning activities developed better performance.

The un-structured interviews were also conducted with students after the experimental applications carried out within the scope of this activity. According to the analysis of the student interviews that when students are asked motivating questions they are motivated to take more responsibilities for further research and are encouraged to discover knowledge related to these questions, they performed better in learning. Students reported that they collected data actively and came to conclusions after performing the analysis and synthesis phases. They mentioned that the experiments were related to the theoretical topics they learnt in their chemistry classes (corrosion, electrochemistry, chemical reactions, acids and bases, etc.). During all applications, students worked in cooperation with their group mates. The researcher-assisted students at all times and motivated them for further research.

CONCLUSIONS

These outcomes obtained from student interviews showed that the inquiry-based learning environment improved students' learning experiences. This conclusion is in line with the findings of some other research (Krajcik et al., 2001; Paris & Paris, 2001; Patrick & Middleton, 2002; Perry, et al., 2002; Chang, Sung & Lee, 2003).

BIBLIOGRAPHY

Abdi, A., The effect of inquiry-based learning method on students' academic achievement in science course, *Universal Journal of Educational Research*, **2**[1], 37-41, 2014.

Alouf, L.J., &. Bentley, M.L. *Assessing the impact of inquiry-based science teaching in professional development activities*, PK-12, Paper Presented at the Annual Meeting of the Association of Teacher Educators, 2003 Februrary 17, Jacksonville, FL.

Azizoglu, N. & Uzuntiryaki, E., The anxiety scale towards chemistry laboratory, Hacettepe University Journal of Education, 30, 55-62. 2006

Berg, C.A.R., Bergendahl, V.C.B., & Lundberg, B.K.S., Benefiting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an exposititory versus an open-inquiry version of the same experiment, *International Journal of Science Education*, **25** [3], 351-372, 2003.

Booth, G., Is inquiry the answer?, *Science Teacher*, **68** [7], 57-59, 2001.

Bowen, C. W., Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students, *Educational and Psychological Measurement,* **59** [1], 171- 187, 1999.

Chang, K.E., Sung, Y.T. & Lee, C.L., Web-based collaborative inquiry learning, *Journal of Computer Assisted Learning,* **19** [1], 56-69, 2003.

Crawford, B.A., Embracing the essence of inquiry: New roles for science teachers, *Journal of Research in Science Teaching,* **37** [9], 916–937, 2000.

DiPasquale, D.M., Mason, C.L. & Kolkhorst, F.W., Exercise in inquiry: Critical thinking in an inquiry-based exercise physiology laboratory course, *Journal of College in Science Teaching,* **32** [6], 388-393, 2003.

Duschl, R., & Grandy, R. (Eds.). (2008). *Teaching scientific inquiry: Recommendations for research and implementation*. Rotterdam, The Netherlands: SensePublishers.

Furtak, E.M., Seidel, T., Iverson, H. & Briggs, D.C., Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis, *Review of Educational Research*, **82** [3], 300–329, 2012.

Geban, Ö., Askar, P. & Özkan, Í., Effects of computer simulations and problem-solving approaches on high school students, Journal of Educational Research, 86 [1], 5-10, 1992.

Güngör Seyhan, H., *Developing inquiry based student experiments in the chemistry education and discussing results*, Unpublished doctoral dissertation, Institute of Science, Hacettepe University, 2008, Ankara, Turkey.

Hinde, R.J. & Kovac, J., Student active learning methods in physical chemistry, *Journal of Chemical Education,* **78** [1], 93-99, 2001.

Hofstein, A., Nahum, T.L., & Shore, R., Assessment of the learning environment of inquiry-type laboratories in high school chemistry, *Learning Environments Research,* **4** [2], 193–207, 2001.

Hofstein, A. & Lunetta, V.N., The laboratory in science education: Foundation for the 21st century, *Science Education,* **88**, 28-54, 2003.

Hofstein, A., The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research, *CERP,* **5** [3], 247-264, 2004.

Hofstein, A., Shore, R., & Kipnis, M., Providing high school chemistry students with opportunities to develop learning skills in an inquiry-type laboratory - A case study, *International Journal of Science Education,* **26** [1], 47-62, 2004.

Hofstein, A., Navon, O., Kipnis, M., & Naaman-Mamlok, 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.

Qinga, Z., Jing, G. & Yan, W., Promoting preservice teachers' critical thinking skills by inquiry-based chemical experiment, Procedia Social and Behavioral Sciences, **2**, 4597–4603, 2010.

Krajcik, J., Marx, R., Blumenfeld, P., Soloway, E., & Fishman, B., *Inquiry based science supported by technology: Achievement among urban middle school students*, Ann Arbor, MI: University of Michigan, School of Education, 2001, (ERIC Document Reproduction Service No. ED443676).

Mamlok-Naaman, R., Taitelbaum, D., Carmeli, M., & Hofstein, A.*, Inquiry in the chemistry laboratory*: Programme of meetings, Continuing Professional Development through Portfolios of Evidence, Weizmann Institute of Science, [Online Available]: http://www.cpdthroughpoe.com/index.html.

Minner, D. D., Levy, A. J. & Century, J., Inquiry-based science instruction – What is it and does it matter? Results from a research synthesis year 1984 to 2002. *Journal of Research in Science Teaching*, **47**[4]. 474-496, 2010.

Okey J. R, Wise K. C. & Burns J. C., Integrated process skill test-2, (Available from Dr. James R. Okey, Depertmant of Science Education, University of Georgia, 1992, Athens, GA 30362).

Paris, S.G., & Paris, A.H., Classroom applications of research on self-regulated learning, *Educational Psychologist,* **36***,* 89–101, 2001.

Patrick, H. & Middleton, M.J., Turning the kaleidoscope: What we see when self-regulated learning is viewed with a qualitative lens, *Educational Psychologist,* **37**, 27–39, 2002.

Perry, N.P., Van de Kamp, K.O., Mercer, L.K., & Nordby, C.N., Investigating teacher-student interactions that foster self-regulated learning, *Educational Psychologist,* **37**, 5–15, 2002.

Supasorn, S., Enhancing undergraduates' conceptual understanding of organic acid-base-neutral extraction using inquiry-based experiments, *Procedia - Social and Behavioral Sciences***,** **46**, 4643 – 4650, 2012.

Tobin, K. & Copie, W., Test of logical thinking, *Educational and Psychological Measurement,* **41**, 413-424, 1981.

Von Secker, C., Effects of inquiry-based teacher practices on science excellence and equate, *Journal of Educational Research,* **95** [3], 151-160, 2002.

APPENDIX I

The application process experienced by Group 7 students participating in inquiry-based chemistry experiment applications:

Group 7

Student 18, Student 19 and Student 20

PRE-INQUIRY PHASE

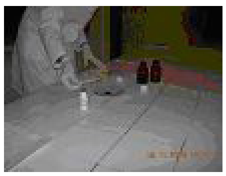
Initial experiment: A piece of cotton immersed in ethyl alcohol inflaming without using any matches due to the utilization of sulfuric acid potassium permanganate

Required tools and equipment for the initial experiment:

Potassium permanganate ($KMnO_4$), [5 g]; Sulfuric acid (H_2SO_4), [2-3 drops]; Ethyl alcohol (C_2H_5OH); Cotton, paper, watch glass and tongs

Experiment Procedures:

5g $KMnO_4$ is placed on the watch glass; (2) 2-3 drops of concentrated H_2SO_4 is added; (3) The piece of cotton is immersed in alcohol; (4) The piece of cotton is held with the tongs and is rubbed against $KMnO_4$ and H_2SO_4 and (5) The piece of cotton with alcohol is inflamed.


Result of the experiment and comments:

There will be release sparks and of oxygen at the first reaction that occurs between sulfuric acid and potassium permanganate. The released oxygen allows the inflaming of ethyl alcohol. When the piece of cotton with ethyl alcohol is rubbed against the mixture of sulfuric acid and potassium permanganate, the inflaming occurs and burns the piece of cotton. Potassium permanganate is a strong oxidizer. Sulfuric acid is used to create the acidic environment. Because potassium permanganate could be reduced from +7 to +2 and similarly from +7 to +4. The value, to which the permanganate is going to be reduced, could be determined by the acidic environment.

INQUIRY PHASE

Producing questions

1. What kind of a reaction occurred between the potassium permanganate and the sulfuric acid during the experiment? **2.** What is the reason for the inflaming of the piece of cotton with ethyl alcohol and the due to the reactions in potassium permanganate-sulfuric acid mixture? **3.** What is the reason for using sulfuric acid in the experiment? **4.** How does the exchange of energy between the environment and the system during chemical reactions occur? **5.** How are chemical transformations related to energy change? **6.** What is chemical energy? **7.** Why are some reactions endothermic or exothermic in terms of bond formation and bond breaking?

Selected question of inquiry

How could we determine that the oxygen and nitrogen gases that exist in the air and do not react with each other produce nitrogen dioxide gas through its reaction due to lightning, while certain reactions in the environment we see, experience, perform or observe require temperature?

Producing sub questions related to the selected question of inquiry

1. If we put some quick-lime in a beaker filled with water, a high degree of temperature is released.

2. Is this a consequence of degradation? If we put another soluble (such as salt) in water, would the temperature be released again? What is the reason for the difference in temperature?

3. The exothermic reaction occurs when oxygen receives 1 electron; however, why does the endothermic reaction occur when the O^{-1} ion receives another electron? In other words, while an oxygen atom releases heat when it receives and electron, why does it require heat from outside in receiving another electron?

4. Oxidation-reduction / neutralization / fusion reactions / dissolution of gases in water / oxidation events / all combustion events / chemical bond formation: which of these could be an example of an endothermic or exothermic reaction?

5. If the temperature of a reaction that either releases or requires heat is measurable at the laboratory environment, will it be possible to determine whether the reaction is endothermic or exothermic by measuring the temperature before and after the reaction?

Establishing a hypothesis on the selected question of inquiry

It is possible to determine whether a reaction is exothermic or endothermic by making use of the change in the reaction temperature through measurement of the temperature before and after the reaction in a chemical reaction.

Proposing solutions to validate the hypothesis

1. Determining whether a reaction is endothermic or exothermic by measuring to what extent the heat released after the reaction changed the reaction environment and outside temperature using a calorimeter container
2. Determining whether a reaction is endothermic or exothermic by measuring the temperature before and after the reaction at constant pressure.

Experiment Proposal:

Determining whether certain reactions are endothermic or exothermic

Experiment Tools and Equipment:

Sodium hydroxide solution, Diluted hydrochloric acid solution, Sodium hydrogen carbonate solution, Citric acid, Copper (II) sulfate solution, Diluted sulfuric acid solution, Magnesium powder and Beaker, thermometer and baguette

Experiment Procedure:

(1)Put some sodium hydroxide in a test tube and put the same volume of hydrochloric acid solution in another test tube; (2) Measure their temperatures separately via a thermometer; (3) Pour the acid solution into the sodium hydroxide solution slowly. Measure the temperature of the mixture via thermometer and (4) Compare the temperatures of the solutions before and after mixing.

The same procedure shall be followed for the following:

(a)Sodium hydrogen carbonate solution and citric acid; (b) Copper (II) sulfate solution and magnesium powder and (c) Dissolution of impure sodium hydroxide (NaOH + water)

The result and interpretation of the experiment:

Reaction: Pre-reaction temperature/Post-reaction temperature

Sodium hydroxide solution + dilute hydrochloric acid solution

$NaOH + HCl \rightarrow NaCl + H_2O$

All acid-base reactions, meaning all neutralization reactions are exothermic.20˚C/22˚C

Sodium hydrogen carbonate solution + citric acid

$3NaHCO_{3(s)} + H_3C_6H_5O_{7(aq)} \rightarrow Na_3C_6H_5O_{7(aq)} + 3H_2O + 3CO_{2\ (g)}$

When Sodium hydrogen carbonate is in reaction with the citric acid into the reaction, CO_2 gas is released.20˚/C21˚C

Copper (II) sulfate solution + magnesium powder

In that, reaction magnesium is a more active metal than copper. Therefore, if we put magnesium into copper sulfate solution, magnesium will replace the copper in the solution and the heat will be released. Copper sulfate solution is blue in color. When we add the magnesium metal as a powder into that, the solution is observed to become transparent and the copper pieces formed precipitation at the bottom of the solution. The measured temperature value proves that the reaction is exothermic.20˚C/29˚C

$NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

Dissolution of impure sodium hydroxide in water is exothermic.20˚C/21˚C

Validating the hypothesis:

The testing at the end of the application concluded that the results obtained were in coherence with the hypothesis constructed.

Received 11-02-2014 /Approved 02 -05- 2015

Student's scientific abilities improvement by using guided inquiry laboratory
Mejoramiento de habilidades científicas de los estudiantes mediante laboratorio de indagación guiada

MADLAZIM, SUPRIYONO , M.N.R. JAUHARIYAH

Physics Department, Science and Mathematics Faculty, Universitas Negeri Surabaya (UNESA) Indonesia, madlazim@fmipa.unesa.ac.id

Abstract

This article describes a study of student activities in Earth and Space Science (IPBA) laboratory, which were designed to help physics teacher candidates to improve scientific abilities that are valuable in the work place. In these labs students design and conduct their own experiments. This study, we started to study whether the IPBA laboratory can support students not only write as scientists but also be involved in working like scientists while in the laboratory. For example, to represent physical processes in multiple ways; to modify a qualitative explanation; to design an experimental investigation; to collect and analyze data; to evaluate experimental predictions and outcomes, conceptual claims, problem solutions, and models, and to communicate experimental results of seven earth science topics. The students were taught the tsunami, tectonic plate, earth's magnetic field, volcano eruption, climate changes, sun's radiation, and green house's effect topics. In the experimental groups Guided Inquiry Laboratory (GIL) model was used while the Regular Laboratory Activity (RLA) was used in the control class. The experimental class was exposed to GIL for a period of seven weeks. The researchers trained the other lecturer in the GIL before the treatment. Pre-test was administered before the treatment and a post-test after seven weeks treatment. The instrument that was used in the study was Scientific Abilities Performance Evaluation (SAPE) to measure student's scientific abilities. The instrument was pilot tested to assess the reliability. The reliability coefficient was 0.76. Experts assessed their validity before being used for data collection. Data were analyzed using t-test and gain score. Hypotheses were accepted or rejected at significant level of 0.05. Results of the study show that GIL was higher improvement than RLA. The researchers conclude that GIL is an effective strategy, which physics lecturers should be encouraged to implement in physics education programs.

Key words: *scientific ability; guided inquiry laboratory; regular laboratory activity*

Resumen

Este artículo describe un estudio de las actividades de los estudiantes en laboratorio de la Tierra y de Espacio (IPBA) , diseñadas para mejorar las habilidades científicas a candidatos a profesores de física. En estos laboratorios los estudiantes diseñan y llevan a cabo sus propios experimentos y realizan las actividades para representar procesos físicos en múltiples formas; para modificar una explicación cualitativa; para diseñar una investigación experimental; para recopilar y analizar datos; para evaluar las predicciones experimentales y los resultados, reclamaciones conceptuales, soluciones de problemas y modelos, y para comunicar los resultados experimentales de siete temas de ciencias de la tierra. Los tema fueron sobre el tsunami, las placas tectónicas, el campo magnético de la tierra, la erupción del volcán, los cambios climáticos, la radiación del sol, y el efecto inverdadero. En los grupos experimentales se utilizó el modelo de laboratorio de indagación guiado (GIL), mientras que la actividad de laboratorio tradicional (RLA) se utilizó en la clase de control. La clase experimental fue expuesta a GIL por un período de siete semanas. Los investigadores entrenaron a otro profesor sobre el método GIL antes del tratamiento. El Pre-test fue administrado antes del tratamiento y el post-test después de siete semanas de tratamiento. El instrumento que se utilizó en el estudio para medir las habilidades científicas de los estudiantes fue la Evaluación de habilidades cuantificas (SAPE). El coeficiente de confiabilidad fue de 0,76 y los expertos evaluaron su validez antes de ser utilizado para la recolección de datos. El estudio muestra que los resultados del laboratorio experimental GIL fue mejor, comparando con el tradicional RLA. Los resultados muestran que GIL es una estrategia eficaz, que debe ser recomendado para profesores de física en los programas de estudio.

Palabras clave: *capacidad científica; laboratorio de investigación guiada;actividades de laboratorio*

INTRODUTION

Scientific abilities are fundamental in conducting experimental science. Most of students of physics education programs are not familiar with how to conduct experimental science or they may believe that they do not know enough about scientific abilities. Indeed, student' misconceptions and inaccuracies regarding randomization, sample size, and proper controls have been described at the college level (Anderson-Cook and Dorai-Raj, 2001; Hiebert, 2007), at the graduate-level (Zolman, 1999), as well as in professional publishing in life sciences (Festing, 2003). However, by using a inquiry model, students can become engaged in the scientific abilities and, in turn begin to think deeply about experimental science.

Levels of inquiry for science learning and later explicated the associated learning sequences are presented by Wenning (2005, 2010), systematically addressing the various of inquiry levels. These are discovery learning, interactive demonstrations, lessons inquiry, laboratory inquiry, and hypothetical inquiry. Lecturers would help students improve a wider range of intellectual and scientific abilities. Herron (1971) and Wenning (2011) classified the inquiry laboratory in three types based upon degree of sophistication and locus of control; guided inquiry laboratory, bounded inquiry laboratory and free inquiry.

The use of inquiry laboratory is hallmark of outstanding earth and space science lecturers or teachers. Earth and space science lecturers or teachers who use this approach improve within their students an understanding that science is scientific attitude, a product and a process. The students of these lecturers or teachers not only learn the rudimentary knowledge, scientific attitude, skills possessed and employed by scientists, they also learn about the earth and space science (Pyle, 2008). There are many reasons why established earth and science lecturers or teachers fail to teach using laboratory inquiry. Among these reasons is that earth and space science teachers often do not themselves possess a holistic understanding of the scientific process. This in all likelihood stems from the nature of traditional earth and space science teaching and the RLA at the university level that commonly uses a 'teaching by telling' approach.

A GIL is the level of inquiry practice. Inquiry laboratory generally will consist of students more or less independently developing and executing an experimental plan and collecting appropriate data. These data are then analyzed to find a law or a qualitative relationship among variables for the seven topics courses. We used GIL for improving scientific abilities because the topics are very difficult to find precise relationships among variables. Wenning (2011) described that in laboratory inquiry students establish empirical laws based on measurement of experiment variables (work collaboration used to construct more detailed knowledge). This laboratory inquiry approach is not to be confused with the traditional "cookbook" RLA. The distinction between the RLA and true inquiry oriented laboratory is presented on Table 1.

We used scientific abilities definition from Etkina et al. (2006) that consist of six of seven scientific abilities; (1) representing physical processes in multiple ways; (2) modifying a qualitative explanation; (3) designing an experimental investigation; (4) collecting and analyzing data; (5) evaluating experimental predictions and outcomes, conceptual claims, problem solutions, and models, and (6) communicating experimental results. We removed a scientific ability about finding quantitative relationship because the earth and space topics are very difficult to find the quantitative relationship in teaching activity.

In most physics education programs little attention is given to how the processes of inquiry oriented laboratory (GIL) should be taught. It is often assumed that the teacher candidates graduate from the programs of higher learning for understanding how to conduct inquiry laboratory and can effectively pass on appropriate concepts and science abilities to their students. Inquiry oriented laboratory processes, if formally addressed at all, are often treated as an amalgam of non hierarchical activities. There is a critical need to synthesize a framework for more effective promotion

Table 1. Distinction between the Regular Laboratory Activity (RLA) and true inquiry oriented laboratory (GIL).

No.	RLA	GIL
1	are given step-by-step instructions requiring minimum intellectual engagement for the students.	are given questions requiring ongoing intellectual engagement using higher-order thinking skills (HOTS) making for independent thought and action.
2	student's activities is focus for verifying information previously communicated in class.	student's activities is focus for collecting and interpreting data to discover new concepts, principles, or empirical relationships.
3	students execute imposed experimental designs that tell students which variables to hold constant, which to vary, which are independent, and which are dependent.	Students create their own controlled experimental designs; require students to independently identify, distinguish, and control pertinent independent and dependent variables; promote student understanding of the skills and nature of scientific inquiry.
4	rarely allow students to confront and deal with errors, uncertainties, and misconceptions; do not allow students to experience blind alleys or dead ends.	commonly allow for students to learn from their mistakes and missteps; provide time and opportunity for students to make and recover from mistakes.
5	employ procedures that are inconsistent with the nature of scientific endeavor; show the work of science to be an unrealistic linear process.	employ procedures that are more consistent with authentic scientific practice; show the work of science to be recursive and self-correcting.

of inquiry laboratory processes among students at all levels. This article presents possible ways to improve student's scientific ability by using guided inquiry laboratory with examples from earth and space science topic that can help physical science lecturers promote an increasingly more sophisticated understanding of guided inquiry laboratory among their students.

DESIGN AND METHOD

Research design in this study was accorded on ADDIE (**A**nalysis, **D**esign, **D**evelop, **I**mplementation, and **E**valuation) model. The ADDIE model was developed by Royce in 1970 (Sommerville, 1989). It has five phases that is the standard basic model for almost all Instructional Design. It is referenced in several documents proposing standard design processes, such as in (AskERIC, 1999; IEEE, 2001) The five phases are shown in figure 1.

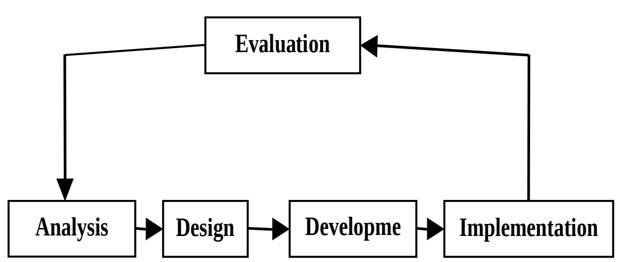


Figure 1. Five phases of ADDIE model.

We used a qualitative approach for **Analysis, Design, Development, Implementation** phases and we used a quantitative approach for the **Evaluation** phase.

Analysis

This step is the description of what is going to be taught the earth science topics and forms the basis of all other steps. In this step, the designer determines the needs and the identifications of scientific abilities, which the learners presently have, and behaviors which they must have or they are expected to have. In other words, a needs analysis is conducted. The system is analyzed and the problem and the roots of the problem are described. The constraints are determined and the possible solutions for the problem are found.

Design

This is the determination process of how the topics are going to be learnt. In this step, a set of specifications for an effective, efficient and relevant learner environment is designed. The development strategy is determined in accordance with the data obtained during the analysis phase and how the objectives will be reached is clarified. In other words, it is where the instruction method, learning activities and evaluation process become clear. During the design process, the tasks are separated into learning steps, thus, the GIL can be implemented in a more accurate and easy way.

Development

All of the components of instructional materials based on GIL development are prepared during this phase. This is the process of producing the instructional material, all the tools which will be used during instruction and any kind of support materials. The instructional materials are created during this phase and an evaluation, which is mostly for correction, is made and modifications are carried out if necessary. The detailed plan prepared during the phases of analysis and the design is implemented and all the components of the learning environment are developed and the environment is prepared for the test.

Implementation

Regardless of whether the end use of the instructional materials will be in the classroom or laboratory, it is necessary to put the instructional materials into practice with the actual learners. The purpose of this part is to introduce the instructional materials in a way that it will be effective and efficient. During this phase, the students should be supported to ensure that they understand the topics and they are aware of the objectives and there should be no doubt that the the topics were being transferred to the learner.

As example for implementing the GIL instructional materials in this paper, we presented only one of the seven topics (tsunami, tectonic plate, earth's magnetic field, volcano eruption, climate changes, sun's radiation, and green house's effect topic). The topic is volcano eruption topic. In the GIL, students were helped to find qualitative relationships among variables using controlled experiments. GIL has five stages of the inquiry levels learning cycle are as follows: *observation, manipulation, generalization, verification and application* (Wenning, 2011). Observation: The lecturer explored with asking students to conduct controlled experiments with volcano topic such that there is only one independent variable and three dependent variables. The lecturer gets students to define variables such as flow velocity of lava (V) and height of location (h), temperature (T), and density of lava (ρ) prior to beginning the next phase. Students then independently design and perform experiments to find qualitative relationships between the velocity of lava (V) and high location (h) in one case, V and temperature (T), V and density (ρ) in the other case. ***Manipulation:*** The lecturer used a jigsaw approach to speed up the process of finding the final form of the empirical law for velocity of lava. The first group of students finds qualitative relationship between V and *h.* The second group finds relationship between *V* and T. The third group finds relationship between *V* and ρ. The students as a group is then are asked to predict the nature of the full qualitative relationship between all variables. There are several possibilities such as sum, product, quotient, and difference. The only relationship that satisfied the experimental findings (how relation V to h, T and ρ) is a product of terms (but 1/ρ). Students are then asked to assume this form of the function and find the values of any constants. By using data already available to them and a *physical interpretation of the data* (knowing that *V* was higher if *h was higher* or *T* was higher or ρ was lower). Testing of predictions based on this relationship would show it to be of the appropriate form. Students conducted controlled all variables of experiments, in the first, change one variable at same time while holding constants and allowing the other variables to vary to see the consequences of changes. ***Generalization:*** Students made a series of observations while changing the independent variable over a wide range, write their findings in words (no mathematic equations) on a whiteboard or other surface that can readily be shared with the entire group. The final physical relationship can then be predicted to be $V \sim hT(1/\rho)$. ***Verification:*** results communicating, students find that other study groups have drawn the same conclusions from evidence. If there are any conflicts additional data are collected until such time as it is clear that nature does act uniformly and that differences that arise are likely the results of human error. This helps students to understand the nature of science. ***Application:*** The students completed a worksheet that includes multiple examples of flow velocity of lava (V) that explain why the V higher at lower location(h), for higher temperature (T) and for lower density (ρ).

Evaluation

This is the process of determining whether the instructional materials are sufficient and are measuring the effect in order to check to what extent the instructional meets the learning objectives and the needs of learners. The evaluation is directly related to all of the previous four stages and it may be necessary to return to any one of the previous stages at the end of this phase. Moreover, at the end of the each of the stages an evaluation is made to ensure that the process is being carried out in a more sound manner. Then at the end of each evaluation, modifications, if necessary, are made for the next implementation. However, it has been realized that resources and implementations appropriate for the understanding of this new way of learning are still limited. Therefore, it is necessary to further develop the instructional materials learning environments and this study aims to contribute to this need to some extent (Arkün, S and Akkoyunlu, 2008).

Quasi-experimental research Control Group Design was used to evaluate the implementation (Robson, 2001). This is because there was non-random selection of students to the groups. Earth and Space Science (IPBA) classes exist as intact groups and Physics Department, Mathematics and Science Faculty, Universitas Negeri Surabaya (UNESA) Indonesian authorities do not normally allow the classes to be dismantled and reconstituted for research purposes. (Borg & Gall, 1989; Fraenkel & Wallen, 2007; Madlazim and Supriyono, 2014). The conditions under which the instruments were administered were kept as similar as possible across the classes in order to control instrumentation and selection. The classes were randomly assigned to the control and treatment groups to control for selection. (Ary et al., 1979).

Where O_1 and O_3 were pre-test score; O_2 and O_4 were the post-test score; X (=GIL) was the treatment where students were taught using GIL. Group 1 was the experimental class which received the pre-test, the treatment X and the post-test. Group 2 was the control group, which received a pre-test followed by the control condition and then the post-test. Group 2 was taught using T (=RLA). The Research design may be represented as shown in Figure 2. To analyze score improvement between experiment and control group gain score analysis was used. Madlazim and Sipriyono (2014) found that base on the gain score analysis can be inferred that the experiment design skills can be improved significantly.

O_1	GIL	O_2
O_3	RLA	O_4

Figure 2. Quasi Experiment Research Design.

The unit of sampling was the sixth semesters of physics education students of Physics Department, Mathematics and Science Faculty, State University of Surabaya (UNESA). This means therefore that all students of each group have been considered that have not studied the seven topics. The researchers visited the groups to ascertain that they were suitable for research. During the visit the researcher established that the other lecturer in the classes were trained and also obtained information on class composition and learner characteristics from Department records. The sample size of two selected groups of the three classes in the division were obtained. Group 1 (Experimental group) N= 40 and group 2 (Control group) N=40. Therefore, the sample size in the research was 80. Fraenkel and Wallen (2007) recommend at least 30 subjects per group. Hence this number was adequate for the study.

The scientific abilities instruments adapted from Etkina et all (2006), Karelina and Etkina (2007) and Science Pioneers (http://www.sciencepioneers.org/sites/default/files/documents/Experimental_Design_vs_Scientific_Method0.pdf) and modified was used to measure the students' performance. It contained 20 indicators with a maximum score of 80. The instrument was given to three experts in physics education for validation. The test was pilot tested using a class of physics education students of UNESA that was not included in the study but had similar characteristics as the sample classes. This ascertained the test reliability. The reliability coefficient was calculated using Kolen et.al.(1996). This method is suitable when performance scale can be scored. The reliability coefficient of the performance instrument was 0.82 which rounds of to α=0.76. According to Fraenkel and Wallen (2007), an alpha value of 0.65 and above is considered suitable to make group inferences that are accurate enough.

The content used in the class instruction was developed based on the revised 2011/2012 physics syllabus. A guiding manual was constructed for the lecturers involved in administering GIL that was used throughout the treatment period. The lecturers of the experimental group were trained by the researcher on how to use the manual. These lecturers taught using GIL on the seven topics for seven weeks. Before this period the pre-tests were administered to Group 1 and Group 2. The treatment period was seven weeks for the seven topics as recommended in the syllabus. At the end of the treatment period a post-test was administered to GIL and RLA groups.

For this study scientific abilities instrument was used to collect data. The pre-test was administered to group 1 and group 2. Then treatment took seven weeks and was given to the one experimental group after which post tests were administered to both the groups. The researchers scored the pre-tests and post-tests and generated quantitative data, which were analyzed. To analyze the data, we need the scores that students got from the both tests which are pre and post scores. These were assessed by the administration of a diagnostic test for scientific abilities on the first and last day of control and experiment group; only students who took both pre-test and post-tests are part of the sample. This is the 20-items Likert-scale related to scientific abilities evaluation. The scientific abilities evaluation is almost entirely on a qualitative scale. The evaluation was adapted from Karelina and Etkina (2007) and Science Pioneers.

RESULTS AND DISCUSSION

To analyze data this study, we used SPSS 12 version. The results of the pre-test scores on SAPE for groups 1 and 2 showed a statistically significant difference 0.325, greater than 0.05. This means that the value was large, and therefore the obtained difference between the sample means is regarded as not significant. This indicated that the both groups used in the research exhibited comparable characteristics. The groups were therefore suitable for the study when comparing the improvement effects of GIL and RLA on scientific abilities. The results of the pre-test scores on SAPE for groups 1 and 2 showed a statistically significant difference 0.325, greater than 0.05. This means that the value was large, and therefore the obtained difference between the sample means is regarded as not significant. This indicated that the groups used in the study exhibited comparable characteristics. The groups were therefore suitable for the study when comparing the improvement effects of GIL with RLA for the seven topics.

To analyze differences of the two means of the experiment and control group, post-test scores used the Wilcoxon W Test. This indicates that there are significant differences in mean post-test scores between the experimental and control group. Based on the mean (average), the average grade post-test experimental group scores are greater than the average post-test scores of a control group. The results indicate that the students' scientific abilities of experimental group are better than the students' control group.

Table 2. SAPE t-Test Scores, Means, Standard Deviation and Gain Scores for Groups

Group	Pre-test		Post-test		Gain scores	t-test
	Mean	S.D	Mean	S.D	g	
Control (RLA)	1,72	0,10	2,66	0.09	0.41	23.45
Experimental (GIL)	1,70	0,09	3,04	0.05	0.58	

(SD = Standard Deviation; Gain score= ((%posttest -%pretest)/(100 -%pretest)), max. SAPE point: 4)

Table 3 shows that the students' scientific abilities were found not to be well developed. According to the findings of pre-test, the scientific abilities in which the students are least successful (less than 60%) are representing physical processes in multiple ways, modifying a qualitative explanation, designing an experimental investigation, collecting and analyzing data, evaluating experimental predictions and outcomes, conceptual claims, problem solutions, and models, and communicating experimental results. When the responses related to the abilities on modifying a qualitative explanation and designing an experimental investigation are examined the percentages are seen as 50% respectively. Collecting and analyzing data and communicating experimental results are at the highest level with 55%. It is thought provoking to see that the students didn't have such scientific abilities.

When the post-test findings were evaluated it was found that the participants improve the scientific abilities that they were not succeeding in the pre-test. They conducted correctly more than 85% of all scientific abilities. When the responses related to the abilities on modifying a qualitative explanation and designing an experimental investigation are examined the percentages are seen as 90% and 100%, respectively. It is thought provoking to see that the students have developed such scientific abilities. This finding shows that the application realized with the GIL is effective. Some problems were seen in the previous studies on students about teaching and improving the scientific abilities, but at the same time these problems were eliminated in these studies with the GIL. (Şimşek, 2010; Bowen & Roth, 1999).

The null hypothesis of this research was given as: "A Laboratory Based on the GIL approach will have no effect on students' SAPE pre and posttest mean difference, gains scores and t-test". The comparison of the groups of test scores is shown in Table 2. Table 2 shows that when the total pretest scores obtained from the SAPE test are taken under control, it is found that there are significant results between SAPE post test scores and group memberships. The GIL approach produced significantly greater scientific abilities than did the RLA approach. Hake (1998) reported that the interactive-engagement (IE) methods can increase mechanics-course effectiveness well beyond that obtained in traditional methods and he found that the average FCI*** gain score of IE methods is ± 48.14. (in the medium-g region). In this study, although GIL is to be much more effective than RLA gain score. The cause of this case can be that in GIL tasks the students are concentrated are given questions requiring ongoing intellectual engagement using higher-order thinking skills (HOTS) making for independent thought and action, student's activities are the focus for collecting and interpreting data to discover new concepts, principles, or empirical relationships, they created their own controlled experimental designs. GIL also required students to identify, distinguish, and control pertinent independent and dependent variables; promoted student understanding of the skills and nature of scientific inquiry, commonly allowed for students to learn from their mistakes and missteps; provided time and opportunity for students to make and recover from mistakes and employ procedures that are more consistent with authentic scientific practice; showed the work of science to be recursive and self-correcting.

The results from our experimental design comparing GIL and RLA, implemented in realistic laboratory environments in seven weeks program, are that GIL and RLA led to comparable scientific abilities in roughly equal instructional times. While students made statistically significant learning differences in both groups, the wide range of scores on pre-and post-tests (reflected in small standard deviations of the data in Table 2, 3, 4, 5 and Table 6) show that both the pre test and post test scores of GIL and RLA differences is enough size for those observed. A larger-scale study would provide larger N-size, but at the cost of precision, since in practical terms it becomes much more difficult to prepare, control and monitor all the instructional and classroom situations and factors, thus increasing variation further. Following Cronbach (1975), a number of separate local studies in various environments would be more informative, to see whether and how the findings generalize to other situations and to refine and study the effect of various parameters. In any case, pre test scores differences between the both groups were thus far not found to be of statistical or practical significance compared to the observed natural variation of students, lecturers and classrooms. It is of interest to consider possible reasons why this might be so, viewed from a number of perspectives. First, we used soundly-designed groups based on acceptable models of good instruction for both groups. Second, we are not comparing active with passive learning. Active-learning activities occur in both groups, though their characters differ. Third, we tried to make the lessons interesting regardless of the groups. Fourth, and importantly, there is an application phase in both groups, during which students *apply* the earth science concepts they have just learned to a variety of cases and problems, which further enhances learning, scientific abilities The application phase in instruction should, to some extent, tend to even out differences in initial scientific abilities and concept learning. The fact that all lessons are composites, with some aspects of the seven earth science topics, is not an issue for the research results since only the active agent aspect which differs between methods is assessed.

There is also merit to the time argument in favor of direct, but our study shows that the time differential is not as great as usually claimed, if both groups include experiential and application aspects, and if inquiry is focused and well guided. Finally, if students develop scientific abilities themselves rather than 'receive' it directly, transfer of the abilities to new situations may conceivably be enhanced and longer-term retention improved, since they should be able to reconstruct that ability. However we reiterate that our study focused explicitly on scientific abilities. Thus the interesting issues noted above become, of course, further research questions. Returning again to our main research question, and given the composite nature of all lessons and the realities of implementation in laboratory, we see that some common claims for the superiority of either GIL in regard to scientific abilities may be viewed as somewhat overstated. Our study shows that GIL and RLA led to different scientific abilities (Table 6 and Fig. 2). It may well be that under more tightly controlled and rehearsed conditions one could better distinguish the scientific abilities differential due to GIL, which would be of significant theoretical interest; but this study gives a practical indication of what is likely to happen in the field under less clinical conditions. Thus, our findings show that the GIL is an effective strategy. GIL is clearly offers significant potential advantages for earth science education, by doing guided scientific inquiry during learning process. These results are good agreement to results study of Brickman et al. (2009).

Table 3. The distribution of the answers of scientific abilities scores pretest and post test for the experiment group (GIL treatment)

Scientific abilities	Pre-test		Post-test	
	f	%	f	%
Representing physical processes in multiple ways	21	52	38	95
Modifying a qualitative explanation	20	50	36	90
Designing an experimental investigation	20	50	40	100
Collecting and analyzing data	22	55	38	95
Evaluating experimental predictions and outcomes, conceptual claims, problem solutions, and models	21	52	37	92.5
Communicating experimental results	22	55	36	90

CONCLUSIONS AND RECOMMENDATION

Many instructional materials, textbooks, laboratory guides and other materials are still prepared on traditional approaches (RLA). In a review of the literature, researchers found that GIL approaches are more effective than verification or traditional laboratory approaches (Pavelich and Abraham, 1977; Allen et. al. 1986; Volkman and Abel, 2003). The laboratory activities, laboratory guides or manuals and instructor must maintain interest and curiosity in earth science and improve scientific abilities. Students should design their experiments themselves, establish their hypothesis and test them, determine the variables about the experiment themselves, decide which data to save, create their own tables, conclude results; briefly, students should not try to exactly perform passively what was written in laboratory guide or the instructions which was given to them by the lectuers. "Many of students enjoy laboratory work and prefer it to other modes of learning. This is not, of course, the universal reaction of all students at all times" (Gardner and Gauld, 1990; Chiappetta and Koballa, 2002). According to Campell et. al. (2000), students' perceptions of the purpose of a laboratory task and understandings of laboratory procedures greatly influence their decisions on what to report and on how much detail to include in a report. The lecturers should provide students with an environment in which they will feel interested in facts, events and subjects; briefly, an environment in which they may think and discuss like a scientist

The result from this study showed that the use of GIL is more effective than the verification laboratory approach (RLA) applications in terms of students' scientific abilities. Moreover, at the interviews that are made with students after application, experiment group students stated that the laboratory environment excited them and that other laboratories (basic physics, basic biology, basic chemistry that are operated with RLA) should be operated like it.

ACKNOWLEDMENTS

We thank two anonymous reviewers for helpful comments. This work was supported by Unggulan Perguruan Tinggi (UNESA) Indonesia; Grants No.: 024.3/UN38.11-p/LT/2014, funded by the Islamic Development Bank (IDB).

BIBLIOGRAPHY

Allen, J.B., Barker L.N. & Ramsden, J.H., Guided inquiry laboratory. *Journal of Chemical Education*. **63**, [6], 533-534, 1986.

Anderson-Cook CM, Dorai-Raj S., An active learning in-class demonstration of good experimental design,. *Journal* of *Statistics Education* **9**, [1], 2001. http://www.amstat.org/publications/jse/v9n1/anderson-cook. Html

Arkün, S and Akkoyunlu, B., A Study on the development process of a multimedia learning environment according to the ADDIE model and students' opinions of the multimedia learning environment. Interactive Educational Multimedia, [17], pp. 1-19, 2008. http://www.ub.edu/multimedia/iem / iemjornal@greav.net

AskERIC, *An AskERIC Write-A-Lesson Plan Guide*, 1999, available online at www.askeric.org

Ary, D., Jacobs, L. C. & Razavien, S. *Introduction to research in education*. New York: Holt, Rinehart and Winston, 1979.

Bowen, G.M. & Roth, W-M., "Do-able" questions, covariation and graghical representation : do we adequately prepare preservice science teachers to teach inquiry? Pare presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, http:// search.ebscohost.com, retrieved date: 16.03.2010.

Brickman P., Gormally C., Armstrong N. and Hallar B. Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence. *International Journal for the Scholarship of Teaching and Learning* Vol. **3**, [2], 2009.

Borg, W. R, & Gall, M. D., *Educational Research: An Introduction* (Fifth ed.). New York: Longman, 1989.

Campell, B., Kaunda, L., Allie S., Buffler, A. and Lubben, F., The communication of laboratory investigations by university entrants. *Journal of Research in Science Teaching*. **37**, [8], 839-853, 2000.

Chiappetta, E. L. and T. R. Koballa, Science *Instruction in the Middle and Secondary Schools*. Merril Prentice Hall, 2002.

Cronbach, L. J, Beyond the two disciplines of scientific psychology. *American* Psychologist, **30**, 116-127, 1975.

Etkina, E., Alan Van Heuvelen, Suzanne White-Brahmia, David T. Brookes, Michael Gentile, Sahana Murthy, David Rosengrant, and Aaron Warren. Scientific abilities and their assessment, *Physical Review ST Physics Education Research*, **2**, 020103, 2006.

Festing MFW., Principles: the need for better experimental design. *Trends in Pharmacol Sciences,* **24**:341-345, 2003.

Fraenkel, J., & Wallen, N., *How to Design and Evaluate Research in Education*, New York: McGraw-Hill, 2003.

Gardner, P. and Gauld, C., Labworks and students' attitudes. In E. Hegarty-Hazel (Ed.), *The Student Laboratory and Science Curriculum*. New York Routledge, 1990.

Hake, R.R., Interactive-engagement vs traditional Methods: A Six-Thousand-Student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, ***66***, [1], 64-74, 1998.

Hiebert SM., Teaching Simple Experimental Design to Undergraduates: Do Your Students Understand the Basics?, *Advances Physiology Education,* **31**:82-92, 2007.

Herron, M. D, The nature of scientific enquiry. *School Review,* **79**, [2], 171-212, 1971.

IEEE, *Reference Guide for Instructional Design and Development*, 2001, available online at www.ieee.org

Karelina, A. and Etkina, E., Acting like a physicist: Student approach study to experimental design, *PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH* **3**, 020106, 2007.

Kolen, M. J., Zeng, L., & Hanson, B. A., Conditional standard errors of measurement forscale scores using IRT. *Journal of Educational Measurement*, **33**, 129-140, 1996.

Madlazim and Supriyono, Improving Experiment Design Skills: Using THE Joko Tingkir Program as a Learning Tool of Tsunami topic, *science of tsunami hazards*, **33**, [2], 133-143, 2014.

Pavelich, M. J. & Abraham, M. R., Guided inquiry laboratories for general chemistry students. *Journal of College in Science Teaching***,** **7**, [1], 23-26, 1977.

Pyle, Eric J. A Model of Inquiry for Teaching Earth Science. *Electronic Journal of Science Education*, **12**, [2], 2008.

Robson, Lynda S. Harry S. Shannon, Linda M. Goldenhar, Andrew R. Hale, Guide to Evaluating the Effectiveness of Strategies for Preventing Work Injuries: How to Show Whether a Safety Intervention Really Works. DEPARTMENT OF HEALTH AND HUMAN SERVICES Public Health Service Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, 2001.

Şimşek, C.L., Classroom teacher candidates' sufficiency of analyzing the experiments in primary school science and technology textbooks' in terms of scientific process skills, *Elementary Education Online,* **9,** [2], 433-445, 2010.

Sommerville, I., Software Engineering, 3rd ed. Reading, MA: Addison Wesley, 1989.

Science Pioneers. Experiment Design and Scientific Method. INSPIRING SCIENTIFIC CURIOSITY AND LEARNING FOR A BETTER COMMUNITY

Students and research: Practical strategies for science classrooms and competitions. Cothron, J. H., Giese, R. N., & Rezba, R. J. (3rd Ed.). Dubuque, IA: Kendall/ Hunt Publishing Company, 2000.

Zolman JF Teaching experimental design to biologists. Advances Physiology Education 277:111-118. Received July 31, 2010; revised October 06, 2010; accepted October 20, 2010. Address correspondence to: Dr. Alexia Pollack, Department of Biology, University of Massachusetts-Boston, 100 Morrissey Blvd, Boston, MA 02125 Email: alexia.pollack@umb.edu, 1999.

Volkmann, M. J. and Abel, S. K., Rethinking Laboratories-Tools for Converting Cookbook Labs into Inquiry. *The Science Teacher*, 38-41, 2003.

Wenning, C.J., Levels of inquiry: Hierarchies of pedagogical practices and inquiry processes. *Journal of Physics Teacher Education Online,* **2**, [3], 3-11, 2005.

Wenning, C.J., Levels of inquiry: Using inquiry spectrum learning sequences to teach science. *Journal of Physics Teacher Education Online,* **5**, [4], 11-19, 2010.

Wenning, Carl J., The Levels of Inquiry Model of Science Teaching. *Journal of Physics Teacher Education Online,* **6**, [2], Summer 2011

Received 02-09-2014 /Approved 02 -05- 2015

Videotaped experiment in chemistry: should I play it before or after sending students to the lab?

Experimento de química grabado en vídeo: ¿debería mostrarse antes o después de enviar a los estudiantes al laboratorio?

[1] Helena Sepúlveda, [2] Luciano Moreira, [3] Carla Morais, João Carlos Paiva

[1]Escola Secundária de Paredes, CIQUP, [2]Faculdade de Engenharia, Universidade do Porto, [3] CIQUP, Unidade de Ensino das Ciências, Departamento de Quìmica e Bioquìmica, Faculdade de Ciências, Universidade do Porto, Portugal

helenamsepulveda@gmail.com, lucianomoreira@fe.up.pt, cmorais@fc.up.pt, jcpaiva@fc.up.pt

Abstract

This article aims to analyse if and how relevant the timing of exposure to a videotaped experiment and its storyboard may be, both before and after the experiment is performed. 27 students of one 11th grade class took part in the experiment, subdivided in two conditions and 5 work groups per shift. Interviews were conducted and their results were analysed using the NVivo software. The results indicate that both student perception and laboratorial work performance are different according to the timing of exposure to the video. Exposure before laboratory work resulted in a more controlled and guided behaviour, fewer mistakes and shorter work time to conduct the experiments. Exposure after the experiment allows a better evaluation of students performance, and a higher level of student's reflection about the way experiment was conducted. Results are thus marked by a tension between goal orientation (appraisal) and learning orientation. The teacher`s role is to manage the pros and cons of both possibilities.

Key words*: instructional video, laboratory video, video pedagogical integration*

Resumen

Este artículo tiene como objetivo analizar si y cómo es relevante el momento de la exposición a un experimento en video y su guión puede ser, tanto antes como después de que se realiza el experimento. 27 alumnos de una clase de 11º grado participaron en el experimento, que se subdivide en dos condiciones y 5 grupos de trabajo por turno. Se realizaron entrevistas y sus resultados fueron analizados utilizando el software Nvivo . Los resultados indican que tanto la percepción de los estudiantes y el desempeño del trabajo de laboratorio son diferentes según el momento de la exposición al video. La exposición antes del trabajo de laboratorio resultó en un comportamiento más controlado y guiado, menos errores y más corto el tiempo de trabajo para llevar a cabo los experimentos. La exposición después del experimento, permite una mejor evaluación de desempeño de los estudiantes y un mayor nivel de reflexión del estudiante sobre la forma en que se llevó a cabo el experimento. Los resultados son por lo tanto marcados por una tensión entre la orientación de meta (evaluación) y la orientación del aprendizaje. La función docente es la gestión de los pros y los contras de ambas posibilidades.

Palabras clave: *video instructivo, video de laboratorio, integración pedagógica de video*

IS VIDEO AN OBSOLETE TECHNOLOGY?

The educational use of video education has long been studied and discussed. Since technology has evolved, studying this topic can be perceived at first sight as somewhat anachronous. However, considering that video is currently available and made more accessible in several platforms and devices, its educational use deserves a new look.

Although it is true that academic discussion has moved from analyzing linear video integration towards interactive videos (Schwan & Riempp, 2004; Zhang, Zhou, Briggs, & Nunamaker Jr., 2006), computer simulations (Rutten, Joolingen & Veen, 2012) and virtual laboratories (Tatli and Ayas, 2010), one must also consider that digital video and presentation technologies have just only recently surpassed several obstacles that a decade ago inhibited the systematic use of this technology in a regular classroom (Michel, Cavallari, Znamenskaia, Sun & Bent, 1999). Moreover, if recent evolution brought increased interactivity, customization and self-production it does not outcast linear video demonstration. The fact is that teachers still use simple, linear videos in their classes and, often, they use it in a non-optimal way, such as to fill students' time or to reward them for good behavior (Hobbs, 2006).

Video, as well as other media, are often referred as allowing for better understanding of abstract concepts by bridging the gap between students' own meaningful realms and science (Harwood & McMahon, 1997). Chemistry students could therefore benefit from video integration. As a matter of fact, chemistry is particularly demanding, because it is simultaneously a highly experimental and a highly abstract science that deals with microscopic reality.

Although teachers are adopting "what if" strategies to explore the potential of technology integrated science teaching (Hennessy, et al., 2007), the fact is that digital technologies are often perceived either as replacing traditional practices (lecture or laboratory) or as introducing and preparing students for hands-on activities. "Another effective way of using simulations is as a preparatory activity for real laboratory activities. Positive effects are found in the comprehension of the lab task as well as for practical laboratory skills during the real lab activity" (Rutten, Joolingen & Veen, 2012, p. 151).

Some authors maintain that demonstration and videotaped experiments are equally effective and thus videotaped experiments can be used in school within laboratory situations (Sever, Yurumezoglu & Oguz-Unver, 2010).

Crocker, Andersson, Lush, Prince and Gomez (2010) found out that video guides bring several benefits. Video guides help to develop students' autonomy, liberating more time to focus on data and to engage in more demanding interaction as well as to set a basis for inquiry learning laboratory through the production of video content. More recently, the discussion has evolved to student-created videos through smart-phones (Benedict and Pence, 2012).

In this work we will focus on the timing of the presentation of video as a 1.0 tool.

Specifically, we intend to:

a. Evaluate whether the exposure to the video before or after the actual laboratory work would affect the development of cognitive and working abilities of the students in different ways, mainly focused on the theoretical concepts and laboratory techniques needed to perform the experiment.
b. Evaluate the student's demeanour when facing the inclusion of video as a pedagogical tool and also their response to the didactical strategy designed for the class.

METHODS AND MATERIALS

In this section, we will describe the methods and materials used in the work.

Subjects

27 students from a Portuguese 11 grade secondary class participated in the study (56% female and 44% male), with average age of 16. In each condition the elements were selected by the teacher in order to form groups with similar average academic performance.

Materials

We used a laboratory video that demonstrated a strong-acid/strong-base titration, in which all the reagents and materials were presented and a detailed demonstration of the steps necessary to conduct the experiment was shown (Figure 1).

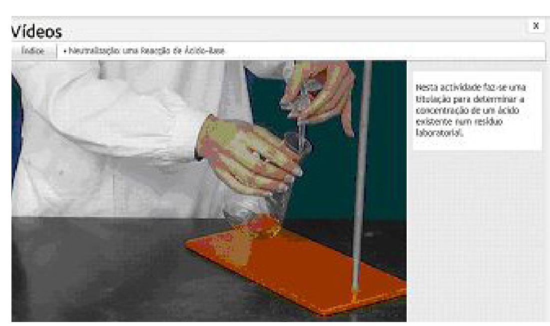


Figure 1. Video prinscreen

A storyboard was constructed that was applied after the video exposure as well as an analysis grid to be filled by the teacher during laboratory work and a script to conduct the semi-structured interviews.

Procedure

The subjects were granted access to the standard protocol for a strong-acid/strong-base titration.

The exposure to the video was made in a laboratory class at two different time moments. In condition 1, the group was exposed to the video before engaging in the laboratorial work. In condition 2, the class started with laboratorial work and only after this were the subjects exposed to the video. Both conditions were divided in 5 work sub-groups. The laboratorial work activities were filmed by a fixed video camera. At the end of the class, volunteers were asked to participate in an individual interview that took place one week after.

Data analysis procedure

The results of the video script were treated with descriptive statistics using an *Excel* worksheet and represented according to the theoretical and practical skills that were tested.

The interviews with the six students (three from each condition) were recorded, transcribed and subjected to qualitative analysis using NVivo 10. A survey based approach and open coding strategy was used, because, during the interview, unexpected answers and new questions arose. This led to a categorization different than originally planned, it being necessary to establish new connections and open new research areas (Glaser & Strauss, 1967).

RESULTS

As Table 1 shows, both conditions showed improved results in practical skills. Condition 1 (exposure before) achieves a higher result than condition 2 (exposure after) in experimental skills and also slightly higher scores in theoretical skills.

Table 1. Average ranking per condition (%)

Skills	Condition 1 Video before (%)	Condition 2 Video after (%)
Theoretical skills	66	60
Practical skills	80	63

Laboratory performance of condition 1 subjects revealed higher scores in terms of materials manipulation and execution method. The subjects concluded the work in about 48 minutes while condition 2 subjects took 67 minutes. About 8 minutes past the beginning of work, condition 2 subjects were still looking for guidance in the protocol and showed insecurity identifying materials, while subjects from condition 1 were already measuring the initial values of acid at about 4 minutes past the beginning of work (Figure 2 and Figure 3)

In condition 2 the teacher has had to intervene directly, showing how to wash and fill the burette since the subjects were unable to correctly perform that step by themselves, although it was clearly explained in the protocol, that all had had access to beforehand. Some of the subjects in this condition showed some difficulties in achieving matching results.

While watching the video, condition 1 subjects showed a more focused demeanour, trying to retain the information that was being passed while subjects in condition 2 appeared more relaxed and showed a more enthusiastic behaviour as they recognized they had executed certain steps as the video showed: "…I did that…" or when they identified the easiest way to perform a certain action: "…with the video it's much easier…".

From the analysis of the interviews we emphasise the following topics: (i) importance of the video in understanding the contents; (ii) importance of practical laboratory work versus exposure to the video; (iii) importance of filling the video exposure grid; (iv) importance of the exposure timing.

(i) All the subjects recognize there are advantages in watching the video, especially in regards to understanding how to perform the different laboratorial techniques and, generally, they do not recognize advantages in obtaining theoretical knowledge.

(ii) Subjects were unanimous in considering that exposure to the video does not substitute laboratorial practice. They expressed a desire to engage in laboratorial work as otherwise they might not fully understand it. They do acknowledge, however, the usefulness of the video in recognizing and understanding the mistakes that were made and as a demonstration of techniques.

(iii) All the subjects recognized value in filling the video exposure grid, independently of exposure timing.

(iv) Concerning the students' perception of the best exposure moment, all suggested that watching the video before eases the experimental work session, diminishes anxiety and increases confidence levels while mitigating pre-laboratorial work doubts.

Positive points in exposure after laboratory work came, especially, from the ability to recognize the mistakes that were made, thus being able to perform a critical evaluation of their performance. In some cases this led to a desire to further develop the skills that were learned.

Those students showing qualitative conceptions do not restrain themselves to merely acting out the tasks they are given, even if they recognize that this could be translated into higher grades, but seek knowledge in a more interactive and also meritocratic manner.

In the examples below we analyse a conflict situation created by the answers of two different students. The first one translates the conflict between easiness and personal commitment and the second refers to the conflict between a better laboratorial performance and the inhibition of exploratory behaviours raised from a pre lab-work exposure to the video.

> *"It would be important to watch the video before because in this case I know what to do and only need to act out what I see in the video. (...) On the other hand, if I don't see the video before I try to do, I seek how to do it, and that makes me learn more. (...) This means that I believe you learn more if you do the experiment before and watch the video after."* (subject from T2A)
>
> *"Watching the video after would probably not have been the best option because even after reading the protocol there are activities I could have not understood, like the washing of the burette and practical mistakes would be made, and even in the final results, that we would not be able to eliminate. When we watch the movie before we are a little conditioned by what we see because we believe it is the correct way to do it and so we want to repeat what was seen so we can get a good grade and that means the video might restrain us a bit by not allowing us to explore our imagination capacity in order to do things"* (subject T1A)

References to negative aspects of exposure to the video were found only in condition 1 subjects (T1A and T1B). Subjects refer the conditioning to which they are subjected because of the suggested procedure and how that might restrict the development possibilities of autonomous and investigative

Figure 2 – Laboratory work Condition 1 (4:22)

Figure 3 – Laboratory work Condition 2 (8:22)

capabilities. In consequence, they were the only students that assumed the importance and possibility of presenting the video both before and after the laboratory work, as neither group would waive the advantages of pre-work exposure.

None of the subjects in condition 2 waives the exposure to the video because, even though they felt less comfortable during work and identified the advantages of a pre-work exposure, they recognize the learning and knowledge gains that derive from post-work visualization, electing it as the most opportune timing.

CONCLUSIONS

The purpose of this paper is to try to understand the effects on students' cognitive and practical skills of watching a lab video experiment, before or after going to the laboratory. According to the results, it is possible to conclude that the time of presentation of the laboratorial video is associated with different performances in the laboratory. Specifically, the participants who have seen the video and have filled the script before going to lab perform better. On the other hand, no substantial differences have been noted in cognitive understanding of the matter. These results are also sustained by the literature.

We are also interested in evaluating the students' attitudes facing the video. The results suggest an ambivalent attitude towards laboratory videos. Although students recognize its intrinsic value, they do not consider it as an alternative activity to laboratory but rather a complementary activity.

An important finding which deserves future exploration suggests a link between students' personal conceptions of learning (Dart et al., 2000) and the timing of video presentation. Those students who value the process of learning would cope better with the learning-by-doing scenario (condition 2) while the students who are strictly focused on results would prefer a vicarious learning scenario (condition 1) which would orient them from the beginning.

Future studies should focus on three key points: First; to clarify the relation this study suggests between student orientation (process vs. product) and video inclusion in class. Second; evaluate if video integration benefits theoretical competences as well as laboratorial ones, and third; returning the film of the whole processed experiment to the students, could constitute an interesting exercise of self-diagnosis through which, each student could evaluate for him/herself what mistakes were made and feel more involved in the teaching and learning process.

BIBLIOGRAPHY

Benedict, L., & Pence, H. E. Teaching Chemistry Using Student-Created Videos and Photo Blogs Accessed with Smartphones and Two-Dimensional Barcodes. *Journal of Chemical Education*, 89(4), 492-496, 2012. doi: 10.1021/ed2005399

Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research*, 93 (4), 262-270,2000. doi: 10.1080/00220670009598715

Hobbs, *R.* Non-optimal uses of video in the classroom, *Learning, Media and Technology, 31, 1, 35–50, 2006.* DOI: 10.1080/17439880500515457

Croker, K., Andersson, H., Lush, D., Prince, R., & Gomez, S. Enhancing the student experience of laboratory practicals through digital video guides*, Bioscience Education* 16, 2010. Retrieved on February, 20, 2010 from

www.bioscience.heacademy.ac.uk/journal/vol16/beej-16-2.pdf

Harwood, W., & McMahon, M. . Effects of Integrated Video Media on Student Achievement and Attitudes in High School Chemistry. *Journal of Research in Science Teaching*, 34, 6, 617-631,1997.

Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., la Velle, L., McFarlane, A., Ruthven, K., & Winterbottom, M. Pedagogical approaches for technology-Integrated science teaching. *Computers and Education*, 48 (1), 137-152,2007. DOI: http://dx.doi.org/10.1016/j.compedu.2006.02.004

Michel, R. G., Cavallari, J. M., Znamenskaia, E., Yang, K. X., Sun, T., & Bent, G. Digital video clips for improved pedagogy and illustration of scientific research with illustrative video clips on atomic spectrometry. *Spectrochimica Acta Part B*, 54 1903-1918,1999.

Rutten, N., van Joolingen, W. R., & van der Veen, J. T. The learning effects of computer simulations in science education. *Computers & Education*, 58(1), 136-153,2012. doi: 10.1016/j.compedu.2011.07.017

Sever, S., Yurumezoglu, K., & Oguz-Unver, A. Comparison teaching strategies of videotaped and demonstration experiments in inquiry-based science education. Procedia - Social and Behavioral *Sciences*, 2(2), 5619-5624, 2010. Doi: 10.1016/j.sbspro.2010.03.916

Schwan, S., & Riempp, R. The cognitive benefits of interactive videos: learning to tie nautical knots. *Learning and Instruction*, 14(3), 293-305, 2004. Doi: 10.1016/j.learninstruc.2004.06.005

Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker, J. F. Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. *Information & Management*, 43(1), 2006. 15-27. Doi: 10.1016/j.im.2005.01.004

Tatli, Z., & Ayas, A. Virtual laboratory applications in chemistry education. *Procedia - Social and Behavioral Sciences*, 9, 938-942, 2010. Doi: 10.1016/j.sbspro.2010.12.263

Received 07-05-2014 /Approved 02 -05- 2015

Active methodologies in science education: an analysis in the light of the theory of social representations

Metodologías activas en la educación científica: un análisis de la teoría de la luz de las representaciones sociales

Antonella Carvalho de Oliveira , Damaris Beraldi Godoy Leite, Antonio Carlos Frasson

UTFPR, PR, Brazil, antonella_0611@hotmail.com, damgodoy@hotmail.com, acfrasson@utfpr.edu.br

Abstract

This research analyzes the social representations of teachers of courses in biology, physics and chemistry, concerning active methodologies. The data were obtained through a questionnaire to 86 teachers from semistructured classroom courses at a public university in the State of Paraná, 31 teachers of undergraduate course in biology, 27 teachers of undergraduate course in physics and 28 teachers of the undergraduate course in chemistry. All teachers surveyed belong to the core business of their specific training courses. The questionnaire has two questions of free association ten multiple-choice questions and two open-ended questions. The excerpts of the justifications evoked by the teachers words that illustrate the meaning abstracted regarding the subject studied received designation in the following account of the work: PB1 to PB31 for professors of biology; PF32 to PF58 for professors of physics PQ59 to PQ86 for the professors of chemistry. The answers to the questions of free association and the open questions were read to identify regularities and unique experiences. After a thorough reading of the responses a report was prepared with an interpretive synthesis of the focus given to active methodologies and words that evoked the experiences of teachers. The data analyzed in the light of the theory of social representations indicates proximity between social representations identified by the teachers and the possibilities and limitations of encouraging the dialectical process, practice and praxis in terms of active methodologies.

Key words: *science education; active methods; social representations.*

Resumen

Esta investigación se basa en las representaciones sociales de los profesores de los cursos de biología, física y química, con uso de metodologías activas. Los datos se obtuvieron a través de un cuestionario a 86 docentes de cursos semiestructurados en el aula de una universidad pública en el estado Paraná, 31 profesores de curso de pregrado de biología, 27 profesores de curso de pregrado de física y 28 profesores del curso de pregrado de química. El cuestionario consta de dos preguntas de la libre asociación, diez preguntas de opción múltiple y dos preguntas abiertas. Las *respuestas a las preguntas de la libre asociación y las preguntas abiertas fueron leídas para identificar regularidades y experiencias específicas. Después de una lectura de las respuestas se preparó un informe con una síntesis interpretativa de la atención dada a las metodologías activas y palabras que evocaban las experiencias de los profesores. Los datos analizados a la luz de la teoría de las representaciones sociales indican la proximidad entre las representaciones sociales identificadas por los profesores, las posibilidades y limitaciones para fomentar el proceso dialéctico, la práctica y la praxis en términos de metodologías activas.*

Plabras clave: *educación científica, métodos activos, representaciones sociales*

INTRODUCTION

In the last century, discoveries in various fields of human knowledge paved the way for a reflection about teaching and learning. The school access for everyone, the result of the educational reforms of the 1990s, as well as other mechanisms for accessing information, have enabled people today to be more aware of their rights and expectations of those outside the school has been changed and raise issues such as : What is the purpose of school? What is the role of the teacher?

The active methods come up as a response to these questions, because they are based on the study process by solving problems and require a change the role of the educator, as stated Orlik (2002, p. 62) "Actualmente el método tradicional lo ejecutan profesores con poca práctica, porque obteniendo la mínima experiencia en la enseñanza el profesor, casi siempre comprende que este método no es el adecuado e intenta modificar y modernizar su trabajo docente" enabling focus on teaching-learning process, Thus the teacher's first responsibility is to develop autonomy in students. The various possibilities for working with active methods are: case study, the incident process, pedagogy projects, scientific research, problem-based learning and problematization with the Maguerez Arch (consisting of five steps: observation of reality and problem definition, key points, theorizing, possible solutions and application to reality) (Colombo; Berbel, 2012).

The anchor of active methodologies is critical pedagogy and all have in common the fact of intentionally working with problems for the development of teaching-learning and enhancing learning to learn (Marin et al, 2013). This is because the human being has the ability to interact with objective knowledge, with the phenomena present in their reality, and to establish social relationships. This context shows the importance of knowing the previous and / or common sense concepts, described by the subjects involved in the teaching-learning process in order to achieve the best form of appropriation of knowledge and overcome the epistemological obstacles (Borille et al 2012). The path of the teaching learning process is built by interaction between the knower and the knowable object, the active methodologies are grounded in a significant theoretical principle: autonomy, something explicit in the invocation of Paulo Freire (1987). Current education requires that the student is able to self-manage and govern his/her own formation process.

Without digression some issues come to the surface because "all human interactions arise between two people or between two groups and this presupposes social representations being necessary to the understanding of social dynamics and relationships among individuals" (Moscovici, 2003, p. 40). So Jodelet (2001, p. 22) corroborates Moscovici when he says that social representations "are a form of knowledge, socially elaborated and shared that have a practical purpose and contributes to building a reality common to a social group."

The study of social representations investigates how the reference systems we use to classify people and groups and to interpret the events of everyday reality are formed and work. There are many ways of understanding and addressing the social representations, relating them to the social imaginary or not. They are related to the imaginary where the emphasis is on the symbolic character of representative activity of subjects who share the same social condition or experience (Mazotti, 2008, p. 25, emphasis added).

Spanning the concept above, we can conclude that social representations are indispensable for understanding the social relations and the dynamics of the subject with the professions. The social representation becomes essential for the apprehension of the components of the teaching profession, particularly as they involve social, historical and cultural dimensions that show from actions experienced in everyday school life. The issues raised provide expansion and produce knowledge, therefore the central research problem can be expressed thus: What are and what indicates the social representations of teachers of courses in biology, physics and chemistry relating to active methodologies?

The present study aims to analyze the social representations of teachers of courses in biology, physics and chemistry of a public university in the state of Paraná, on active methods, seeking to understand their constituents. Given the above, the relevance and contribution of the work in question is due to the fact of the actuality and relevance of the topic, considering that aims to deepen the conversation and perspectives between areas covered by the teaching of science, given that the issue affects directly the conditions and quality of education offered in Brazilian schools.

METHODOLOGY

Applied research, qualitative, exploratory and phenomenological, accomplished through application of semi-structured questionnaires to 86 teachers at a public university in the state of Paraná, and 31 teachers of the degree course in biology, 27 teachers of undergraduate course in physics and 28 teachers in degree course in chemistry. The excerpts of the justifications evoked by the teachers words that illustrate the meaning abstracted regarding the studied subject received the following title in the narrative of the work: PB1 to PB31 for professors of biology; PF32 to PF58 for professors of physics PQ59 to PQ86 for the professors of chemistry.

The questionnaire has two questions of free association ten multiple-choice questions and two open-ended questions. Closed questions involving constructs were measured using an interval Likert metric scale rating of five points, where 1 represents "Do not Agree" and 5 is "Strongly Agree".

Hoppen et al (1996) warns that when the researcher uses an instrument to collect data not validated, it should be subjected to validation in the categories of "trustworthiness and reliability" and "content". To assess the validity of the instrument "Content Validity" method was used, and for its operation were asked four experts in the field of active methodologies. Judged relevant suggestions were accepted and incorporated into the first version of the instrument.

Aiming to demonstrate that the questionnaire now prepared is consistent, the same was submitted to reliability analysis of each factor by Cronbach alpha coefficient (Cronbach, 1951). The value found was 0.85, allowing the consideration that the internal consistency presents coefficients that prove its cohesion.

The treatment of the words evoked in the matter of free association and open question were performed by EVOC, software that lends itself to the analysis of words and widely used to support research on social representations and justifications evocations, through content analysis. After a thorough reading of narratives an interpretive synthesis was developed, to focus on active methodologies and words evoked from the experiences of teachers.

ANALYSIS AND DATA DISCUSSION

In the questionnaire we used expressions and words that , according to the literature, refer to the active methods. The teacher was asked to list words by their level of importance and to justify the word pointed first. In questions of free association and the open questions it was also possible to determine the words evoked by teachers as well as its justification. The 86 teachers surveyed evoked 335 words. The average number of words per teacher was 3.8. After analysis and processing it was found that most of the words contained identical or very similar to other meanings, and therefore could be grouped in 48 words. Treatment performed in the EVOC, discarded 29 words (low frequency).

Profile of the population studied

In preparing the survey instrument was decided to draw the profile of the population studied, because it is understood that the features / conditions of teachers compete to influence the results, Table 1 presents these data.

Table 1: Population Profile

Gender	
Female	20%
Male	80%
Age	
Between 25-35	27%
Between 35- 45	48%
Between 45-55	25%
Title	
Master	27%
Doctor	73%

Time Teaching	
Up to 10 years	35%
Between 10-15 years	13%
Between 15-20 years	19%
More than 20 years	33%

There is among the population, a predominance of males (80%) and individuals between 35 and 45 years old (48%). These data are in line with the national average, because according to the census of Brazilian higher education standard of public HEI teacher is male, 44 years old, Brazilian doctor and works full time (INEP, 2012).

As to titles, 27% have a master's degree and 73% have a doctorate, this is a striking feature in public HEIs, because according to INEP (2012) in the number of private HEIs doctors is only 18%. It was also possible to observe that the master teachers are among the oldest within the institution.

Regarding the time of teaching, there is almost an alignment in the percentage of teachers who work less than 10 years (35%) and those with more than 20 years of teaching (33%). This fact can be justified by the number of teachers who have retired in the last five years.

Restrictive Perception of Teachers on the Active Methodologies

The factors named here as restrictive to active methods (Table 2) are derived from open and free association questions. This research aimed to not induce research participants to raise these questions. The justifications refer to understand that the terms "lack of time / overwork", "lack of institutional support", "lack of respect" and "learning resources" are conditions of the HEI where they live, of regulatory bodies and monitoring of school, families and society in general.

Table 2 – Restrictive Perception of Teachers on the Active Methodologies

Restrictive Perception			
	Biology	**Physics**	**Chemestry**
Lack of Time / excessive work	15,8%	17,4%	11,6%
Lack of Institutional Support	13,4%	12,8%	15,9%
Lack of respect	12,4%	10,7%	12,6%
Teaching Resources	8,7%	-	9,5%
Salary	4,5%	-	5,9%
Other	45,2%	59,1%	44,5%
Total	100%	100%	100%

The element lack of time / overwork appears in 44.8% of cases**, a factor that leads to poor condition of teaching. Among all the surveyed teachers, 86% work more than 40 hours per week and maintains daily contact with approximately 110 students. The teacher's work gets done not only within the classroom but also in the intervals, in the corridors, watching students. For lack of planned schedule activity such as guidance, explanations of additional curriculum content, clarification of student questions and even requests for advice on personal issues.

The time required from the teacher outside of the classroom for non-teaching activities, tests and papers to grade, lessons to prepare is substantial. It was found that teachers who teach less time are those who continue performing these tasks in extra time, teachers who teach longest commit less to its performance, because they do not feel valued within the education system. Another factor raised are the changes of the modern world that end up making new demands on teachers' work, requiring not only the creation of new spaces, but also the creation of time, because these changes generate excessive increase and go beyond the contract relating to the loading weekly hour teacher. It remains to consider the other requirements of the position, as reported by the respondent PB11:

Here in the department after having completed PhD, I face pressure to publish [...]. No matter what work I do in class, what matters is what I publish. It's all quantifiable [...], and we have published in prominent journals in the field. I see far more experienced colleagues than me, better than me ... But they are from another time ... And I feel they are not valued because they did not enter in this whirlwind, to publish, some even retire because they feel excluded. It's so much work devoted to research and publication especially, lacking time to plan lessons.

Lack of institutional support was reported by 42.1% of the population surveyed. The justification for the evocation of that term was virtually unanimous: lack of managerial support for deployment of active methodologies as well as other innovative projects is a deterrent factor for its consolidation. In the opinion of teachers, lack of institutional support from the lack of time to study (some teachers are waiting up to ten years to get clearance for master and PhD) and is a defining and sometimes crucial point that they cannot withstand the pressures and quit to achieve new teaching strategies. Worsens are issues of a different nature as bad wage policy (4.5%) and lack of teaching resources for the achievement of work (8.7%).

Some teachers explained the lack of institutional support by bureaucracy, lack of dialogue, lack of prestige and impoverishment and precariousness of installed teaching job at the university, which ends up being a variable responsible for the feeling of helplessness brought on teachers. It is impossible not to feel dissatisfied with the established antagonistic situation, as contends the respondent PF34.

In our department, and I believe that the entire institution, there are two factions: the situation and opposition [...]. I am in opposition and all requests I make are expensive to me. I tried to get a bus to perform a technical visit with students and was denied. How do I do the pedagogy of questioning if politics always sing louder, there are feuds ...We don't have educational support from the department, it is very fragmented, it is as if we did not have any problems in the classroom, as if the problems only exist the schools of basic and special education [...] a lot goes under the carpet [...].

The disrespect, disinterest dressed up, indiscipline and violence was mentioned by 35.7% of teachers. From the evoked words you can see that the teachers are sceptical that the political will to confront these issues exists and that the lack of awareness of families and societal pressures are the main factors of this process. Teachers seems clear that this procedure is disrespectful to the teacher heritage of a society in a state of anomie, full of problems of social control, with absent or conflicting values with subjects who do not fit the cultural guidelines imposed, so the school discipline/cohesion becomes totally ineffective. This multiplicity of factors makes problematic the introduction of active methodologies in educational institutions because its basic axis consists in dialectic and has its guiding principle in action reflection transformation process mediated by the teacher, that this methodology is not based on disrespect, analogous to teacher's PF53 speech:

Students no longer want to study, do not want to come to the classroom and hear what teachers have to teach, do not want to read a book. Education became liquid. Even with Active Methodologies lack of respect is a serious problem faced by all levels of education in the country. The center of the process was the teacher, was not meeting the educational needs of the school age population [...] we become mediators ... But the lack of respect is growing, only increases and we do not have instrumental to solve it . How can I give a lesson to a class that has no respect for me? For my work? **Quoting Paulo Freire: There is no teaching without students** (emphasis added).

The a priori schemes Paulo Freire in which "nobody educates anybody, nobody educates himself, men are educated with each other, mediated by the world" (Freire, 1987, p. 68) suggest that individuals are educated by themselves in just as they interact with others, share ideas, discuss, collaborate, cooperate and support each other. Educate, interact, share, discuss, collaborate, cooperate and support are verbs that do not conjugate without mutual respect. From the point of view of the subject, it confers upon students' disrespect one of the main causes and justifications (mentioned by respondents) the inability to apply the active methodologies in everyday classrooms more autonomously. Some teachers also seek to consolidate ethical rules of coexistence in the classroom, so it is possible to neutralize disrespect for teachers, overcoming this deadlock.

Pedagogical Perception of Teachers on the Active Methodologies

Words derived from closed questions (Table 3) are related to perceptions about active teaching methodologies. So the words that were most often mentioned are closely related to "problem based learning", "Active participation" and "advisor teacher". This shows that the number of analyzed teachers are in tune with the concepts of active methodologies and the role of the teacher of the twenty first century, which became a mediator of knowledge construction by the learner.

Table 3 – Pedagogical Perception of Teachers on the Active Methodologies

Pedagogical Perception			
	Biology	Physics	Chemestry
Problem-Based Learning	12%	13%	12%
Active Participation	11%	10%	8,5%
Advisor Teacher	9,5%	8%	9%
Professional Challenge	6%	9,5%	8%
Pedagogical Mediation	5%	10%	6,5%
Project-Based Learning	4%	7%	4%
Reconstruction of Teacher's Role	-	3%	11%
Criticism and Reflection	4,5%	7%	2%
Other	48%	32,5%	39%
Total	100%	100%	100%

The problem-based learning, term evoked by 37% of respondents refers to the natural sciences, the active methodologies are understood (and supported) by teachers, because most respondents were trained with expository classes (fruit of the traditional school), carving in themselves a transmission of content that became purely informative and greatly committed to the construction of scientific knowledge. Respondents point out that the indiscriminate use of traditional pedagogy, unknowingly causes the student to perceive the sciences as the disciplines that are difficult to understand because they are filled with scientific terms that end up with no practical purpose to the student, which causes a lack of involvement of this in the learning process. Conceptions of education grounded in traditional, New School and technicist schools are called uncritical theories because they do not exert commitment to social change, endorsing the economic and social system imposed through a curriculum that emphasizes the culture of the ruling elite.

In contrast the method of problem-based learning is supported by the post-critical theory which share the possibility of working with problem solving for the development of the teaching-learning process. The post-critical theory "advocates a curricular organization based in areas of knowledge in which the multiple dimensions of content are integrated and interrelated with each other, awakening a critical and reflective analysis in students" (Lima; Zanlorenzi; Pinheiro, 2011 p. 94). However, with the testimony of the respondent PB17, is displayed that there are still teachers who choose to work with reproductivist pedagogy.

Few science teachers possess skills and abilities to work actively in curriculum content and which enables students to develop the scientific spirit [...]. I've been reading some research about my area (genetic) whose aim was to raise the knowledge that students have about the topic in various contexts [...] And the conclusion is astounding, they demonstrated that students leave the classroom without basic concepts of genetics, as the relationship gene / chromosome and the process of mitosis and meiosis [...].

The term active participation, mentioned by 29.5% of teachers surveyed contains at its core some very peculiar characteristics found in the literature. Active participation in the literature refers to the participation of students in the teaching and learning process of knowledge construction, as prior reading of texts, pretests, work in pairs, teaching strategies grounded in mediation movement of student participation and other (Arraro et al, 2011). Almost all teachers used the term active participation in the context of praxis. This vision is clear in the survey conducted herein, insofar as there is no dissociability between theory and practice it is urgent to discuss the term active participation and practice for teacher performance.

The challenge imposed to the faculty of the XXI century is to develop in its students the individual autonomy, but in close alliance with the whole. Teaching practice should be able to trigger the vision for the whole but provide opportunities for social change, coupled with the attainment of the individual conscience. The active methodologies admit an emancipatory pedagogical practice, fulfilling the goal of education, which is to enable an individual who is born dependent, and that alone, by mere process of growth and maturation would not become an autonomous adult human being or an emancipated subject (post-critical theory).

This is only possible because the human being is capable of learning, has the innate ability of interacting with other human beings develop skills and competences necessary for their implementation. So one of the merits of active methods is precisely the growing trend to seek innovative methods, which admit an ethical pedagogical practice, critical, reflective and transformative, exceeding the limits of purely technical training, to effectively achieve the formation of man as a historic being (Mitre et al, 2007, p. 2134), inscribed in the dialectic of action-reflection-action. This dialectic is interpreted by Professor PF38 as the result of praxis:

It bothers to analyze teaching practices, the dichotomy that exists between theory and practice [...] They are treated as practices linearly so different. Teaching is historically constructed before and during the career path of teaching. Then it creates a vicious circle, where teacher training depends basically both from theories, as of the practices developed in school life. The active methodologies emphasize the mobilization of knowledge built to solve specific problems [...] But we should not prioritize theory over process ... And vice versa.

The vision of the teacher advisor is shared by the population studied, we found no reports on the condition of different mediator that the teacher occupies the position of active methodologies. The justifications found in this evocation refers to the appropriation of knowledge about the mechanisms of learning and teaching, allowing teachers to choose new ways of working, overcoming difficulties and envisioning new possibilities for teaching with quality.

Another point of the educational proposal to the active methodologies that guides the behavior of teachers is one that puts the student at the center of the process, giving him responsibility and autonomy in the construction of knowledge, but it seems clear that the teachers surveyed stating the student as a central element of educational action does not mean to remove from the teacher the responsibility for the educational process, leaving students adrift, as argued by some proponents of more traditional teaching to being opposed to critical pedagogies, accusing them of stimulating a laissez-faire, harmful to the educational process (Mourão et al, 2012). Rather, it means to say that student learning should be the focus of teacher performance and the guarantee and learning, and that all efforts should be made by the teacher in providing experiences that promote the achievement of the objectives established for all students (Gomes 2010, p. 187) This behavior are the required for those teachers who seek to conduct the training of future professionals who can be stimulated by active methods.

CONCLUSIONS

In this work was assumed the hypothesis that social representations of sciences teachers of IES researched refer to the role of the university professor of the twenty first century, because they express the dialectical movement with the social aspects, not just emanating from the initial training received, but considering all social relationships, their contexts and their possibilities for obviousness. However, after analyzing the data, we consider a variable that was not expected to find, the social representations nominated here as restrictive factors the active methodologies.

The relevance of the representational plan in this case specifically focuses on analyzing that the active methods by themselves cannot change the perception that students have of the learning process and if there is no commitment on the their side, little or nothing will change. According to the classics in motivational psychology, is the scant possibility that all students in the same classroom, engage unpretentiously in all proposed activities. It must be emphasized that the material conditions of teaching work found here is a facilitator for the problem to persist. Given the above, and assuming that education is a collective, supportive, committed, act it is necessary for the teacher to do his/her part and evaluate the appropriateness of their teaching to active methodologies.

The social representation of restrictive factors towards active methodologies presented in Table 1, can express, among other factors, the accommodation of professional teacher who sometimes have greater ease in delivering pre-set jargon than maintaining a real interest in getting to know and apply new educational approaches in daily school life, as these require study, updating, suitability and new postures in front of a globalized and complex world. You must take the first step to engender new ways. So you need to work on changing pre-established social representations and seek to build new representations of what is possible, feasible, advisable, since learning is always mutual.

From a theoretical standpoint, it is not possible to reduce in a thoughtless way a teaching theory to a theory of how to help some students learn in the classroom (Oliva, 2011). One cannot ignore that central learning problems are concentrated not only in classrooms but also reside in institutional education systems. Therefore, the investigation in the field of social representations restores the conversation with teachers from what exists within the imagination, the consensual and school practices, requiring awareness and adaptation of pedagogical practice these as elements that also make their learning and, as the student, are in a constant process of learning to learn.

BIBLIOGRAPHY

Arraro, Telma Elisa ; Prado, Marta Lenise Do ; Silva, Denise Guerreiro Vieira Da; Radunz, Vera; Kempfer, Silvana Silveira ; Sebold, Luciara Fabiane. Socialização como processo dinâmico de aprendizagem na enfermagem. Uma proposta na metodologia ativa. *Investigacion y Educacion en Enfermeria,* Sept, v.29 , p. 248, 2011.

Borille, Dayane Carla; Brusamarello, Tatiana; PAES, Marcio Roberto; Mazza, Verônica de Azevedo; Lacerda, Maria Ribeiro; Maftum, Mariluci Alves. 2012. A aplicação do método do arco da problematização na coleta de dados em pesquisa de enfermagem: relato de experiência. *Texto Contexto Enfermagem*, Florianópolis, jan-mar. v. 21, p. 209-216, 2012.

Colombo, Andrea Aparecida; Berbel, Neusi Aparecida Navas. ProblematizationMethodology with Maguerez' Arch and its relation to teachers' knowledge. Semina: *Ciências Sociais e Humanas*, Londrina, v. 28, n. 3, p. 297-334, 2012.

Cronbach, L. J. Coefficient alpha and the internal structure of tests. *Psychometrika,* Greensboro, NC, v. 16, n. 3, p. 297-334, set. 1951.

Freire, Paulo. *Pedagogia do Oprimido.* 39 ed. Rio de Janeiro: Paz e Terra, 1987.

Gomes, Maria Paula Cerqueira; Ribeiro, Victoria Maria Brant; Monteiro, Dilva Martins; Leher, Elizabeth Menezes Teixeira; Louzada, Rita de Cassia Ramos. The use of active learning methodologies in graduate courses in health and social sciences – students's evalution. *Ciência & Educação,* v. 16, n.1, p.181-198, 2010.

Hoppen, Norberto; Lapointe, Liette; Moreau, Eliane. Um guia para a avaliação de artigos de pesquisa em sistemas de informação. *Revista Eletrônica de Administração.* Porto Alegre, ed. 3, v. 2, nº 2, nov., 1996.

Jodelet, Denise. Contribuições das representações sociais para a análise das relações entre educação e trabalho. In: Pardal, L. et al. (Org.). *Educação e trabalho:* representações, competências e trajetórias. Aveiro: Universidade de Aveiro, 2007.

Lima, Michelle Fernandes; Zanlorenzi, Claudia Maria Petchak; Pinheiro, Luciana Ribeiro. *A função do currículo no contexto escolar.* Curitiba: IBPEX, 2011.

Marin, Maria José Sanches et al. Aspectos das fortalezas e fragilidades no uso das metodologias ativas de aprendizagem. *Revista brasileira de educação médica.* v.34, n.1, p. 13-20, 2010.

Mazzotti, Alda Judith Alves. Representações Sociais: aspectos teóricos e aplicações à educação. *Múltiplas Leituras.* São Paulo: Universidade Metodista de São Paulo, Vol 1, n. 1, 2008.

Moscovici, Serge. *Representações sociais:* investigações em psicologia social. 3. ed. Petrópolis: Vozes, 2003.

Mourao, M. G. M.; Maciel, R. C.; Santos, M. S.; Mourao, D. M. ; Marques, M. S. Active methodologies in medical graduate. *Motricidade*, April, V.8, p.875, 2012.

Oliva, Francisco Javier Castejón. Perceptions and difficulties in the use of participative methodologies and formative evaluation in science of physical activity degree. *Revista Electronica Interuniversitaria de Formación del Profesorado,* v. 14, p. 117, 2011.

Orlik, Yuri. Química: metodos activos de ensenanza y aprendizaje. *Editorial Iberoamérica,* México, 358 p. 2002.

Received 29-01-2014 / Approved 02 -05- 2015

La física en la vida cotidiana: curso no formal para adultos mayores

Physics in everyday life: a non-formal course for elderly adults

[1] Farina, Juan, [1]Tabares, Ignacio, [1] Silva, Carlos, [1] Blesio, Germán, [2] Milicic, Beatriz

[1]Instituto Politécnico Superior Gral. José de San Martín, [2] Facultad de Ciencias Exactas, Ingeniería y Agrimensura, Universidad Nacional de Rosario, Argentina - jfarina@ipolitec.unr.edu.ar

Resumen

El incremento de la esperanza de vida de la población debe estar asociado a un envejecimiento activo y a un rol socialmente significativo: ello implica la generación de nuevos espacios para su enriquecimiento social y cultural, entre los que se encuentran los educativos. Desde hace varias décadas se han ofrecido programas de educación no formal para la tercera edad que dan respuesta a estas inquietudes culturales, a la organización del ocio y el tiempo libre y a la ampliación de las relaciones interpersonales. En 2011 se creó en la Universidad Nacional de Rosario el Programa Universidad Abierta para adultos mayores, que incluye, entre otros, un curso de física, centrado en aspectos relativos a la física de la vida cotidiana. En este trabajo se presentan el diseño del curso y los resultados de una encuesta destinada a conocer si este curso de física es considerado significativo por los participantes, es decir, cumple con los objetivos de programas educativos no formales para adultos mayores.

Palabras clave: *adultos mayores, educación no formal, curso de física, envejecimiento activo*

Abstract

An increase in life expectancy should be associated with active aging and a significant social role: this involves the creation of new spaces for social and cultural enrichment, among which is education. For several decades non-formal education programs for seniors have been offered that respond to these cultural concerns, the organization of leisure and free time and expanding relationships. In 2011 we established at the National University of Rosario an Open University Program for Elderly People, which includes, among others, a Physics course, focused on the Physics in everyday life. This paper presents its design and the results of a poll designed to determine whether this physics course is considered significant by participants, that means, meets the objectives of non-formal educational programs for elderly people.

Key words: *elderly people, non-formal education, physics course, active aging*

INTRODUCCIÓN

Una de las transformaciones sociales más importantes que se han producido desde mediados del siglo pasado está relacionada con la mayor esperanza de vida de la población y con la reducción del índice de natalidad, que impacta en el incremento de los adultos mayores en la población. Datos publicados por las Naciones Unidas en el 2012 (United Nations, 2012a) muestran el incremento mundial del número de personas mayores a 65 años, en el año 1950, el porcentaje de la población mayor a 65 años fue del 8% (United Nations, 2012b) mientras que en el año 2012, la relación fue del 11 %. En relación con los países sudamericanos, en 2012 Uruguay posee la relación más alta, con un 19% y Argentina ocupa el segundo lugar con un 15%.

Este envejecimiento poblacional no tiene precedentes (United Nations, 2012b) en la historia de la humanidad, el incremento de adultos mayores de 65 años va acompañado de la disminución de jóvenes menores a 14 años y posee importantes consecuencias en distintas áreas: respecto de lo económico, incidirá en el ahorro, la inversión y el consumo, los mercados de trabajo, las jubilaciones, la tributación y las transferencias intergeneracionales. Respecto de lo social, en la atención de la salud, la composición de la familia, las condiciones de vida, la vivienda y la migración, en lo político, puede incidir en los patrones de voto, etc.

Si se analiza la evolución del porcentaje de la población mayor a 65 años y el de menores de 14 años respecto del total de población en la República Argentina (INDEC, 2011), se observa en la Figura 1 que la relación entre ambos grupos etarios disminuye drásticamente a partir de inicios del siglo XX, pasando de un 19,6 para 1914 a un 2,6 en 2011.

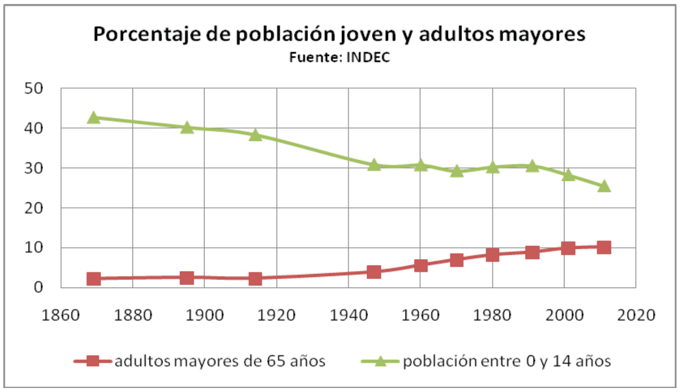


Figura 1: Porcentaje de población menor a 14 años y mayor de 65 años respecto de la población total en la República Argentina (Fuente: INDEC, 2011)

El incremento de la esperanza de vida debe tener correlación con una vida activa y un rol socialmente significativo. La vida activa se refiere no sólo a estar activos física o económicamente, sino a la participación de los adultos mayores en asuntos sociales, económicos, culturales, espirituales y cívicos. Esto les permite tomar parte en la sociedad de acuerdo con sus deseos, necesidades y capacidades, mientras se les proporciona apoyo, protección, seguridad y cuidados adecuados cuando necesitan asistencia (Ganso y col., 2012).

Para que exista esta vida activa se deben generar nuevos espacios diferentes de los relacionados con la vida laboral para su enriquecimiento social y cultural, entre los que se encuentran los educativos. Desde hace varias décadas en todo el mundo se ofrecen programas de educación no formal para la tercera edad que dan respuesta a estas inquietudes culturales, a la organización del ocio y el tiempo libre y a la ampliación de las relaciones interpersonales.

Si bien en la República Argentina desde la década del ´90 se ofrecen diferentes tipos de programas en distintas universidades, en 2011 se creó en la Universidad Nacional de Rosario el *Programa Universidad Abierta para Adultos Mayores*, (UNR; Res. C.S. 016/2011) enmarcado en la filosofía de la formación permanente, consiste en la implementación de cursos, talleres y otras actividades educativas y culturales destinados a los adultos mayores, dictados por docentes universitarios, con temáticas pertinentes o afines al contexto disciplinar de la oferta académica de la UNR. Al estar destinada a una población heterogénea, el diseño de esta oferta constituye un desafío respecto de la selección de los temas a desarrollar y de la metodología a emplear.

Es en este marco que se viene implementando un curso de física para adultos mayores, centrado en la física de la vida cotidiana. En este trabajo se presentan el diseño del curso, los criterios que guiaron su organización y los resultados de una encuesta destinada a conocer si este curso de Física es considerado significativo por los participantes, es decir, si cumple con los objetivos de programas educativos no formales para adultos mayores.

LA EDUCACIÓN NO FORMAL PARA ADULTOS MAYORES

La percepción general sobre la vejez está asociada con la demanda de servicios, ayuda y cuidados, tratándola en consecuencia como un problema o carga social. El adulto mayor percibe que se pierden lazos que dieron sentido a su vida: mueren los padres, cónyuges y amistades, los hijos se independizan, el retiro aparta o limita las relaciones con los grupos de compañeros de trabajo, desciende notablemente la actividad social, todo ello unido a restricciones económicas debidas a montos exiguos de jubilación y a un deterioro físico creciente. Esta situación plantea la necesidad de que emerjan políticas que promuevan redes sociales de contención para el adulto mayor, para incrementar una participación social significativa y un estilo de vida activo, vinculados al mantenimiento de una buena calidad de vida y a la prevención y atenuación de enfermedades (Sánchez Salgado, 2010).

La participación social significativa permite el desarrollo del potencial personal y de nuevas relaciones sociales repercuten no sólo en su bienestar personal sino además en una renovación de la representación social de la vejez (Urquijo y col., 2008). La participación social del adulto mayor se desarrolla en asociaciones y movimientos sociales, en el voluntariado, en actividades educativas, políticas, de ocio y tiempo libre, recreativas, culturales o religiosas.

Los factores que explican un envejecimiento exitoso (Vellas, 1996) pueden resumirse en el desarrollo y mantenimiento de una buena red de relaciones socio afectivas, de una adecuada capacidad funcional física, alcanzada mediante ejercicios apropiados de mantenimiento físico, de una capacidad funcional cerebral, lograda mediante la estimulación de la activación cerebral, de un buen estado nutricional, de un proyecto de vida motivante para prevenir déficits psicológicos, para evitar la carencia de actividades se debe sustituir lo que ya no se puede hacer con lo que se hace, y emplear paliativos apropiados que permitan compensar incapacidades.

Es en este marco que la educación propone un tipo de intervención que trata de descubrir el mejor modo de ayudar a las personas a reconocer las posibilidades que ofrecen los diferentes momentos de la vejez, tratando de favorecer un mejor ajuste y una mayor satisfacción vital, para potenciar los aspectos positivos de los cambios y disminuir los efectos negativos (Martín García y Requejo Osorio, 2005). Es por ello, que la educación es un importante espacio de intercambio e integración para las personas mayores, pero además puede ser considerada como una posibilidad de resarcimiento frente a la falta de oportunidades que tuvieron en otras etapas de la vida (Yuni y Urbano, 2005).

Desde hace varias décadas, los programas universitarios para adultos mayores se vienen desarrollando en un gran número de universidades. Sus objetivos principales tienen que ver no sólo con el aprendizaje sino también con fomentar la interacción social y aumentar la calidad de vida de las personas mayores de 60 años. En los años ’80 funcionaban entre 110 y 120 universidades de la tercera edad, con un número total de alumnos superior a 125.000 (Vazquez Clavijo y Fernández Portero, 1999). Estos autores citan programas en las Universidades españolas de Alcalá de Henares, Alicante, Almería, Autónoma de Madrid, entre otras, mientras que en América Latina existen más de 160 programas (López La Vera, 2011), por ejemplo, la Universidad de Costa Rica, con más de 25 años de experiencia, la Universidad Nacional de Santiago del Estero (Argentina), con 20 años de experiencia, la Universidad Cubana, el Tecnológico de Antioquia (Colombia), la Universidad de la Experiencia (Perú), etc.

Martín García y Requejo Osorio (op.cit.) citan los siguientes objetivos para estos cursos: a) mostrar el reconocimiento de las posibilidades que ofrece la vejez al sostener que el *enriquecimiento social* siempre es posible. b) *sensibilizar* a los adultos y ancianos ante determinados programas de intervención socioeducativa en función de los contextos sociales y culturales. c) desarrollar un nuevo modo de vivenciar la vejez, de relativizar la influencia biológica y social de la edad cronológica y de eliminar formas institucionalizadas de prejuicios y estereotipos hacia los adultos mayores. d) ser una oportunidad para la *comunicación e interacción humana*, que fomenta el *desarrollo personal* junto a otros al ofrecer alternativas socialmente compartidas al ocio y al tiempo libre, facilitando roles significativos para su integración. e) ofrecer un entrenamiento en procesos de razonamiento deductivo, memoria y otras funciones mentales para *mejorar los niveles de salud. f)* facilitar *roles significativos* a los adultos mayores para su integración en el contexto social, desarrollar o potenciar el crecimiento y el desarrollo personal en las esferas afectiva, física y mental, aumentando la calidad y el disfrute de la vida. g) aumentar la *autosuficiencia* y mejorar creencias sobre las habilidades propias al aumentar la capacidad de resolver problemas de la vida diaria, disminuyendo la dependencia familiar y social.

Estos autores señalan las características esperables en las aulas para la tercera edad, que se basan en la filosofía de la formación permanente, cultural y social. Deben ser participativas, tratando de implicar a las personas en el proceso, no competitivas, buscando la cooperación y la solidaridad, motivadoras, para lo cual se emplean técnicas de animación sociocultural, donde prima lo lúdico, lo creativo, el aprendizaje basado en problemas, en estudios de caso, proyectos, etc.

Respecto de la educación en física para adultos mayores, son escasas las publicaciones en este área, en la búsqueda bibliográfica llevada a cabo sólo se encontró un trabajo que analiza cómo afecta el envejecimiento a las capacidades para establecer relaciones inversas en la vida diaria, empleando ejemplos de la física intuitiva (Leoni y col., 2002).

CURSO DE FÍSICA PARA ADULTOS MAYORES

El curso “*Física en la vida cotidiana*” forma parte del Programa Universidad Abierta para adultos mayores. Se inicia en el año 2011 con una duración de dos meses, desarrollado en un encuentro semanal de 2 horas. En el año 2012, a pedido de los participantes, se extendió a 8 meses, en 2013 su duración fue de 4 meses, pero con encuentros de 3 horas de duración. En 2014 se está dictando con una duración de 6 meses y dos horas semanales de duración. Hubo 20 participantes en 2011, 14 en 2012, 20 en 2013 y 28 en la actualidad.

Como se ha mencionado, este curso se enmarca en la filosofía de la formación permanente, con fines no sólo de brindar conocimientos relativos a la física, sino además de ampliar las relaciones interpersonales de los participantes. El curso persigue despertar curiosidad, estimular la forma de aprender más, acercar de manera no formal conceptos e ideas básicas de la física relacionados con la vida cotidiana. Con el objetivo de atender los intereses de los participantes, los temas tratados en los cursos implementados en el segundo y tercer año han sido propuestos por los participantes.

La metodología empleada se basa en el análisis de experimentos mostrativos sencillos para explicar conceptos, ideas y principios básicos desde el punto de vista fenomenológico. Los contenidos son flexibles y se adaptan a los emergentes que surgen en cada encuentro. Asimismo, se prioriza el trabajo colaborativo, debido a que el grupo de personas que acceden a estos cursos es heterogéneo, con niveles de escolarización desde primaria inconclusa hasta graduados universitarios, los temas se presentan de manera que puedan ser comprendidos por personas con conocimientos generales sin formación matemática elevada. En cada uno de los temas se incluyen ejemplos de aplicación relacionados con el cuerpo humano y dispositivos tecnológicos conocidos. Por ejemplo, al desarrollar el teorema general de la hidrodinámica se realizó en primer lugar una experiencia con un balde perforado a distintas alturas, para calcular la velocidad de salida del agua en función de su alcance en el piso. Se graficaron los resultados y luego se los aplicó al análisis de la instalación de cañerías de agua en el hogar, con cálculos sencillos de la velocidad de salida del agua por las canillas en los distintos pisos, hasta qué altura llegaba el agua sin necesidad de colocar bombas, etc. Al estudiar el caudal se analizaron los procesos de arterioesclerosis y aneurismas, temas que están presentes en las conversaciones de los mayores.

Como una manera de incentivar el gusto por la ciencia y en particular por la física, se incluyen algunos textos de lectura en donde se destacan aspectos relacionados con el contexto histórico en que se desarrolló una experiencia de física, comentando situaciones socioculturales en que estaban inmersas estas personas que habían descollado como físicos como por ejemplo Arquímedes, Bernoulli o Tesla. En el curso del año 2012, los participantes aportaron en los encuentros posteriores artículos de diarios o revistas en las que se los mencionaba, enriqueciendo la clase con la sociabilización del conocimiento que cada uno de ellos brindaba. Esto permitió descubrir en parte el interés que los participantes depositaban en el curso y qué esperaban de los docentes su cargo.

A solicitud de los participantes, en cada encuentro se entrega material escrito donde se desarrolla cada tema y en el que se incluyen preguntas y problemas sencillos que deben contestar los participantes en su casa, las que son discutidas en el siguiente encuentro. A continuación se detallan los temas tratados en cada curso:

Año 2011: Óptica geométrica. La ciencia del color. Fenómenos térmicos.

Año 2012: Fluidos Newtonianos y No Newtonianos. Presión hidrostática. Dinámica de fluidos. Ecuación de Bernoulli. Viscosidad. Tensión superficial. Capilaridad. Electricidad. Magnetismo. Física de la cocina

Año 2013: Mecánica. Ondas. Astrofísica

Año 2014: Óptica Geométrica y óptica física. Colores. Ondas electromagnéticas. Física cuántica. Sonido. Fenómenos térmicos. Fluidos Newtonianos y No newtonianos. Estática y dinámica de Fluidos

OPINIÓN DE LOS PARTICIPANTES RESPECTO DEL CURSO

Para saber si los cursos son significativos para los participantes y si realmente cumplen con las características propias de los cursos para adultos mayores, se realizan encuestas al finalizar cada uno de ellos, cuyos resultados se muestran a continuación:

Programas educativos como promotores de oportunidades

Se observa una buena acogida al programa por parte de los participantes, no sólo debido a su interés personal, sino además porque encuentran un ámbito en donde se los valora. Se refleja en la mayoría de las respuestas la alegría de sentirse integrados y reconocidos. Por ejemplo, sostienen que "*siempre tuve inquietud por asistir a cursos y estos me parecen muy buenos, por el contenido y por insertar a los adultos mayores, que aún tienen ganas de aprender, repasar, compartir espacios con gente joven* [profesores]. *Es muy valorable.*"

Motivaciones para participar

Varios son los motivos por los cuales los participantes realizan el curso, desde *"esta actividad contribuye a la calidad de vida del adulto, ya que entusiasman las clases y el adulto siente que todavía puede aprender, recordar lo poco que vimos en el secundario y poder compartir con nuestros pares.",* como el mero hecho de conocer, en este caso, qué es esa cosa llamada física*" que durante mi vida no tuve la oportunidad de estudiar"*, así como "*estudiar mantiene mi mente ágil y abierta"* con apertura a nuevos conocimientos, o refrescar conceptos y aplicaciones olvidadas.

Importancia otorgada por los participantes:

En la encuesta han surgido diferentes razones por las que el curso ha sido importante para los asistentes, entre las que se encuentran la integración social: "*Trata de evitar la marginación de los adultos mayores, promoviendo su integración*", promueve la autovaloración: "*Se nos tiene en cuenta y aún, a pesar de nuestra edad, estamos activos y podemos adquirir, utilizar y transmitir conocimientos*", "*Es una manera de demostrarnos primero a nosotros mismos y luego a los demás (especialmente a los más jóvenes) que siempre se puede hacer algo con voluntad y decisión*", es beneficiosa para la salud "*Es importante, no sólo por ser un espacio referente a la cultura, sino también a la salud porque evita enfermedades que disminuye el área cognitiva*". Se observa también la dureza con que vivencian la marginación social como "*somos un sector olvidado de la población*"

Obstáculos al acceso a la educación continua:

Respecto de los obstáculos que perciben al acceso a estos cursos no sólo surgen factores externos como el económico, la familia, la falta de posibilidades, sino además el cultural, la discriminación, la concepción de que el adulto mayor ya terminó su vida útil y es innecesario que pueda alcanzar un desarrollo personal. Entre los factores internos no sólo aparecen la salud, la movilidad, la falta de perseverancia y de motivación, sino también las inseguridades "*el primer obstáculo a vencer somos nosotros mismos y nuestros miedos*.",

Relativos al curso de física:

En relación al curso de física en particular, si bien existe una gran heterogeneidad en los participantes, no sólo en su nivel escolar sino en sus intereses, que van desde "*la materia es apasionante*" hasta "*no habiendo cupos para otros cursos, elegí física*", se observa interés por los temas desarrollados "*Fue mejor que lo que esperaba, didáctico y preciso", "Esperaba conocer un poco de una materia que era prácticamente desconocida para mí, fue una introducción que cubrió mis expectativas y deseo más", "Me parecieron clases amenas y me dejaron conceptos básicos sobre los temas abordados. Eran mis expectativas sobre el curso*."

Los participantes han realizado requerimientos respecto de prolongar el curso, incrementar el número de horas e incluir resolución de problemas y textos para estudiar en la casa. *"Con el resumen de lo dado en clase podemos estudiar para la clase siguiente"* Hay que recalcar también que, debido a la heterogeneidad, surgen requerimientos de realizar cursos con niveles de profundidad diferenciados.

CONSIDERACIONES FINALES

La planificación e implementación del curso de física no formal para adultos mayores ha sido un desafío para los docentes responsables respecto de sus rutinas de enseñanza, quienes son profesores universitarios y/o de una escuela técnica dependiente de la universidad, habituados a desarrollar contenidos pautados de antemano en un intervalo de tiempo especificado, con un alto grado de abstracción y formalidad matemática. Por lo tanto, los docentes debieron realizar un esfuerzo de adaptación a las características propias de estos cursos, con una programación semiestructurada, flexible respecto de los contenidos y del cronograma, para poder ir atendiendo a los emergentes en cada clase, el desarrollo de los temas se realiza desde un punto de vista fenomenológico a través de una metodología basada en experimentos y análisis de gráficos y distribución de los tiempos en función de los requerimientos de atención y físicos de los participantes.

Una ventaja importante es que, a diferencia de los cursos formales, es manifiesto el interés de los participantes tanto por los temas, que han sido propuestos por los mismos asistentes, como por la alta participación durante los encuentros. Asimismo, es de destacar la bidireccionalidad que existe en la comunicación, ya que los participantes aportan sus experiencias de vida en los encuentros.

Los asistentes han solicitado temas para futuros cursos en los que no es fácil su explicación a partir de experimentos sencillos, es por ello que los docentes están abocados a encontrar metodologías que se adapten a las características propias de estos cursos, por ejemplo, el uso de simulaciones.

Considerando el resultado de las encuestas se observa que el curso proporciona un espacio que los participantes consideran válido para su desarrollo personal y el incremento de su autovaloración. Muchos consideran que han demostrando, no sólo para sí mismos sino para la sociedad, que todavía tienen ganas de hacer cosas, de aprender y que poseen la capacidad para hacerlo. Consideran que el curso facilita un estilo de vida activo, ofrece un ámbito de interacción social, donde el aprendizaje se realiza *con otros*, y una participación social significativa, todos ellos vinculados no sólo a su bienestar personal sino que además repercute en una renovación de la representación social de la vejez. Dada la especificidad de la física, el curso ofrece además una oportunidad de entrenamiento en procesos de razonamiento y de ejercitación de la memoria, contribuyendo a mejorar la capacidad funcional cerebral.

Por todo esto, se considera que el curso es apropiado para aportar a la calidad de vida en los adultos mayores, como expresó un participante: "*No sólo contribuye a la calidad de vida, sino que enriquece y hace sentir que aún se puede hacer algo para uno mismo y la comunidad".*

BIBLIOGRAFÍA

Ganso, H., Berezin, S. & Scarímbolo, G. Talleres de adultos mayores: un aporte para el envejecimiento activo, *Palabras Mayores,* **5** [9], 2012.

INDEC. *Indicadores demográficos seleccionados para fechas censales. Total del país. Años 1869-2010.*2011

Léoni, V., Mullet, E. & Chasseigne, G. Aginig and intuitive physics. *Acta Psychologica* ***11**, 29-43.* 2002.

López La Vera, B.; Programas educativos para mayores en América Latina: los retos del inicio y los retos de hoy, *Memorias del IV Congreso Iberoamericano de Universidades para Mayores*, CIUUMM -2011, 1121-1142. 2011

Martín García A. V & Requejo Osorio A. Fundamentos y propuestas de la educación no formal con personas mayores. *Revista de Educación* **338**, 45-66. 2005

Requejo Osorio A. La educación de "personas mayores" en el contexto europeo. *EFORA* ***3,*** 45-63. 2009.

Sánchez Salgado C. D. Participación social de las personas mayores y redes. *Memorias III Congreso Internacional de Gerontología*. Costa Rica. 2010.

United Nations Population Division *Population Ageing and Development 2012 – World Chart*. 2012a.

United Nations Population Division *World Population Ageing 1950-2050*. 2012b.

UNR - *Programa Universidad Abierta para Adultos Mayores.* Res. 016. 2011

Urquijo, S., Monchietti A. & Krzemien D. Adaptación a la crisis vital del envejecimiento: Rol de los estilos de personalidad y de la apreciación cognitiva en adultos mayores. *Anales de psicología*, **24** [2], 299-311. 2008.

Vázquez Clavio, M & Fernández Portero, C. Aprendizaje universitario y personas mayores. El Aula de la Experiencia en la Universidad de Sevilla. *Escuela abierta.* **3,** 33-66. 1999.

Vellas P. Envejecer exitosamente: concebir el proceso de envejecimiento con una perspectiva más positiva. *Salud Pública de México*, **38** [6], 513-522. 1996.

Yuni J. A. & Urbano C. A. Aportes para una conceptualización de la relación entre el aprendizaje y resignificación identitaria en la vejez. *Palabras mayores*, **6**. 2011.

Received 04-03-2014 /Approved 02 -05- 2015

Assessment of Marie Curie's first classes at the "Teaching Cooperative" based upon Isaac Watts

Análisis de las primeras lecciones de Marie Curie en la "Educación Cooperativa", basada en Isaac Watts

Ingrid Nunes Derossi , Ivoni Freitas-Reis

Chemistry Department, Federal University of Juiz de Fora, Minas Gerais, Brazil, ingriderossi@gmail.com

Abstract

The focus in this work is to show scientist Marie Curie as an educator, a less well known characteristic. To that end, an analysis was made of selected episodes/ instances of the two first experimental physics classes in her educational project of a "Teaching Cooperative". This analysis was based upon the book "The Improvement of the Mind" by Rev. Isaac Watts (1674-1748. Within these approaches the researcher attempts to relate Marie Curie's teaching methodology to 21st Century teaching methods.

Key words: *teaching, Marie Curie, experimentation, Isaac Watts*

Resumen

Este trabajo presenta una característica poco revelada del científico Marie Curie, como educadora. Para tal fin, se propuso analizar episodios seleccionados de las dos primeras clases experimentales de física, señalado por uno de sus alumnos en un proyecto educativo "Educación Cooperativa". Este análisis comparativo se basa en el libro The Improvement of the Mind del reverendo Isaac Watts (1674-1748). Discutimos también extractos de la vida de la investigadora en un intento de justificar su metodología de enseñanza.

Palabras clave: *Marie Curie, experimentación, Isaac Watts*

INTRODUCTION

Marie Curie's Christian name in her home country, Poland, was Marya Salomee Sklodowska (1867-1934); although as she spent the greater part of her life in France, where she became a prominent scientist, and, although it is not well known she was also a prominent educator. In the French manner she began to be called Marie, and after she married she adopted her husband's name. Her family was traditionally involved with education; her mother had studied in one of the private schools for women, and her father, Mr. Wladyslaw Sklodowski was one the most influential people in his academic field and this contributed to the design and conjuring of one of her ideals (Curie, 1957).

Within this familiar scenario, Marie finished school in 1883 and just after that she began attending classes in a local clandestine higher education school, since Warsaw's university still would not admit women. In this environment, she came upon the ideas of Auguste Comte (1798-1857) and positivism, which, in the Polish version/strand brings up equality between genders in terms of education and the importance of reason and science for society. This young lady found she was home to some of positivism's ideals and advocated them (Reid, 1974; Quinn, 1997).

At the time, she was living with Bronia, her sister, who had already majored in Medicine as Marie arrived in Paris, in 1891. At last, the Polish young lady was able to join a select group of twenty-three women, out of nearly two thousand students enrolled in the Sorbonne School of Sciences. In July, 1893, she received was delighted with the announcement that she had achieved first place in the class for "physical" sciences (Curie, 1957).

Involvement with science teaching

Her conceptualization of teaching, in how to teach, was largely influenced by the way her father brought her up and how he taught her. Upon contemplating his children's education, Mr. Sklodowski would see, in simple things, learning opportunities; and Marie already regretted the absence of a laboratory to perform experiments and tests on the subjects encountered.

Such an appreciation for experimental tasks would remain with her for all her life, augmenting her university attainments in the Sorbonne. In her formal career, in the School of Sèvres in 1900, Marie's stand on experimentation made her include practical classes in her teaching methods. For such practice, she increased the time of classes and arranged her own hands-on material (Quinn, 1997, p. 234).

With such distinguished views on teaching, Marie and a group of hardworking science students in Paris, in 1907, decided to create a "cooperative of teaching", wherein one of the scientist-parents would be in charge of one subject and the students would attend one class per day; in most cases, practical classes. Marie was assigned to the teaching of Physics, and her classes would go on happily, among snacks and smiles, on Thursday afternoons (Curie, 1957).

With the purpose of assessing the scientist's teaching methodology, the work entitled *The Improvement of the Mind,* by Isaac Watts (1674-1748) was employed, a book which was first published in 1741 as a supplement to a previous work about logic. Since then, this work has been reissued until the twenty-first century, the last edition that we know it was in 2012.

The option to use the book by Isaac Watts (1674-1748), happened to us when we read the book Faraday: The Life of James Hamilton (2002), in which he said that Michael Faraday was a persistent concern for the improvement and the improvement of mental perception, which lead to the development of a distinctive methodology. The art of designed experiments leads us to disciplined ordered exercises, training and improving mental removed from the work of Isaac Watts, in the words of Hamilton:

"Faraday first came across *The Improvement of the Mind* at Riebau's shop: it was one of the best-known and most widley read text books of the late eighteenth and early nineteenth centuries, and over Faraday's years with Riebau many copies must have passed throught his hands for binding and selling. Watt's book is a student's guide to study, to the attainment of knowledge, and to the means of learning". (Hamilton, 2002, p. 30)

While we cannot say that Marie Curie, even your father, or the Clandestine University of Warsaw was read I. Watts. Realizing that scientists interested in education as Faraday and Jane Marcet (1769-1858), very interested in the writings of this scholar, we consider it appropriate uses a means of comparison with the methods or teaching strategies used by Marie.

The work of Marie Curie at the "Teaching Cooperative" in the student Isabelle Chavannes' Notes.

When we found the book "Marie Curie classes annotated by Isabelle Chavannes in 1907" and we read the preface in Portuguese writing by the famous member of the Science academy and Emeritus Professor of the *École Polytechnique de Paris* Yves Quéré, he doesn´t evade to make comparisons of the methods used by Marie. It is difficult to disagree with his opinion:

"How don´t we find here remarkable anticipated parallels and intuitions? [...] the accumulation of question marks that are the starting points of all science; the relevance of the experience undertaken by children themselves; the dialectical that established between experimentation and reflection". (Quéré *apud* Chavannes, 2007, p.14)

We did not have doubts this matter was precious to the sciences. Isabelle, was thirteen years, she was the eldest of the student´s group of the Cooperative. The book brings together the notes of the ten classes taught by Marie and brings also images of the handwritten notes made by Isabelle.

We have tried, in this article, to highlight episodes selected from the first two classes, some passages of the dialogs in which knowledge build-up is performed more explicitly. Each and every class brings along vast richness of situations and interventions, both from Madam Curie and from the students. However, by way of an assessment of the first classes, we attempt try to externalize these issues.

First Class: How different is vacuum from air

The first registered class by Isabelle, dated as of January, twenty-seven, 1907 was conducted at the Paris' *École Municipale de Physique et de Chimie* (EPCI), located in Street Lhomond. In this class, the scientist attempts to develop the concept of vacuum with her students. During all of the experiments, Marie summons the students to interact, questioning them, eliciting them and allowing them to actively partake in the experimental part. This pattern in her speech resembles Watts' details-driven descriptions of the conversation method, wherein he says that it is through "mutual discourse and inquiries that learning about others' feelings and communication takes place" (Watts, 1743, p. 32), hence it is feasible to concede that such passage is similar to a class in which there is interaction between the teacher and the student. This is exemplified below:

Marie Curie (MC): "Here we have a bottle … it seems to be empty. What is there inside it?" (Chavannes, 2007, p. 27).

After the students answer that there is air, Marie moves on:

MC: "How can you tell if there is something inside it?" (Chavannes, 2007, p. 27)

In the speech above, and, in her attitude presented as follows, it is feasible to perceive the educator's intention in getting the students to question, to investigate. Such characteristic resembles another passage, also from the Conversation method, which links to the ideal that if the student still does not show a clear understanding of what is discussed. She must endeavor to attain a more expressive conception through investigation (Watts, 1743, p. 33), that is, the student, as faced with the experiments shown, by way of investigation, he/she would build up a personal meaning of all that he/she would be seeing.

In another part of the same class, Marie makes an effort for her students first to fathom the phenomenon and only later take on the scientific language. This again takes us back to the Conversation method, in a part in which Watts advises the tutor in that realizing the presence of an inexperienced person in debates, he/she must walk him/her through a clear knowledge on the subject (Watts, 1743). That is, when the teacher realizes that his/her student does not have a suitable "scientific vocabulary" for dialogs on a given subject, it is the teacher's role to provide the adjustments to the student, by presenting firstly a popular form of expression and then, aid him/her to transition to the scientific form. In the episode referred to, Marie proposes that an experiment with mercury be done, immersing the bottle that contained it upside down in a receptacle full of water, but before removing the cap; she inquires what would happen, and her students respond go on and answer:

Students (SS): "Mercury will go to the bottom of the receptacle". (Chavannes, 2007, p. 28)

"Irène removes the flask's cap and in fact the beautiful and bright mercury falls down quickly to the receptacle bottom" [describes Isabelle]:

SS: "That is because it is heavier than water."

MC: Almost quite that, but not really that. Might a small drop of mercury be heavier than water from a large bottle?

SS: Ah, no!

MC: However, if one fills up a bottle with water and a similar bottle with Mercury, which one is going to be the heavier?

SS: The one that was filled with mercury.

MC: So then, observe this, it is necessary to say that 'for a same volume, Mercury weighs more than water'. Instead of saying this long phrase, it is usually said: 'mercury is denser than water'. […] Air is less dense than water, as we observed just now" (Chavannes, 2007, p. 28).

In an experiment in which a pear made from rubber is used, Marie calls the attention to a property of that object's material; the students observe and feel the air let out by the object and the object fills up once again:

MC: Rubber is an elastic body. After we squeeze a rubber-pear, because of its elasticity, it resumes its initial shape and air is forced back inside the pear (Chavannes, 2007, p. 30).

She makes a comparison using lungs' air. In this passage, it is possible to note a resemblance with a feature highlighted by Watts in the method Public or Private Lectures, wherein he says that "A tutor or instructor, when paraphrasing or explaining another author [or a situation] may seize a precise point of difficulty or controversy") Watts, 1743, p. 38), thus, in making analogies, Marie facilitates understanding of what she was trying to make clear to her students, saying:

MC: When one breathes in, the ribs rise up, the lungs are open and air comes in the rubber pear (Chavannes, 2007, p.30).

In the Conversation method, Watts stresses that "a tutor must explain ideas through familiar examples, and clear ones" (Watts, 1743, p. 39); such concern may be perceived in several moments of Marie Curie's class, since the educator seeks to bring to her students' reality the experiments which they were doing. Where does that pear experiment take place in their lives? The passage below is an example that may be observed in various other moments of her classes. When it is about building up the concept of vacuum, by working with a pear which lets out air and is filled up with water, she explains how suction occurs by way a straw:

MC: As one inhales, the lungs become opened up; there is a vacuum and water emerges (Chavannes, 2007, p. 32).

Marie develops activities that review what has already been done during class, as she demonstrates to her students that there is a relationship among the experiments, and that they are not isolated matters. That becomes evident at the moment the vacuum tube is used in order to remove air from inside the campanula – a glass vase in the shape of a bell or a small dome (glass dome) – so that it is shown what would happen, in a system where the end is closed by way of a pig's bladder, if all air were removed, besides introducing the concept of atmospheric pressure, which is going to be next class' topic.

MC: There is air inside the campanula and outside of it, and such air pressures the two sides of the bladder skin with the same strength. What happens if air is removed from campanula? Let's see. [...] (Chavannes, 2007, p. 34).

MC: [...] It is going to blow up, if we continue, if we remove almost all air from the campanula, that is, as usually is said, producing vacuum (Chavannes, 2007, p. 34)

It is feasible to realize with the passage above, that once again, she introduces scientific language to her students, by reaching the conclusion that if the receptacle is completely airless, that is called vacuum, a feature that has already been presented.

Second Class: In which it is discovered that air weighs on the shoulders

The second class has a possible objective to develop the concept of atmospheric pressure and is dated as of February 3rd 1907. The class was started with a review of what had been discussed and learnt, by means of the teacher's effort to recall the topics and by means of mounting a vacuum tube:

MC: We saw, last class that air exacts pressure. Here we have a large rubber pear which contains air. It communicates with a small thin rubber balloon which is, at the moment, soft and lax. If I wish to increase pressure in the large pear, by compressing the air it contains, I see a small balloon becoming round and full, which proves that pressure has increased in this balloon. The pear's air communicates with the balloon's air by way of a small channel and the pressure is not able to increase on one side without enlargement, at the same time, on the other side (Chavannes, 2007, p. 41).

After this introduction, the educator (teacher - Marie) makes a comparison between what she had just said and the environment in which they are found.

This in turn adapts to the characteristic clarified by Watts, on utilizing analogies to facilitate understanding. If not, let us see:

MC: This room communicates with the exterior by way of doors and windows; the air pressure it has is the same air pressure in the exterior. This pressure it named *atmospheric pressure.* What can be done to increase air pressure in a rubber pear? (Chavannes, 2007, p. 42).

One of the students kids answers the question, saying that it would suffice to compress it; and for such reaction, Marie reminds herself of the way to fill up bicycles' tires, a very common example for kids. It is evident here, once again, the feature already mentioned, wherein the teacher/tutor should provide explanations grounded in familiar examples for the listeners, a tendency of attempting to tighten the proximity of laypeople's science, either by striving to use language that is easy to understand is constantly perceived in Marie.

Then the teacher goes on:

MC: Yes, but there is another way: It is to make air go inside it. There are bicycle air pumps that are utilized to insert air into a receptacle. How do you fill up a bicycle tire? Making air to go in the tire. By means of a new amount of air, air pressure that is inside the chamber becomes greater, and the tire is filled up (Chavannes, 2007, p. 42).

While Marie nurtures her students to investigate, the teacher moves on to the next experiment, which would clear out how air pressure is transmitted, complementing the previous experiment, and already developing a cognitive way for a better understanding of the task which would follow. It is relevant to point out that besides all the features presented in detail by Watts (1743) for a good teacher, in Chapter VI - *Of Living Instructions and Lectures, of Teachers and Learners* from *The Improvement of the Mind*, he approaches precisely what is oftentimes a teacher's question: How to collaborate with the students' betterment and progress? He continues goes on to say that the teacher must be interested, she must be patient and must adapt his/her method to the learners (Watts, 1743, p. 100). In the passage of the class below, it is seen, once again, the concern regarding the understanding of what had just been demonstrated:

MC: We have two small rubber balloons here which communicate with each other. I then dip one of these balloons in water, and I see the other one being filled. This proves that pressure has increased in the set formed by the two balloons and the tube that connects them. What has pressured the balloon that is inside the water? […] The water, evidently, but also air, which exerts pressure on water. This last pressure is transmitted through water. When this balloon was on the surface of the water, only *atmospheric pressure* would pressure it. When I inserted it into the water, it had to withstand the atmospheric pressure and the water pressure. Provided that this balloon is kept inside the water, pressure remains the same in both balloons, nonetheless, the more deeply I dip it in the water, the greater is the set's pressure. Can you fathom that the greater the amount of water in the balloon immersed, the greater is the pressure that water exerts? (Chavannes, 2007, p. 42)

Figure 1: The balloons dip in water (Chavannes, 2007, p. 43)

Seeking to develop a perspective of the whole, while she was concerned with the effect that could lead to elaboration of an experiment without highlighting its dissimilarities, Marie performs a new experiment, this time, in order to demonstrate what happens with water pressure. What would possibly happen? Would this (water pressure) be transmitted like it is with air, as demonstrated previously? After questioning her students, she starts the experiment using a U-shaped tube:

MC: [...] With this tube we are going to show that water, like air, transmits pressure which it is subject to. I fill this tube with water and I cap both of the ends with a rubber cork. I then push the right cork with my hand and I see that the left cork goes up; if it is the left cork that I push, then it is the right one that goes up. Do you see how water really transmits the pressure that it is subject to? (Chavannes, 2007, p. 44)

In the passage above, two factors may be pointed out: Firstly, the presence of "I", indicating that the experiment was all developed by the teacher, so that her students would observe. Later, the experiment is redone by the students, from which it may be inferred that the intention was to make the students carefully analyze the scheme developed. Thus, they would be able, in this second moment, to reproduce it, mount the apparatus and elaborate their own conclusions. In this experiment she does not question her students in relation to what they had expected to take place, as is verified in other moments of her classes. Likely, the lack of questioning in this moment was a way of making the students themselves associate what happened with the rubber balloons with what would take place with the corks, or it would be a way wherein the students would make their own reflective questions, without the need of the teacher to prod them.

Aiming at clarifying to her students how water reaches their residences, once again making use of known examples, the educator is going to track a path that goes from explaining what communicating vases are how they work to how pressure varies according to the substance which is being utilized:

MC: Over here we have a U-shaped tube, it forms with its two branches, two vases that communicate with each other. I put water through one of the branches of the tube; I see the water reach the same level in both of the branches. The water located in the horizontal section of the U-shaped tube stays balanced, it does not move any longer, because it suffers the same pressure on the right and on the left: the *atmospheric pressure* and one from the same water column. (Chavannes, 2007, p. 48)

Marie would always be concerned about the material to the used; in this passage, she aids her students in how they could build their own U-shaped tubes, which brings together the utensils of a laboratory to common materials in the students' lives. In questioning them on the possibility of using those common objects in order to perform the same experience, she transfers that science carried out within a laboratory to the lives of the students outside of this environment:

MC: We have yet two communicating vases: two equal flasks, joined by a rubber tube. Can the same experience be done? (Chavannes, 2007, p. 48)

Irène aids a mother to repeat the same experiment using, this time, a U-shaped tube made by the students. It is possible to suppose, through Isabelle's notes and her conclusions, that what had just been presented by Madam Curie was then understood, since Isabelle advocates the teacher's discourse, making use of the term *atmospheric pressure* and the concept of pressure ripple effects/propagation, outlining the characteristic already presented, in which it is suggested that the next student develops reasoning on the subject:

IC: Irene puts water in the left flask and part of the same water goes to the flask on the right. It seems that there is more water in the left flask. However, there is not. Water ends up reaching the same height in both flasks. The water in the rubber tube does not move anymore, for it is being pressured equally on the right and on the left. Pressure exerted on each side is the atmospheric pressure plus pressure from a same column of water. (Chavannes, 2007, p. 50)

It is important to point out that it is not possible to assert whether Madam Curie followed some found the experiment in a book. Once it was noted that Isabelle describes in many moments how the experiment was conducted, drawing it; it is feasible to suppose that in class, the students would not follow a printed agenda but the steps proposed by the teacher, instead.

The teacher goes on with the experiment:

MC: I put mercury in a U-shaped tube; it is naturally going to reach the same level in both branches. Notwithstanding, if I put water in the left branch, what is going to happen? Will water move mercury much? A little, at least. The mercury has lowered its level on the side I had put water in (Chavannes, 2007, p. 52)

In face of the outcome of the experiment, the students are questioned whether they knew what was going on in that column of mercury; a feature that Watts tackles on the rules for betterment of conversation, in which he says that for such betterment, so that one "exits ignorance", the student has to inquire/question and investigate so as to get the information on which he/she is doubtful about. (Watts, 1743, p.133)

In the passage below, the educator makes use of common analogies and examples in order to link the experiment with the students' lives, a constant feature in the classes presented here. Thus, the vases which communicate with the pipe and the home water reservoir/water tank:

MC: It is this way that, in our kitchens, water reaches the tap which is open or closed at any time. The water is in a straight tube or in a pipe that communicates with the water tank placed in uppermost heights, therefore the pipe and the water tank form two communicating vases. (Chavannes, 2007, p. 54)

As has already been mentioned in many passages of the classes presented so far, the educator attempts, whenever possible, without forcing, to make a plausible relationship between science and the student's life, not only citing examples or seeking random connections/links, but creating situations that would have some similarity with the daily routine.

CONCLUSIONS

Isabelle Chavannes's file contains ten experimental classes with different topics, but which follow a sequence aimed at facilitating students' understanding, besides demonstrating to the students that the concepts taught are related to each other. It is possible to observe in the passages presented and in other classes, that the educator's concern is focused on her students, in a way that she elicits all the time investigations, questions and reflections on the topics being worked on.

It is surely necessary to point out that this scientist, so much involved with teaching and learning, brings in her teaching methodology, contemporary features of a good educator, such as in how to appreciate and solicit students' participation, the search for building up knowledge and/or rebuilding of knowledge as a group and allowing that the students themselves make up their understandings and that they draw their conclusions in relation to the experiments.

BIBLIOGRAPHY

Chavannes, I. *Aulas de Marie Curie.* São Paulo: Edusp, Brasil, 2007, 134p.

Curie, È. D. Madame Curie. Tradução de Monteiro Lobato. São Paulo: Companhia Editora Nacional, Brasil, 1957, 329 p.

Derossi, I. *Proposal for Teaching Characterization Methodology of the Scientist and Educator Marie Curie in the Beginning of the XX century in "Teaching Cooperative",* Master's Dissertation. Universidade Federal de Juiz de Fora, Minas Gerais, Brasil, 2013, 103 p.

Hamilton, J. *Faraday: The Life*. Harpercollins Publishers Ltd, London, England, 2002, 465 p.

Reid, R. Marie Curie. The New American Library, New York, EUA, 1974, 284 p.

QUINN, S. *Marie Curie uma vida.* São Paulo: Scipione, Brasil, 1997, 526 p.

Watts, I. *The Improvement of the Mind…* Library of the University of Virginia, EUA, 1743, 413 p.

Received 04-03-2014 /Approved 02 -05- 2015

The collective diary as a tool for training chemistry teachers aimed at school inclusion

O diário coletivo como ferramenta para formação de professores de química visando a inclusão escolar

Karla A. P. Field´s[1,2], Warlandei C.S. Morais[2], Waleska Arcanjo[2], Anna M. C.Benite[2]

[1]Instituto Federal de Educação, Ciência e Tecnologia de Goiás , Câmpus Itumbiara.

[2]Laboratório de Pesquisas em Educação Química e Inclusão-LPEQI, Instituto de Química, Universidade Federal de Goiás (UFG), Brazil

kapf2@hotamail.com,warlandei@hotmail.com, waleskinha89@hotmail.com, anna@quimica.ufg.br

Abstract

This study presents the use of the collective diary as a tool for training chemistry teachers seeking school inclusion. The research data were collected through constructing collective diaries by the subjects, which were analyzed using the content analysis technique. The results show that to actualize the inclusive education in schools, it is necessary to invest in the initial training of teachers for the development of teacher knowledge in a perspective of critical reflection of the reality that surrounds the future teachers of chemistry.

Key words**:** *school inclusion, training of chemistry teachers, collective diaries.*

Resumen

Este estudio presenta el uso del diario colectivo como herramienta para la formación de profesores de química. Los datos de la investigación se recogieron a través de la construcción de los diarios, mediante la técnica de análisis de contenido. Los resultados muestran que, para mejorar la educación inclusiva en las escuelas, es necesario invertir en la formación inicial de los profesores. En este camino se pueden aprovechar las etapas del desarrollo del conocimiento y aprender las necesidades de reflexión crítica hacia la realidad que rodea a los futuros profesores de la química.

Palabras clave: *La educación inclusiva, la formación del profesorado de química, diario colectivo.*

INTRODUCTION

Studies have claimed that teachers who do not have a positive attitude toward school inclusion will not implement effective teaching strategies as do teachers who have a positive attitude (Van Reusen, Shoho &-Barker, 2000). These differences are because the practice of teachers, their way of thinking, feeling and acting during the teaching - learning process are related to their different biological contexts with their life stories and social contexts (Holly, 2000). Nietfeld and Wilkins (2004) identified several factors influencing the unwillingness of teachers to address school inclusion, among them, according to Stephen and Brown (1980) is related to the non-preparation during the initial training. In this context, numerous studies indicate that a good performance of teachers on inclusive education requires that they acquire specific knowledge in this area in the initial formation (Pearson, 2009; Hettiarachchi &-DAS, 2014). Also, for Naor and Milgram (1980), the most effective strategy for this training is to provide future teachers contact with children with special educational needs.

It is understood that teacher education is not given by accumulation of courses or techniques, but rather by a critical reflection of the knowledge of experiences acquired in during the training (Garcez et al, 2013). These moments nurture future teachers to establish connections between the knowledge acquired during undergraduate education and extracurricular knowledge. The recognition and valorization of all these aspects is fundamental for the construction of their professional identity, so we emphasize the importance and the need to invest in internship as a place to build knowledge, valuing the experiences and trajectories of this journey, recognizing that all reference knowledge that the teacher holds is closely linked to their experience and identity (Pereira,Fernandez, 2013).

According to Tardif (2007), teachers' knowledge comes from different sources, defining the teacher knowledge as a "plural knowledge, formed by the combination, more or less coherent, of knowledge derived from **training and disciplinary, curricular and experiential knowledge**" (p.36). The author defines professional knowledge as the knowledge produced by institutions for teacher education, is knowledge transformed into knowledge for the scientific training and, if incorporated into teaching practice, can be transformed into scientific practice. At the institutional level, it is through initial or continuing training of teachers that the link between science and teaching practice is established precisely, because it is during their training that teachers come in contact with theoretical and methodological foundations of science education. The disciplinary knowledge corresponds to the various fields of knowledge in the form of subjects, such as mathematics, chemistry, biology, etc. The curricular knowledge corresponds to speeches, objectives, content and methods from which the school categorizes and presents social knowledge defined and selected as models of high culture, this knowledge is accomplished as school programs. And finally, the experiential knowledge is that based on their daily work and knowledge of their environment, their everyday experiences. It is knowledge that emerges from experience and therefore validated by it (Tardif, Lessard, Gauthier, 1998). According to Candau (1996, p.146), "knowledges of experience now constitute the teaching culture in action, and it is very important to be able to perceive this culture, which cannot be reduced to the cognitive level".

The pedagogical practices of teachers are reflections of what they appropriated, internalized throughout their lives. For example, the idea that students in undergraduate programs have on curriculum, assessment, teaching-learning processes, etc., are conceptions appropriated of their teachers during training. But these views can be modified when future teachers have their own experiences and new pedagogical relationships are modified.

The theoretical framework of this study is guided by the assumptions of the model of critical rationality, in which teacher training is designed from a context of praxis, in view of the construction of new knowledge mediated by a dialectical relationship between trainer, trainee and knowledge (Pimenta & Ghedin, 2005; Echeverria, et al, 2010) and in the cultural-historical approach of Vygotsky (2001). Thus, it is necessary to offer and provide opportunities for future teachers to appropriate knowledge, skills and values necessary to the profession, to build their teaching knowledge related to inclusion from the needs and challenges of their practice.

Given these assumptions, this study investigated the use of the collective diary as a tool for training chemistry teachers seeking educational inclusion and intending to understand how the collective diary contributes for the appropriation of teaching knowledge. To Copello (2007), daily is understood as a strategy that aims to establish the socialization practices of experienced and consequences of the interaction between the opinions of teachers and students.

METHODOLOGY

This qualitative research is based on action research; therefore four stages of a cyclical spiral were developed. The participants of this investigation were: three scholarship students, teachers in initial training of the Laboratório de Pesquisa em Ensino de Química e Inclusão (LPEQI) (PFI1, PFI2, PFI3), two graduate students of the Universidade Federal de Goiás (UFG) (PG1, PG2) and one trainer teacher (PF) also of the UFG. Since March 2001, this group has been conducting weekly meetings of four hours for discussions backed up by contributions from the scientific community about school inclusion (Masini, 2007; Camargo, 2005; Bueno, 1993; Rodrigues, 2006; Glat, 1985).

These meetings were periodically restructured in order to initiate discussions regarding inclusive education in initial training, and were planned three research projects, developed as part of the completion of the supervised internship of the undergraduate program in chemistry of the Institute of Chemistry (training by research) by teachers in initial training at the support institution Centro Brasileiro de Reabilitação e Apoio ao Deficiente Visual-Cebrav. In all research projects, the interns developed weekly Pedagogical intervention (PIs) from March 17th, 2011 to November 20th, 2011. This phase was characterized as the first stage.

After the end of each intervention, the group met to reflect on: the achievement of the objectives of the classes; if the used teaching strategies allowed addressing the concepts considering the specificities of Visually Impaired VI-students; the main obstacles; dilemmas related to the difficulty of teaching chemistry to VI-students. This phase was characterized as the second stage.

Considering these reflections, the group redesigned the Pedagogical Interventions (PIs) based on the teaching experiential knowledge acquired. This movement was characterized as a time of collective reflection that was later chronicled in the diaries; this phase was characterized as the third stage of the spiral. Reflections narrated in the collective diary allowed evaluating the action strategies and identify the mobilization of teaching knowledge in the interns. The fourth stage of the spiral was the redesign of the actions, which signaled the need for the use of adapted educational materials.

The collective diary was characterized both as a tool for data collection and as a strategy for the subjects of this research to develop the ability to reflect on their practice (Schön, 1987; Zeichner, 1993; Nóvoa, 2003; Garcez, et al., 2013). The data collected through the collective diaries were analyzed using content analysis (CA), which sought to identify in the written discourse (narratives) what they express, regarding both the description and interpretation. For Bardin (2010, p.40) the AC is "[...] a set of techniques of analysis of communications that uses systematic and objective procedures to describe the content of the messages".

RESULTS AND DISCUSSION

Six Pedagogical Interventions (PIs) were performed, about the themes: atomistic, solutions, carbon chains, chemical and physical transformations, oxidation and mixtures separation process, totaling 13 meetings as shown in Table 1. During these interventions, the chemistry teachers in their initial training produced their diaries. The themes were chosen to establish dialogue with the chemical knowledge studied by the VI in their regular schools.

The categories of analysis that emerged from the narratives produced in this stage are depicted in Figure 1. This paper presents only three categories

1-Needs to carry out practical activities

Hodson (1988) argues that practical work is not only the one performed in the laboratory, also including activities that require concrete participation of students such as demonstrations made by the teacher or videos/films supported by data logging activities, case studies, representations of roles, written task, confection of models, posters and albums. Thus, the practical work in laboratory for science teaching or in classroom can assume different roles.

Table 1 –Activities performed during the research at the CEBRAV

Date	Themes addressed	Participants	Activities developed and resources used
03/17/2011	Solutions and periodic table	PG1, PFI1, PFI2, PA, PFC, DV1	We presented the proposal of PI to PA and to student VI1. We knew the location and activities developed. We identified the focus of interest of the student VI1, starting our 1st PI.
03/24/2011	Solutions	PG1, PFI1, PFI2, PA, DV1, DV2	We developed a PI on solutions using modeling as a teaching strategy.
03/31/2011	Organic Chemistry	PG1, PFI1, PFI2, PA, DV1, DV2	We developed an organic chemistry class, talking about the classification of carbon chains, using the atomlig and adapting this material.
04/07/2011	Organic Chemistry	PG1, PFI1, PFI2, PA, DV1, DV2	We used hands to explain the nomenclature of hydrocarbons.
04/14/2011	Classification of solutions into electrolyte and non-electrolyte solutions	PFI1, PFI2, DV1, DV2	The class started by characterizing the differences between the solutions that conduct or not electric current. We used a sound sensor (material adapted and developed by us) so that VI-students could realize the differences between the solutions. We used an EVA-modeling strategy to explain the solvation of ions.
04/28/2011	Solutions- volume measurements	PG1, PFI1, PFI2, DV1, DV2, DV3	We presented to VI-students the materials used in the laboratory, some of these adapted.
05/05/2011	Preparation of solutions using adapted materials	PG1, PFI1, DV2	We explained the operation of the adapted cylinder and requested the student to prepare a solution containing 5.44 g NaCl in 100 mL of water.
05/19/2011	Vapor pressure of a liquid.	PG1, PFI1, DV2	We presented models for the student to become familiar with the layout of the vapor pressure. While we explained the theme of vapor pressure we helped the student to grope the models so that he could relate our speech to the model.

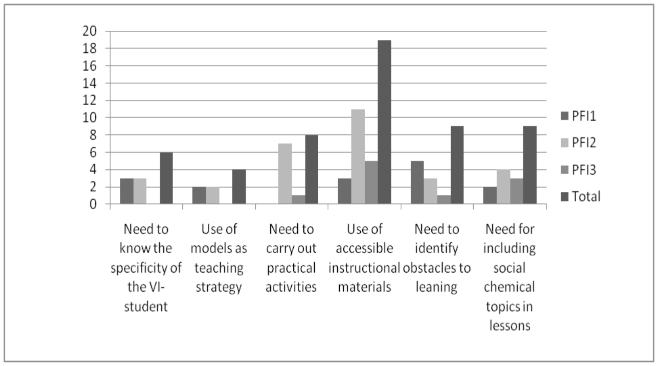


Figure1: Categories that emerged from narratives of teachers at initial training.

Considering these assumptions, it was identified the production of the following narratives:

PFI2: Glassware and their names were previously presented for the student to become familiar and associate names with different formats. We presented beakers, volumetric pipettes, squibb, Erlermeyer, NaCl, spatula and a PET bottle cap.

PFI1: After a class in which we took some laboratory instruments, so that VI have the notion of shapes, sizes and use of each, we discussed common and molar concentration, we concluded that VI-students had not much autonomy when handling instruments and were much less able to properly access the volume of water they were using to prepare solutions at the concentrations we asked.

PFI3: We used a level buoy to mark the volume of water added to a volumetric cylinder with embossed markings.

The narratives of PFI refer to intentionality to provide the presentation of instruments of the chemical science, therefore, the PI provided to VI-students meet, handle and acquire familiarity with the apparatus in the chemistry lab. The narrative from PFI2 shows the use of inexpensive materials such as a PET bottle cap. This highlights the creativity and the ability to tailor daily materials with lesson objectives. Again, we identified the need of VI-student for handling and contacting with laboratory objects. Practical activities allowed VI-students to recognize and differentiate the equipments, by means of the shape, texture, and height and relate these objects with their uses, applications and purpose in a laboratory class. This category shows that interns identified that VI-students give meanings to objects handled by them from their own experiences, and therefore these interns developed practical activities.

The narrative from PFI1 indicates the recognition of the importance of handling of glassware used in chemistry labs by VI-students, but also shows the PF11 concern regarding VI-student autonomy to prepare a solution. The narrative shows that laboratory glassware, as presented to VI-students still not allow them to identify the volume of water without the help of interns. Thus, the glassware had limitations, that is, not allowed VI-students to prepare a solution alone.

In this way, Fernandes (2006) reminds that the cognitive development of the blind student is quite complex, because on the one hand the student is completely dependent on the seer teacher, and on the other, the student is separated from the conception that the teacher has of the world. In this section we identified that the interns realized that at that time they had no minimum conditions of materials and resources to lead the VI-student to acquire knowledge in order to develop skills at a level equal to seer students regarding the preparation of solutions. Thus, the role of interns to these difficulties was to manipulate the materials available, so that they could give real meaning to the VI-student for understanding and acquiring skills to measure volume, prepare solutions and perform calculations related to preparation of solutions.

All these reflections and actions in order to help the VI-student to prepare solutions demonstrate the appropriation of professional knowledge, acquired at university, in the experience with VI-students in discussions with the group (TARDIF, 2002). This reflects in an attempt to contribute to the learning of VI-students.

The convergence of speeches shows that empowering learners meant to make use of teaching knowledge needed to adapt the PI to the social group, with the intention of allowing these individuals to adopt active attitudes before the knowledge that was presented, such as collecting data, as narrated by PFI2.

PFI2: The PI with adapted cylinder enabled DV2 to measure volume, to think about preparing a solution, and still make calculations.

The narrative from PFI1 evidences the reflection in identifying the limited resources and PFI3 shows that, given such determination, the group developed accessible materials that might give more autonomy to the VI-student in the preparation of solutions, as shown in the next category.

2- Use of accessible instructional materials

According to Fiscarelli (2008), several terminologies are proposed to indicate the objects used by teachers and students during teaching – learning process. In this investigation, were named as accessible instructional materials those materials constructed or adapted for teaching chemistry to students with visual impairments. The construction or adaptation of accessible instructional materials to VI-students were developed because most resources used for teaching chemistry is essentially visual, causing the detachment of these students in relation to chemical knowledge, excluding the access to information, compromising the communication with respect to the content being worked.

The narratives below show that interns through the construction of accessible educational materials to VI-students enabled a better access to chemical information, to handling of laboratory equipment and a greater autonomy of these students.

PFI2: We always tried to use materials that we had in the lab, we thought of a kind of buoy made of a piece of polystyrene, a lightweight material that would not interfere with the measurement of the volume, but stay inside the cylinder.

PFI1: We used the trademark to draw molecules because that seems to be the representation of atom that they might have a more general view of all the links and also that they best abstract.

These speeches show the need to build accessible educational materials in order to create opportunities for VI-students to exploit them, by teaching them how to manipulate the materials. And from that contact with these materials, they obtain tactile information to be used for the construction of knowledge about the topic under study, either in the preparation of solutions or in the bond between the atoms of an organic molecule as described in the narratives of PFI2 and PFI1.

In the diary, PFI1 wrote that used balls to represent a solute in a solution and that the more balls in the beaker, more solute in that solution and therefore will be more concentrated and, in another situation, the fewer balls in the beaker, lower solute and lower concentration. However, PFI1 emphasizes that the most used resource was hearing.

PFI1: Somehow we did it, we adapted resources for DV2 using little balls, we represented the solute (salt) of a particular substance, and it may or may not be concentrated, the more balls in the beaker, the greater the concentration of the solutions and vice versa, but the most used resource was the hearing.

For Sá (2010, p. 01), the performance of VI-students can be compromised by a lack of resources "help to overcome functional difficulties in the environment of the classroom and beyond", thus the need for accessible instructional materials. One can consider that the accessible learning materials built by interns and may be called Assistant Technologies (AT), as are materials that contributed to provide and expand the functional abilities of VI-students promoting independent management of materials and school inclusion. These materials make it possible conditions so that these students could learn with significant results, as shown by PFI1.

In this perspective, accessible instructional materials now acquire important meanings in the implementation and effectiveness of PI, therefore are able to make lessons more exciting and interesting to students, by increasing efficiency in the teaching-learning process. In this context, the interns made possible conditions for the VI-student from accessing chemical knowledge conquering and expanding their autonomy.

CONCLUSIONS

The approximation between the University and Support Institution-CEBRAV enabled the contact of chemistry teachers at initial training with the reality of the social group of VI-students through participation in activities conducted by CEBRAV and development of strategies for teaching chemistry for these students. Our results pointed that, at that time, were constructed experiential knowledges related to educational inclusion, since future teachers know the specificities of VI-students.

Moreover, our results indicated that this research generated professional and subject knowledges, once the participants could were able to integrate the knowledge learned in various subjects taken during undergraduate education for the development of PI and exercise professional activities through the support classes. These results corroborate the proposed Pearson (2009), Hettiarachchi and Das (2014), Naor and Milgram (1980), it is necessary to start the initial training of teachers of inclusion practices.

Finally, the role of the University in the Support Institution can offer different strategies to access chemical knowledge and its relationships to social life for VI-students.

ACKNOWLEDGEMENTS

To Fundação de Amparo à Pesquisa do Estado de Goiás and to Conselho Nacional de Desenvolvimento Científico e Tecnológico for financial support.

BIBLIOGRAPHY

Bardin, L. *Análise de Conteúdo.* Lisboa: Edições 70, 2010.

Bueno, J. G. S. *Educação Especial brasileira: integração / segregação do aluno diferente.* São Paulo: EDUC/PUCSP, 1993.

Camargo, E. P. O ensino de Física no contexto da deficiência visual: elaboração e condução de atividades de ensino de Física para alunos cegos e com baixa visão. 2005, 285p. Tese (doutorado) – Universidade Estadual de Campinas, Faculdade de Educação, Campinas, 2005.

Candau, V. M. F. Formação continuada de professores: Tendências atuais. In: Reali, A. M. M. R; Mizukami, M. G. N. (Orgs.). *Formação de professores: tendências atuais.* São Carlos: EDUFSCar, 1996, p. 139 – 152.

Copello, M.I. Diários Y articulo em la practica docente Del profesor/a de biologia. Enseñanza de lãs Ciencias. 2005. número extra. VII congreso. Available in http://ddd.uab.cat/pub/edlc/edlc_a2005nEXTRA/edlc_a2005nEXTRAp354diaart.pdf Accessed May 2013.

Echeverría, A. R.; Benite, A. M. C.; Soares, M. H. F. B.; A Pesquisa na Formação Inicial de Professores de Química – A experiência do Instituto de Química da Universidade Federal de Goiás. In: Echeverría, A.R.; Zanon, L.B. (Org.). *Formação Superior em Química no Brasil: Práticas e Fundamentos Curriculares.* Ijuí: Ed. Unijuí, 2010, p.25-46.

Fiscarelli, R. B. O. *Material didático: discursos e saberes***.** Junqueira&Marin: Araraquara, SP, 2008.

Garcez, et al. Reflection on the action: supervised pre service teachers' practice as formative space. *Journal of Science Education*.**14,** [Specialissue], p. 52- 55, 2013.

Glat, R.Um enfoque educacional para a Educação Especial. *Fórum Educacional*, **9** (1), 1985, p.88-100.

Gonçalves, F. P.; Fernandes, C. S. ; Lindeman, R. H. Galiazzi, M. C. O diário de aula coletivo no estágio da licenciatura em química: dilemas e seus enfrentamentos. *Química Nova na Escola*, n.30, novembro, p.42-48.2008.

HettiarachchI, S., Das, A. Perceptions of 'inclusion' and perceived preparedness among school teachers in Sri Lanka**.** *Teaching and Teacher Education***. 43**, pp. 143-153, 2014.

Hodson, D., Experiments in science and science teaching, Educational Philosophy & Theory, 20, pp. 53-66, 1988.

Naor, M.; Milgram, R. Two pre-service strategies for preparing classroom teachers for mainstreaming**.** *Exceptional Children* , 47, p. 126–9, 1980.

Nóvoa, A. Diz-me como ensinas, dir-te-ei quem és e vice-versa. IN: Fazenda, I. (org.): *A pesquisa em educação e as transformações do conhecimento. Campinas,* SP: Papirus. 2003. p. 23- 42.

Pereira, P. G. L. M.; Fernandez, C. Evidence for integrative model during PCK development in chemistry student teachers during pre-service training. *Journal of Science Education* ,**14,** [2], p. 74-78, 2013.

Pearson, S. Using activity theory to understand prospective teachers' attitudes to and construction of special educational needs and/or disabilities. *Teaching and Teacher Education***. 25**, [4], p. 559–568, 2009.

Pimenta, S. G. Formação de professores: identidade e saberes da docência In. Pimenta, S. G (Org.). *Saberes Pedagógicos e atividade docente*. 3 ed. São Paulo: Cortez, 2002. p. 15-34.

Pimenta, S. G.; Ghedin, E. (Orgs) *Professor Reflexivo no Brasil:* gênese e crítica de um conceito. 3 ed. São Paulo: Cortez, 2005.

Rodrigues, D.; Dez ideias (mal) feitas sobre a educação inclusiva. In: Rodrigues, D. (org). *Inclusão e educação: doze olhares sobre a educação inclusiva* – São Paulo: Summus, p. 299- 318. 2006.

Sá, E. D. Educação inclusiva no Brasil: *Material Pedagógico e Tecnologias Assistivas.* [2010]. Disponível em: www.cnotinfor.pt/inclusiva/pdf/Tecnologias_assistivas_pt.pdf Acesso em: 21.11.12

Santos, L. L. C. P. Formação do professor e pedagogia crítica. In: Fazenda. I. C. A. (Org). *A pesquisa em educação e as transformações do conhecimento.*Campinas : Papirus, 5ªEd. 2003. p.17-28.

Schön, D. *Educating the reflexive practitioner*. São Francisco, Jossey-Bass, 1987.

Tardif, M., Lessard, C. e Gauthier, C. *Formation de maîtresetcontextessociaux.* Paris: Presse Universitaire de France, 1998. 290p.

Tardif, M. *Saberes docentes e formação profissional.* 8ª ed. Petrópolis, RJ: Vozes, 2007.

Van Reusen, A., Shoho, A., Barker, K. High school teacher attitudes toward inclusion. *The High School Journal*, **84,** p. 7-13, 2000.

Vygotsky, L. S. *A construção do pensamento e da Linguagem***. (**P. Bezerra, Trad.) S.P.: Martins Fontes, 2001.

Wilkins, T., Nietfeld, J. L. The effect of a school-wide inclusion training programme upon teachers' attitudes about inclusion. *Journal of Research in Special Educational Needs.* **4**. [3], p. 115-121, 2004.

Zeichner, K. M. *A formação reflexiva de professores: ideias e práticas*. Lisboa: Educa, 1993.

Received 12-09-2013 /Approved 02 -05- 2015

Coloring of titanium plate by the method of electrochemical reaction for teaching material in chemistry

Colorear la placa de titanio por reacción electroquímica como material didáctico en química

Haruo Ogawa[1], Naoki Koike[1], Toshinori Nakajima[2], Yukako Ohashi[2]

[1] *Department of Chemistry, Faculty of Education, Tokyo Gakugei University, 4-1-1 Nukuikita-machi, Koganei-shi, Tokyo 184-8501,* [2] *Faculty of Education, Bunkyo University, 3337 Minamiogishima, Koshigaya-shi, Saitama 343-8511, Japan*

ogawah@u-gakugei.ac.jp

Abstract

Coloring of titanium plate on experimental scale was proposed as teaching materials for subject introduction by the method of electrochemical reaction. The plate was readily colored where variable change of color pattern could be observed and easily controlled through the electrochemical conditions such as applied voltage and electrified time. For example, the voltage of 30 V in 5 minutes led the plate to change vivid color of blue from apparently original color gray. The method is effective with the hope of teaching material for student to be promoted to interest in the electrochemical reaction and motivated to act next stage.

Key words: *teaching material, coloring of titanium, electro-chemical reaction, experiment module*

Resumen

Se propone colorear la placa de titanio en la escala experimental como material didáctico de introducción de quimica por el método de la reacción electroquímica. La placa fue coloreada a través de proceso, en donde se pudo observar el cambio variable del patrón de color y controlar las condiciones electroquímicas tales como *voltaje aplicado y tiempo. Voltaje de 30 V en 5 minutos llevó la placa a cambiar el vívido color azul al original color gris. El método es eficaz para promover el material didáctico y crear interés en la reacción electroquímica y motivar a los estudiantes a actuar en la siguiente etapa.*

Palabras clave: *material didáctico, coloración de titanio, reacción electroquímica, módulo de experimento*

INTRODUCTION

We have reported a survey of present textbooks of "Science" in primary school and junior-high school and "Chemistry I" and "Chemistry II" (Keirin-kan, 2003; Tokyo-shoseki. 2003; Dainihon-tosho, 2004) in senior-high school compiled based on Japanese course of study (MEXT, 1999). Boldface as a representative of knowledge (Ogawa et al., 2006), skills for experimental study (Ogawa et al., 2009), and schemes as a representative of image (Ogawa et al., 2008) could be ordered. Large numbers of boldface, schemes, and skills were cited in present textbooks in Japan in order to understand scientific concepts, topics, and methodology. We have introduced a fundamental feature of school lesson in science and chemistry in which a **S**pecial **E**mphasis on **I**magination is regarded toward **C**reation (**SEIC**) (Ogawa, Fujii, & Sumida, 2008) Promoting creativity in science has been reported and discussed in papers (Child, 2009; Osborne et al., 2003; Jarvis, 2009; Höhn, Harsh, 2009; Longshaw, 2009; Ohshima, 1920). It is important for student to have thinking and behaving imaginatively, and finally to have an outcome which is of value to the original objective (Wardle, 2009; Finke, Ward, & Smith, 1992).

Thinking and behaving imaginatively are very important for students to realize and understand in chemical education also.

Visualization of phenomena and chemical-abstract concepts helps us greatly to realize images of them. It is no exaggeration to say that teaching materials for visualization in chemical education are very important, for example, interesting experiments and/or instruments, videos, CG graphics, and so on. The visualization needs to be more user-friendly and appealing for learners from the standpoint of a useful teaching material.

Titanium is in some interesting material for science education of course not to mention science and technology, *e.g.*, coloring titanium for decorative item, titanium alloy from the standpoint of hydrogen storage and so on. Titanium can be colored in a variety of vivid colors. Coloring titanium is evaluated in an industrial as solid and decorative items. Titanium coloring by taking advantage of anodic oxidation (Azumi, 1998; Ohnaka, 1993) and titanium alloy as electrode at the counter part (Numata, Tomizuka, & Tsujimoto, 1995; Morishita, et al., 1991) has been reported in electrochemistry field. Normally, large scale and high applied voltage was adopted for manufacturing. For example, soaking titanium plate in 1.5M H_2SO_4-0.3MH_2O_2 solution with applied voltage of 200V in direct current of 3.0Adm^{-2} (Itoh, 2001).

It is one of our aims to produce a teaching material, in which students have good experiences of the joy of discovering the "how" and "why" of chemical reactions. Teaching materials for visualization in chemical education are very important, for example, interesting experiments and/or instruments. In this paper, creating teaching material by the usage of visualization of titanium coloring in electrochemistry is reported. This paper provides one type of teaching materials to introduce a subject, which would motivate students to have an interest in electrochemistry in chemical education.

SURVEY OF CHEMISTRY TEXTBOOK

Experiments with color change as a common or a specific

Popular experiments in high school level were extracted from all six publishers of high school texts of "Chemistry I" or "Chemistry II" in Japan. Well-known experiments are listed in Table 1. Almost all of the experiments (78% of 191) are in liquid-phase, which could be easily treated in a school laboratory (Fig. 1).

Distinct experiments as specifically adopted by only one publisher in three-publishers were classified in Table 2. Almost all experiments as a familiar theme are shown in the table and of the type of experiment as a challenge study (or problem research).

2.2 Contents of experiments

The number of experiment *vs. their*-content in "Chemistry I" and "Chemistry II" of all six publishers are classified in Fig. 2. The contents of both A (Metal ion & deposit formation) and B [pH method (indicator)] were adopted as a typical chemical-reaction, which is in the field of analytical chemistry.

Table 1. Common experiments[a]

Experiment	Phase[b)]	Type[c)]
pH method (indicator)	L	Exp
Flame reaction	G	Exp
Metal ion & deposit formation	L, S	Exp
Colloidal nature	L	Exp
Movement of chemical equilibrium	G, L	Exp
Reaction speed & catalyst	L	Exp
Working of the enzyme to the starch	L	Exp
Iodostarch reaction	L	Exp
Fehling's solution & silver mirror reaction	L	Explo
Color changing reaction of protein	L	Exp
Synthesis & dyeing (azo compounds)	L	Exp
Color changing reaction of Phenols with iron chloride	L	Exp
Water quality survey	L	Chal

a) Common experiments by all publishers in the texts of "Chemistry I" of 3 publishers or "Chemistry II" of 6 publishers; Tokyo-shoseki, Keirinnkann, Suken-shuppan, Daiiti-gakusyusya, Dainihon-tosyo, and Jikyo-syupan.
b) Phase; G: gas-phase, L: liquid-phase, S: solid-phase.
c) Type of experiment; Exp: experiment & observation, Explo : exploration activities, Chal : challenge studies.

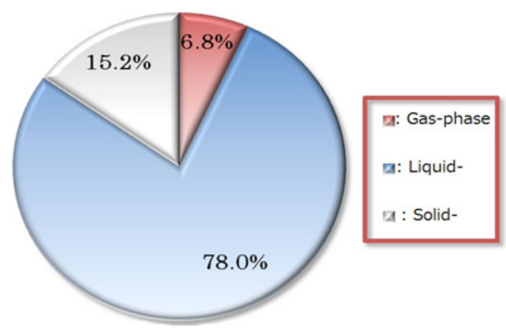


Figure 1. Percentage of the phase in experiments in ´Chemistry I´of 6 publishers (Total number of 191 experiments)

Table 2. Specific experiments[a]

Experiment	Phase[b)]	Type[c)]	Publishers[d)]
Nature & quantitative analysis (vitamin C)	L	Chal	A
Analysis of food additives	L	Chal	B
Extraction & dyeing (Natural dye)	L	Chal	B
Electrolytic reaction of thawing salt	G,L	Chal	C
Manufacturing of blue glass	L	Exp	C
Quantitative analysis (NO_2 in the atmosphere)	L	Chal	D
Chemical light-emitting	L	Chal	E
Blue bottle reaction	L	Chal	E

a) Specific experiments: adopted by only one publisher in "Chemistry I" of 3 publishers or "Chemistry II" of 6 publishers.
b) Phase; G: gas-phase, L: liquid phase.
c) Type of experiment; Exp: experiment & observation, Chal : challenge studies.
d) A-E: Tokyo-shoseki, Keirinnkann, Suken-shuppan, Daiiti-gakusyusya, Dainihon-tosyo, and Jikyo-syupan (order out of order).

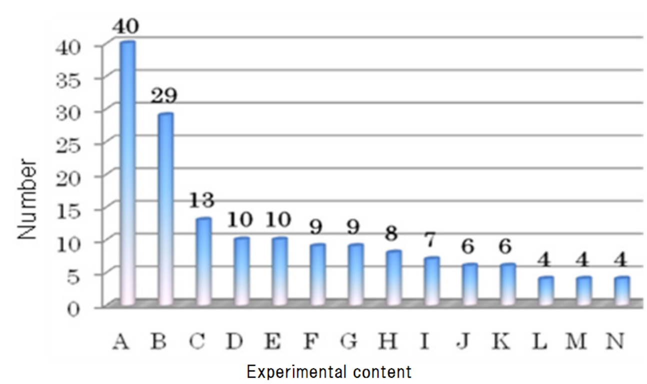


Figure 2. Contents of experiments in "Chemistry I" and "Chemistry II". A: Metal ion & deposit formation; B: pH method (indicator); C: Fehling's solution & silver mirror reaction; D: Movement of chemical equilibrium; E: Working of the enzyme to the starch; F: Color changing reaction of protein; G: Synthesis & dyeing (azo compounds); H: Color changing reaction of Phenols with iron chloride; I: Reaction speed & catalyst; J: Flame reaction; K: Water quality survey; L: Colloidal nature; M: Chromatography; N: Synthesis of organic compound

RESULTS AND DISCUSSION

Experimental

Electrolysis equipment and schematic diagram in typical experimental-conditions are organized in Fig. 3. Conditions were as following; titanium plate (anode) and aluminum plate (cathode): 25 x 25 x 2 mm, distance between the electrodes: 10.0 mm as shown in Table 3.

Treatment of titanium plate was made as stated in Appendix 1. Titanium (Ti) plate was processed in advance through polishing, mirror finishing, degreasing, and rinsing, and then anodic oxidation was started. After the oxidation in the certain conditions, oxide-filmed Ti plate (coloring Ti plate) was obtained through the treatment of rinsing and drying. Typical experimental-conditions are of the volume of 50 mL of 1.0 wt%-phosphoric acid aqueous solution was used as an electrolyte as in Table 3.

Color change vs. electrified time

The color change of Ti plate *vs.* electrified time was conducted with an applied voltage of 30.0 V (Fig. 4.1). Vivid color was observed in the period from one minute to about 30 minutes. Especially vivid color of blue was observed by one minute of electrified time. After 30 minutes it was a dark color. The change was traced on CIE chromaticity diagram in Fig. 4.2. The color change was sequential. The tendency of color change is listed in Table 4. The value of saturation and brightness was decided relatively by comparing the intensities of the samples where the relatively highest intensity was assumed to be nine, and the lowest one was done to be zero. The color changed from blue entirely to green. The first coloring blue changed successfully to cyan and green with the decrease in intensities of both saturation and brightness upon the electrified time. One minute is an appropriate time to observed high values of both saturation and value of brightness.

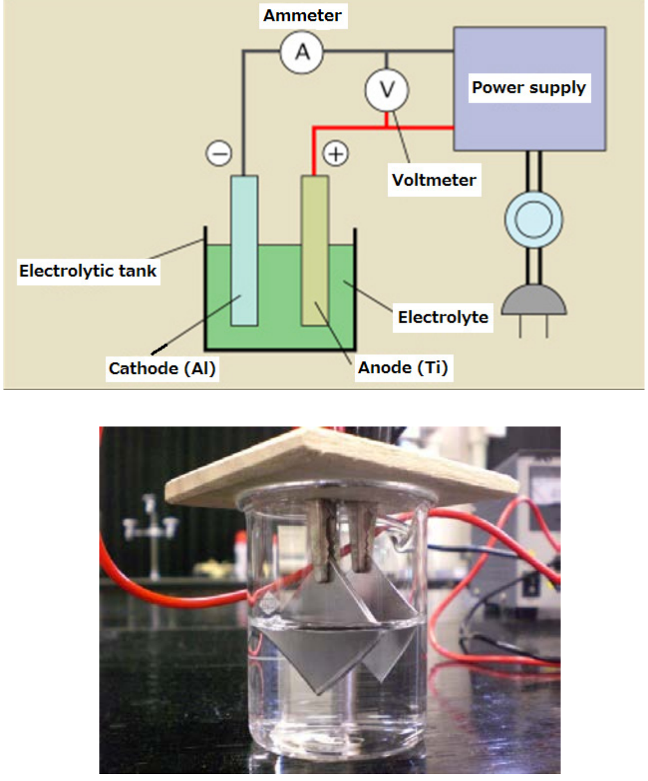


Figure 3. Electrolysis equipment

Table 3 Typical experimental-conditions

Ti (anode)& Al plate (cathode):	25 x 25 x 2 mm
Distance between the electrodes:	10.0 mm
Electrolyte: 1.0 wt%-Phosphoric acid aqueous solution (50 mL)	
Applied voltage:	0 - 30.0 V (elevated voltage/ 10.0 $Vsec^{-1}$)

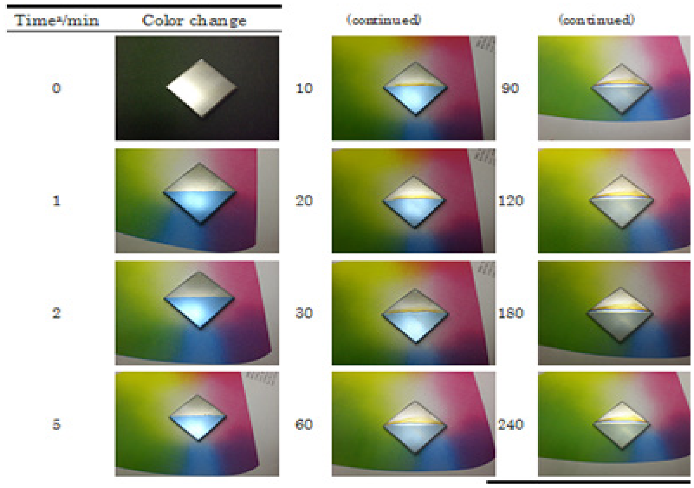


Fig. 4.1 Color change of Ti plate vs. electrified time. Applied voltage: 30.0 V.

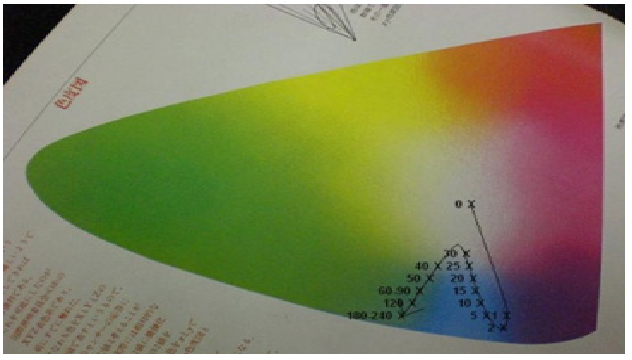


Figure 4.1. Trace on CIE[a] chromaticity diagram of color change of titan plate vs. electrified time. Applied voltage: 30.0 V. a: CIE: Commission

Table 4 Color change of Ti plate vs. electrified time

Time[a)]/min	Color change		
	Hue	Saturation[b)]	Brightness[c)]
1	Blue	9	9
2	Blue	8	8
5	Blue	7	7
10	Cyan	6	6
20	Cyan	5	5
30	Cyan	4	4
60	Green	3	3
90	Green	2	2
120	Green	0	1
180	Green	1	0
240	Green	1	0

Applied voltage: 30 V. a) Electrified time: b) Colorfulness: c) Lightness

Table 5. Color change of Ti plate *vs.* applied voltage

$E^{a)}$/ V	Color change		
	Hue	Saturation[b)]	Brightness[c)]
0	Clear	0	9
2.5	Yellow	1	8
5	Yellow	2	7
7.5	Yellow	3	6
10	Yellow	8	6
12.5	Yellow	9	1
15	Red	8	0
17.5	Magenta	7	3
20	Blue	9	1
22.5	Blue	8	2
25	Cyan	6	4
27.5	Cyan	5	5
30	Green	4	6

Electrified time: 1 min. a) Applied voltage;
a) Colorfulness; c) Lightness

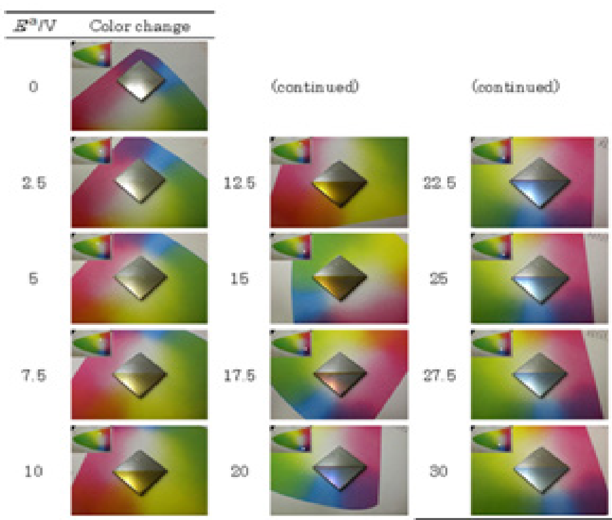


Figure. 5.1 Color change of Ti plate vs. applied voltage. Electrified time: one min

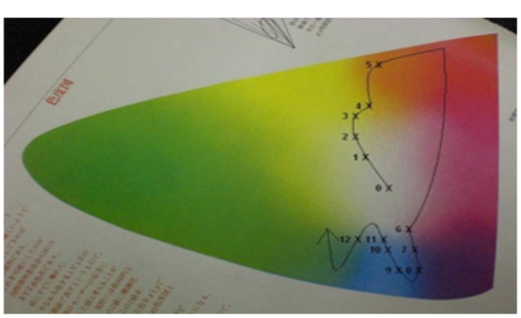


Fig. 5.2 Trace on CIE[a] chromaticity diagram of color change of titan plate vs. applied voltage. Electrified time: 1 min.

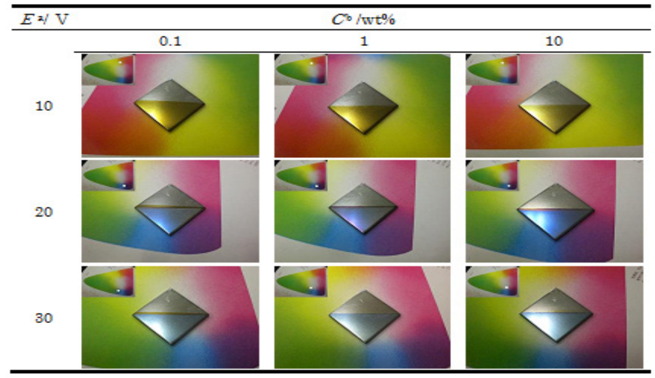


Fig. 6 Color change of Ti plate vs. concentration of electrolyte (0.1-10.0 wt%). a) Applied voltage: 10.0 V-30.0 V; b) Concentration of phosphoric acid aqueous solution (50 mL).

Color change *vs.* applied voltage

The color change *vs.* applied voltage was carried out. Vivid color variation was developed with the applied voltage where sequential color change with yellow, red, magenta, blue, cyan, and green was observed on each applied voltage in one minute of electrified time (Fig. 5.1). The sequential change on CIE chromaticity diagram is expressed for tracing the color change in Fig. 5.2 and listed up for an in-depth review of the change in Table 5. The color variation started from yellow and ended up in green. The first color change of yellow was created by the applied voltage with the increase in the value of colorfulness and with decrease in the value of brightness. Change of applied voltage was in effect for getting Ti plates of various colors.

Color change *vs.* concentration of electrolyte

The concentration of electrolyte of phosphoric acid aqueous solution was changed from 0.1 wt% to 10.0 wt% with applied voltage of 10V, 20V, and 30V. The color change was shown in Fig. 6. Vivid color was observed on the whole where color trend of blue was demonstrated with the applied voltage of 20V and 30V while color trend of yellow was observed with the voltage of 10V. Apparently a similar state in color change was observed with various concentration of the electrolyte. Sequence of the color change from yellow to blue was also the same manner with applied voltage as described the former section of 3.2 even in different concentration of the electrolyte. Details of the relation of the color change with the oxide thickness are now obviously not.

DISCUSSION

Coloring of titanium plate on experimental scale was demonstrated by the method of electrochemical reaction in order to motivate the student to study chemistry. The plate was readily colored where variable change of vivid color pattern could be observed and easily controlled in color through the electrochemical conditions such as applied voltage and electrified time, *e.g.*, vivid color change of blue was observed through an applied voltage of 30.0 V by 1 minute of electrified time, and then the color of blue entirely changed to green due to the time elapsed with the decline in both saturation and brightness. One minute is an appropriate time to observed vivid color of both saturation and brightness. Sequential color change to yellow, red, magenta, blue, cyan, and green was observed on each applied voltage from 2.5V to 30V on 1 minute of electrified time. The color change was also observed in some concentration of phosphoric acid aqueous solution with applied voltage of 10.0 V, 20V, and 30.0 V. Color trend of blue was demonstrated on the whole.

CONCLUSIONS

The method of anodic oxidation would be one of an effective teaching material with the hope for student to be promoted to interest in the electrochemical reaction and motivated to move to the next stage.

BIBLIOGRAPHY

Azumi, K. *Hyomenngijutu-shi*, 49(1), 39-43, 1998 (in Japanese).

Child, E. P. Improving chemical education: turning research into effective practice, *Chem. Educ. Res. Pract.*, **10**, 189-203, 2009.

Dainihon-tosho. Chemistry I, Issue & Chemistry II, Issue, published by Dainihon-tosho Co. (in Japanese). 2003.

Finke R. A., Ward T. B., & Smith S. M. CREATIVE COGNITION Theory, Research, and Applications. The MIT Press, Cambridge, MA., USA; *id., ibid.*, translated in Japanese by Kobashi Y., 1999, Tuttle-Mori Agency, Inc., Tokyo, ISBN4-627-25111-4. 1992.

Höhn L., & Harsh G. Indigo and creativity: a cross-curricular approach linking art and chemistry. *School Science Review*, **90** (332), 73-81. 2009.

Itoh, S. *Hyomenngijutu-shi*, 52 (1), 88-89, (in Japanese). 2001.

Jarvis, T. Promoting creative science cross-curricular work through as in-service programme. *School Science Review*, **90** (332), 39-46. 2009.

Keirin-kan. Chemistry I & Chemistry II, Published by Keirin-kan Co., Issue (in Japanese). 2003.

Longshaw S. Creativity in science teaching, *School Science Review*. **90** (332), 91-94.

MEXT. (1999). Japanese course of study (high school). *Bull. 1999-3*, printed by Ministry of Finance (in Japanese). 2009.

Morishita, M., Chikuta, M., Ashida, Y., Morinaga, M., Yukawa, N., & Adachi, H *Nihonnkainnzokugakkai-shi*, 55 (6), 720, (in Japanese). 1991.

Numata, H., Tomizuka I., & Tsujimoto, T. *Nihonnkainnzokugakkai-shi*, 59 10, 997 (in Japanese). 1995.

Ogawa, H., Okada, S., Takehara, Y., & Ikuo, A. Survey of boldface in textbooks of "Science and Chemistry" used in primary, junior-high, and senior-high school in Japan. *Bull. Tokyo Gakugei Univ. Sect. 4*, (**58**), 95-106, (in Japanese). 2006.

Ogawa, H., Takano, H, Ikuo, A., Yoshinaga, Y., & Fujii, H. Development of teaching material of experimental-skills possible especially with significant figures besides a survey of experimental skills concerning chemistry in textbooks of "Science" and "Chemistry I·II" used mainly in junior-high and senior-high school in Japan. *Bull. Tokyo Gakugei Univ. Division of Natur. Sci.*, **61**, 29-46 (in Japanese). 2009.

Ogawa, H., Ishiwaki, K., Ikuo, A., Yoshinaga, Y., & Fujii, H. Survey of scheme expression concerning chemistry in textbooks of "Science" and "Chemistry I·II" used in junior-high and senior-high school in Japan. *Bull. Tokyo Gakugei Univ. Natur. Sci.*, **60**, 9-18, (in Japanese). 2008.

Ogawa H., Fujii H., & Sumida M. Development of a lesson model in chemistry through "Special Emphasis on Imagination leading to Creation" (SEIC). *The Chemical Education Journal (CEJ)*, **13**, 1 (Serial No. 24). 2009.

Ohshima S. Principle of science teaching, published by Doumonnkann Co., Tokyo, 314-330, (in Japanese). 1920.

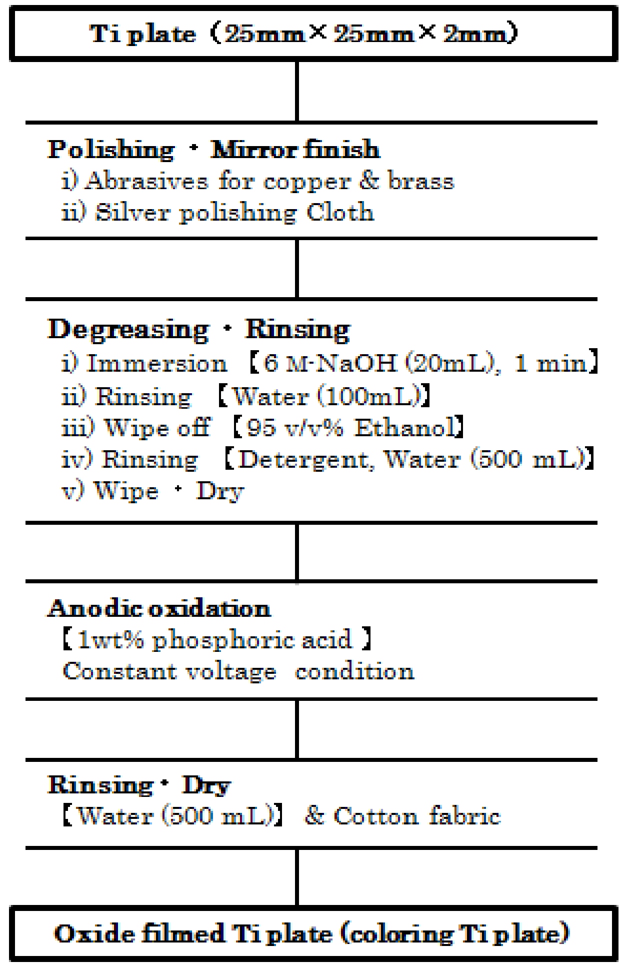
Ohnaka, T. *Titan*, 41. 2, 19 , (in Japanese). 1993.

Osborne J., Ratcliffe M., Bartholomew H., Collins S., Millar R., & Duschi R. Towards evidence-based practice in science education 3: teaching pupils 'Ideas-about-science', available at http://www.tlrp.org/pub/documents/no3_miller.pdf, accessed 10/10/15. 2003.

Tokyo-shoseki. Chemistry I & Chemistry II, published by Tokyo-shoseki Co., Issue (in Japanese). 2003.

Wardle J. Creativity in science. *School Science Review*, 2009, **90** (332), 29-30. 2009.

APPENDIX 1



Scheme Treatment process

Received 04-11-2014 /Approved 02 -05- 2015

Un experimento demostrativo simple para estudiar el roce cinético

A simple demonstrative experiment for the study of kinetic fricction

WALTER BUSSENIUS CORTADA[1] , JORGE PINOCHET ITURRIAGA[2]

1Instituto de Matemáticas y Física, Universidad de Talca, 2 Norte 685, Talca,

[2]Facultad de Educación, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, Macul, Santiago, Chile, japinoch@uc.cl

Resumen

En este trabajo se presenta un experimento demostrativo cuyo objetivo es probar que el coeficiente de roce cinético no depende de la rapidez con que se mueve el cuerpo que resbala, ni tampoco de su masa o del área de las superficies en contacto. Se trata de un experimento de bajo costo y fácil de realizar, diseñado para implementarse en cursos de física de escuela secundaria o superior. Para lograr una adecuada descripción de la experiencia, se comienza estableciendo las relaciones entre las magnitudes físicas en juego, para luego describir el procedimiento experimental y los resultados obtenidos, los que son analizados y comparados considerando posibles fuentes de error experimental. Finalmente, se extraen las principales conclusiones, y se hacen sugerencias generales para orientar la labor de los docentes al momento de desarrollar el experimento.

Palabras clave*: experimentos demostrativos, escuela secundaria, educación superior, roce cinético, actividades demostrativas interactivas.*

Abstract

This paper presents a demonstration experiment which aims to show that the kinetic friction coefficient does not depend on the speed at which the sliding body moves, nor on its mass or contact surface area. This low cost and easy experiment is designed to be deployed in physics courses in secondary or higher education. To achieve an adequate description of the experience, this paper starts by establishing the relationships between the physical quantities involved and then describes the experimental procedure and results. These are analyzed and compared considering possible sources of experimental error. Finally, the main conclusions are drawn and some general suggestions are given to guide the work of teachers when developing the experiment.

Key words*: demonstration experiments, secondary school, higher education, kinetic friction, interactive lecture demonstrations.*

INTRODUCCIÓN

En el presente trabajo se describe un sencillo experimento demostrativo diseñado para desarrollarse en cursos de física de escuela secundaria o de educación superior. Se trata de un experimento de bajo costo y fácil realización, que permite aproximarse a una temática que, de acuerdo con la dilatada experiencia docente de los autores, es fuente de errores conceptuales persistentes y difíciles de erradicar: el roce cinético. La literatura presenta algunos trabajos sobre esta temática (e.g., Dumbrajs, et al., 2011; Calderon, et al., 2007; Alvarenga, et al., 2012; Mills, 2008; Gratton & Defrancesco, 2006; Kaplan, 2013), aunque en términos comparativos, parece tratarse de un área poco explorada.

El experimento propuesto tiene como objetivo, por una parte, determinar el coeficiente de roce cinético, y por otra, establecer que dicho coeficiente no depende de la rapidez con que se mueve el cuerpo que resbala, ni tampoco de su masa o del área de las superficies en contacto. Para ello, el experimento se divide en tres partes; en la primera se hace deslizar una pieza de madera sobre una superficie lisa; en la segunda parte se repite lo anterior, pero se modifica la masa de la pieza de madera; en la tercera parte se hace variar el tamaño de la superficie de la madera. En los tres casos, el valor obtenido para el coeficiente de roce resulta idéntico, dentro del error experimental.

Para alcanzar los objetivos propuestos, el artículo comienza describiendo la teoría del roce cinético, relacionando las principales magnitudes físicas en juego. Luego se describen las distintas etapas que conforman la metodología experimental, para luego presentar los resultados obtenidos en cada una de ellas. Después se analizan y comparan dichos resultados y se discuten posibles fuentes de error. Finalmente, se extraen algunas conclusiones y se efectúan sugerencias para una adecuada realización del experimento.

Marco teórico: El roce cinético

Los aspectos básicos del roce cinético se describen en casi todos los textos de Física General (e.g., Serway & Beichner, 2001; Tipler, 1999; Serway, et al., 2010; Serway, & Jewett, 2008; Giáncoli, 2006; Alonso, & Finn, 1986). Si se tiene un cuerpo resbalando sobre una superficie horizontal con velocidad $\vec{v}$, sobre él actuarán la fuerza de gravedad $m\vec{g}$ y la normal $\vec{N}$ en el eje vertical, y en el eje horizontal sólo actuará la fuerza de roce resbalante $\vec{F}_{RC}$, tal como muestra la siguiente figura:

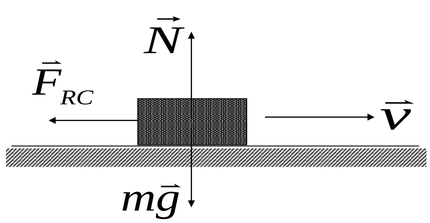


Figura 1. Las fuerzas que actúan sobre un cuerpo que se desliza sobre una superficie.

Al aplicar la segunda ley de Newton al eje horizontal, se tiene:

$$F_{RC} = -ma \quad (1)$$

donde F_{RC} representa la magnitud de la fuerza neta que actúa sobre el cuerpo de masa m, generando una desaceleración de modulo a. Experimentalmente se ha demostrado que la magnitud de la fuerza de roce resbalante cinético F_{RC} viene dada por la siguiente expresión (Serway & Beichner, 2001; Tipler, 1999; Jones, & Childers, 2001):

$$F_{RC} = \mu N \quad (2)$$

donde N representa la magnitud de la fuerza normal, que cuando actúa en un plano horizontal viene dada por: $N = mg$, siendo g la aceleración de gravedad. Además, μ corresponde al "coeficiente de roce resbalante cinético". Igualando (1) y (2) resulta:

$$-am = \mu gm \quad (3)$$

Suponiendo que no varía la masa ni los materiales de las superficies en contacto, es esperable que el cuerpo tenga un movimiento uniformemente desacelerado, donde la rapidez inicial y final se relacionan con el desplazamiento Δx y la aceleración a mediante la conocida expresión (Serway, et al., 2010; Serway, & Jewett, 2008):

$$2a\Delta x = v^2 - v_0^2 \quad (4)$$

donde v es la rapidez final (en este caso es nula porque queda detenido) y v_0 es la rapidez inicial. Combinando (3) y (4) para el caso de una superficie horizontal, se tiene:

$$-m = -am \frac{(v^2 - v_0^2)}{2\Delta x} = \mu m \quad (5)$$

Además, al considerar que finalmente el cuerpo se detiene, (5) puede reescribirse como:

$$\frac{v_0^2}{2g} = \mu \Delta x \quad (6)$$

Nótese que si se lanza a resbalar un cuerpo, conociendo la rapidez inicial (v_0) para diversos lanzamientos, y midiendo el respectivo desplazamiento (Δx), resulta posible graficar Δx como variable independiente, tomando $v_0^2/2g$ como variable dependiente. Por tanto, la gráfica (6) es una recta que pasa por el origen, y cuya pendiente vendrá dada por el coeficiente de roce resbalante cinético μ entre las superficies.

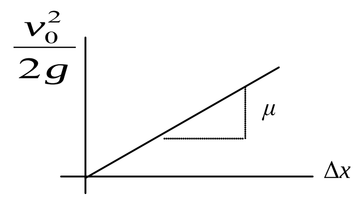


Figura 2. Gráfica x versus $v_0^2/2g$. Se observa que la gráfica corresponde a una recta que pasa por el origen, y cuya pendiente es igual al coeficiente de roce cinético μ.

METODOLOGÍA EXPERIMENTAL

A continuación se describen los materiales empleados en el experimento. Desde luego, cada docente puede adaptar el experimento en función de sus propios requerimientos, de modo que la siguiente lista de materiales debe considerarse una simple sugerencia.

***Instrumentos*:** 1 huincha de medir (300±1) (*cm*); 1 cronómetro (±0,1*s*), es reemplazable por un cronómetro de teléfono móvil.

***Materiales*:** 2 o más trozos de madera de distinta área; 1 bolita de acero.; 1 plumón; 1 objeto para impulsar; 1 peso de aproximadamente 1*kg*.

El desarrollo del experimento requiere que sobre un suelo liso se lance un trozo de madera para medirle su rapidez inicial. Sin embargo, dicha medición no resulta simple. Una forma de medir la rapidez inicial consiste en utilizar algún tipo de sensor de movimiento computarizado. No obstante, ese tipo de instrumental se aparta de los objetivos de este trabajo, donde se busca describir una experiencia de fácil realización.

Un procedimiento posible para salvar las dificultades anteriores, que pese a no ser exacto conduce a una buena aproximación, consiste en emplear una bolita de acero que se antepone al trozo de madera al momento de impulsarlo (ver figuras 3 y 4); puesto que el roce resbalante afecta sólo al trozo de madera, a poco andar la bolita deberá separarse. Así, mientras el trozo de madera se frena hasta detenerse, la bolita continuará con un movimiento aproximadamente uniforme rectilíneo. Si antes de lanzar el trozo de madera se hace sobre el suelo una marca lejana (entre 3*m* y 8*m* aproximadamente) del punto en que se suelta el trozo de madera, y se cronometra el tiempo desde que se suelta dicho trozo hasta que la bolita cubre la distancia establecida, se podrá determinar la rapidez media (v_m) de aquélla, la que será similar a su rapidez inicial (v_0), pues al rodar por una superficie lisa, la pérdida de rapidez será pequeña. Puesto que el trozo de madera parte junto con la bolita, la rapidez media de aquélla será muy similar a la inicial del trozo de madera. De esta forma se tendrá toda la información asociada a cada medición. Si se denomina L a la distancia que cubre la bolita, y Δt al intervalo de tiempo que emplea en recorrer dicha distancia, se tiene:

$$v_0 = v_m = \frac{L}{\Delta t} \quad (7)$$

Reemplazando (7) en (6) se obtiene:

$$\frac{L^2}{2g\Delta t^2} = \mu \Delta x \quad (8)$$

De acuerdo con estimaciones efectuadas por los autores, la variación de la rapidez media es despreciable, pues la desaceleración de la bolita de acero es pequeña y bordea el 10%, siempre que la superficie sea lisa y la rapidez inicial de la bolita supere los 2,0*m*/*s*.

Las figuras 3 y 4 muestran el montaje experimental:

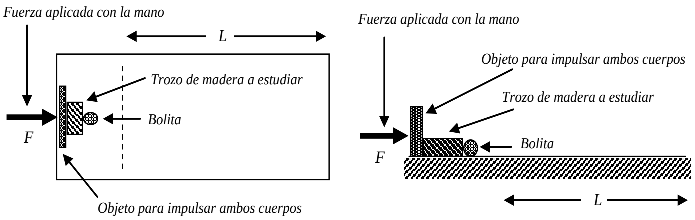


Figura 3. Montaje experimental en vista superior (izquierda) y lateral (derecha). La línea punteada corresponde al punto donde termina el impulso sobre el trozo de madera. Esta línea coincide con el inicio de la medición del tiempo de la bolita, el cual finaliza cuando la bolita ha recorrido la distancia L.

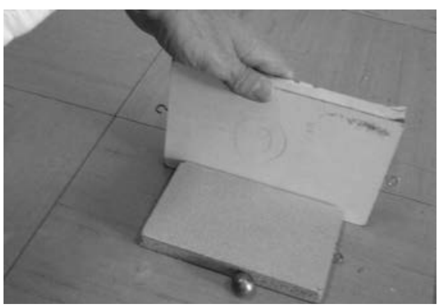


Figura 4. Montaje experimental, donde aparece la ubicación del trozo de madera, de la bolita de acero, y del objeto para impulsarla, que es sostenido por una mano.

Como se ha señalado antes, el experimento se repitió tres veces. Primero se lanzó un trozo de madera pequeña con melamina sobre suelo de flexit, luego se incrementó la masa del trozo de madera pequeño añadiéndole 1,0*kg* sobre ella; por último, se modificó el área de contacto, usando un trozo de madera más grande, sin agregar peso adicional. La Tabla I consigna los parámetros empleados para realizar el experimento.

Tabla I. Parámetros del experimento

Objeto	Ancho ±0,1(cm)	Largo ±01(cm)	Área (cm2)	±δA (cm2)	Masa ±0,1(g)
Madera pequeña	4,6	12,0	55,2	1,7	56,9
Madera pequeña con masa	4,6	12,0	55,2	1,7	1.054,3
Madera grande	9,9	12,0	118,8	2,2	124,3
Bolita de acero	-	1,10	-	-	44,7
Recorrido bolita	-	500,0	-	-	-

Como sugerencia, es importante lanzar el trozo de madera de modo que cubra distancias disímiles, es decir, aplicarle impulsos pequeños y grandes. También es conveniente que la bolita recorra distancias de entre 1*m* y 5*m*. Otro aspecto a tener presente es la cantidad de mediciones a realizar, dada la significativa variabilidad de valores. En este sentido, es recomendable tabular al menos una decena de puntos para graficar. Como última sugerencia, es conveniente realizar el experimento con la colaboración de 3 o 4 estudiantes, de manera que mientras el docente impulsa el objeto de estudio junto con la bolita de acero, los colaboradores miden el tiempo de recorrido de la bolita; así, se consigue que el tiempo promedio tenga un valor más confiable, pues suele ocurrir que la manipulación del cronómetro conlleva errores y éstos pueden detectarse más fácilmente si hay 4 medidas de tiempo para cada lanzamiento. Si alguna medida resulta defectuosa, es posible identificarla y descartarla del conjunto de datos.

RESULTADOS OBTENIDOS

A continuación se presentan los resultados experimentales para la determinación del coeficiente de roce cinético, consignando separadamente los resultados para cada etapa.

A. *Primera etapa: Madera pequeña sola*

En la tabla II aparecen los resultados obtenidos al hacer deslizar la madera pequeña sin peso adicional; por simplicidad, se omite el subíndice en la expresión para la rapidez inicial al cuadrado. Esta misma convención será adoptada en lo que resta del artículo.

Los valores consignados en la Tabla II corresponden al intervalo de tiempo Δt durante el cual rueda la bolita, el desplazamiento Δx de la madera, y el factor proporcional a la rapidez v de la bolita. Al graficar los datos de la Tabla II mediante el método de los mínimos cuadrados (Gil & Rodríguez, 2001), se obtiene una buena tendencia a recta, tal como muestra la siguiente figura, donde también aparece el valor de r^2:

Tabla II. Resultados para la madera pequeña sola

Δt (s)	Δx (m)	v2/2g (m)
1,69	1,63	0,45
1,99	1,36	0,32
1,38	2,73	0,67
1,00	3,76	1,28
1,53	3,00	0,54
0,90	5,06	1,57
2.17	1,21	0,27
3,49	0,45	0,10
2,99	0,62	0,14
1,24	3,03	0,83
1,13	4,14	1,00

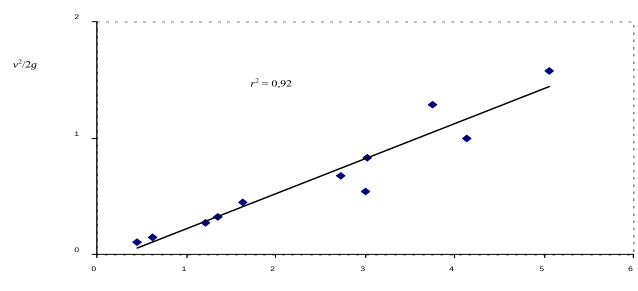


Figura 6. Gráfica obtenida mediante el método de los mínimos cuadrados, para los datos de la Tabla II. Se aprecia que los puntos presentan una buena tendencia a recta.

La función correspondiente a la gráfica anterior es:

$$\frac{v^2}{2g} = (0{,}03 \pm 0{,}03)\,\Delta x \qquad (9)$$

B. *Segunda etapa: Madera pequeña con masa*

Los valores obtenidos al hacer deslizar la madera pequeña con un peso adicional de aproximadamente 1*kg* aparecen en la siguiente tabla:

Tabla III. Resultados para la madera con peso

Δt (s)	Δx (m)	v2/2g (m)
4,14	0,36	0,07
2,39	1,04	0,22
1,63	2,14	0,48
1,77	2,10	0,41
1,48	2,56	0,58
1,35	2,50	0,70
1,06	3,50	1,14
1,43	2,95	0,62
1,54	2,64	0,54

Al graficar los datos de la Tabla III empleando nuevamente el método de los mínimos cuadrados, también se obtiene una buena tendencia a recta, tal como se muestra en la siguiente figura, donde se incluye el valor de r^2:

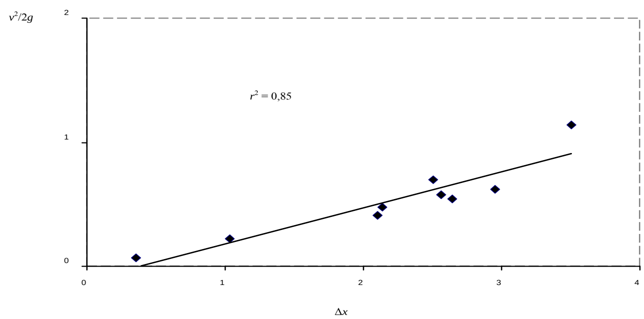


Figura 7. Gráfica obtenida mediante mínimos cuadrados para los datos de la Tabla III. Nuevamente los puntos presentan una buena tendencia a recta.

Para este gráfico, la recta asociada tiene la función:

$$\frac{v^2}{2g} = (0{,}30 \pm 0{,}05)\ \Delta x \qquad (10)$$

C. *Tercera etapa: Madera grande*

Los valores obtenidos al hacer deslizar la madera grande sola, aparecen en la tabla IV:

Tabla IV. Resultados para la madera grande

Δt (s)	Δx (m)	v2/2g (m)
2,17	1,37	0,27
1,55	3,32	0,53
1,81	1,84	0,39
1,08	2,95	1,09
1,27	3,40	0,79
1,26	3,67	0,80
1,15	3,88	0,96
0,90	4,90	1,57
2,33	1,11	0,23
2,34	1,03	0,23

A continuación aparece la gráfica correspondiente a la Tabla IV:

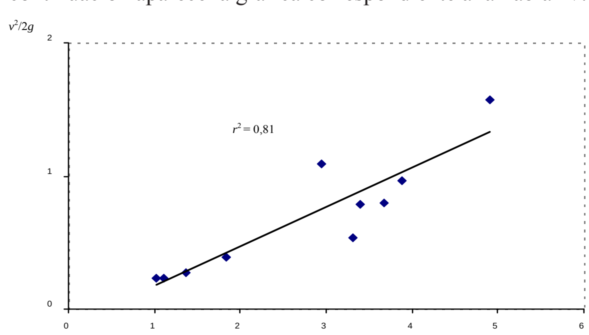


Figura 8. Gráfica obtenida mediante mínimos cuadrados para la Tabla IV. La tendencia a recta sigue siendo buena, pero la correlación es menor que en los casos anteriores.

Nuevamente, aunque no con tan buena correlación como en las partes A y B, la gráfica muestra una buena tendencia a recta, donde la función obtenida por el método de mínimos cuadrados es:

$$\frac{v^2}{2g} = (0{,}29 \pm 0{,}05)\,\Delta x \qquad (11)$$

DISCUSIÓN DE RESULTADOS

En primer lugar es importante destacar que en los tres casos discutidos en las subsecciones A, B y C, se determinó el mismo valor para el coeficiente de roce cinético asociado, dentro del error experimental, lo cual permite establecer que el valor de μ es correcto. En un experimento independiente, que se espera publicar como segunda parte del presente artículo, los autores midieron el coeficiente de roce cinético utilizando un timer, obteniendo el valor 0,34±0,03, el cual es prácticamente igual al que aquí se ha determinado, lo que refuerza la validez de los resultados obtenidos en este experimento.

En relación a la modificación del área, discutida en la sección anterior, cabe señalar que pese a la significativa diferencia en el tamaño de las superficies de los trozos de madera, se determinó el mismo coeficiente de roce, lo cual muestra que no depende del tamaño del área de contacto. Por otra parte, al agregar peso al cuerpo, y pese a que se incrementó su masa en casi 20 veces, se encontró el mismo valor para μ, lo cual muestra que efectivamente dicho valor no depende de la fuerza normal, y por lo tanto tampoco depende de la masa del cuerpo. Sin mucho trabajo adicional se podría extender el experimento, modificando el material de la superficie, lo cual permitiría mostrar que μ depende del material utilizado.

Finalmente, en relación a las incertidumbres asociadas al experimento, es complejo establecer una fuente de error principal, debido a que las mediciones no son rigurosamente reproducibles, pues el objeto se lanza con la mano, y no es factible repetir ese impulso en forma exacta. Por lo tanto, la estimación de incertidumbre asociada al resultado corresponde a un error de tipo estadístico asociado a la distribución de puntos en el gráfico, el cual se estimó mediante el método de mínimos cuadrados, y está asociado al procedimiento experimental junto con el experimentador.

CONCLUSIONES

Los experimentos demostrativos constituyen una valiosa herramienta para promover el aprendizaje activo de la física. Una metodología que los autores de este trabajo consideramos adecuada para implementar en esta clase de experimentos son las Clases Interactivas Demostrativas (*Interactive Lecture Demonstrations ILD*) (Sokoloff & Thornton, 1997; Sokoloff & Thornton, 2004), que desde hace más de una década se han venido utilizando con éxito en diferentes universidades. Aunque las ILD suelen usarse mediante la exposición de videos donde los estudiantes observan y discuten situaciones físicas de interés, las ILD se adaptan espléndidamente a los experimentos demostrativos, efectuados directamente frente a los estudiantes. Para más detalles puede consultarse la extensa bibliografía sobre el tema (e.g., Sokoloff & Thornton, 1997; Sokoloff & Thornton, 2004; Tanahoung, et al., 2009; Sharma, et al., 2010; Jairuk, 2007; Loverude, 2009; Thornton & Sokoloff, 1998; Crouch, et al., 2004).

Finalmente nos parece relevante enfatizar que las tres fases del experimento permiten combatir errores conceptuales frecuentes entre los estudiantes cuando se aborda el roce cinético, a saber: que μ depende de la rapidez con que se desliza el cuerpo, que depende de su masa, y también del área de las superficies en contacto. En nuestra experiencia en aula, el experimento propuesto ha sido una valiosa herramienta para combatir y erradicar estos errores conceptuales. Por lo tanto, confiamos en que el presente trabajo constituya un aporte a la labor desarrollada por los docentes de física.

BIBLIOGRAFÍA

Alonso, M. & Finn, E. J., *Física, Volumen* II, Addison Wesley, Wilmington, 1986.

Alvarenga, M. A., de Castro I. C., & Gaspar, A., Abordagem experimental da força de atrito em aulas de Física do Ensino Médio, *Caderno Brasileiro de Ensino de Física*, **29**, [3], 61-66, 2012.

Calderon, S. E., López, S., & Gil, S., Determinación de la fuerza de roce con el aire usando nuevas tecnologías, *Enseñanza de la física*, **20**, [1-2], 55-64, 2007.

Crouch, C. H., Fagen, A. P., Callan, J. P., & Mazur, E., Classroom demonstrations: Learning tools or entertainment? *American Journal of Physics* , **72**, [6], 835-838, 2004.

Dumbrajs, S., Helin, P., Kärkkäinen H., & Keinonen T., Towards meaningful learning through inquiry, *Eurasian J. Phys. Chem. Educ*., **3**, [1], 39-50, 2011.

Giáncoli, D. C., *Física*, 6ª ed., Pearson Educación, México D.F., 2006.

Gil, S., & Rodríguez, E., *Física re-creativa: Experimentos de física usando nuevas tecnologías*, 1ª ed., Pearson Educación, Buenos Aires, 2001.

Gratton, L. M., & Defrancesco, S., A simple measurement of the sliding friction coefficient, *Physics Education*, **41**, [3], 232-235, 2006.

Jairuk, U., *The Use of interactive lecture demonstrations in force and motion to teach high school level physics*, Mahidol University, Bangkok, 2007.

Kaplan, D., Observing the Forces Involved in Static Friction Under Static Situations, *The Physics Teacher*, **51**, [4], 224-230, 2013.

Loverude, M. E., A research-based interactive lecture demonstration on sinking and floating, *American Journal of Physics*, **77**, 897-901, 2009.

Mills, A., The coefficient of friction, particularly of ice, *Phys. Educ*., **43**, [4], 392-395, 2008.

Serway, R. A., & Beichner, R. J., *Física para ciencias e ingeniería, Tomo* I, 5ª ed., McGraw-Hill, México D.F., 2001, p. 132-133.

Serway, R. A. & Jewett, J. W., *Física para ciencias e ingeniería, Volumen* 1, 7ª ed., Cengage Learning, México D.F., 2008, p. 121.

Serway, R. A., Vuille, C., & Faughn, J. S., *Fundamentos de física, volumen* 1, 8ª ed., Cengage Learning, México D.F., 2010, p. 103.

Sharma, M. D., Johnston, I. D., Johnston, H. M., Varvell K. E., & Robertson, J. G., Use of interactive lecture demonstrations: A ten year study, *Phys. Rev. Special Topics-Phys. Educ. Res*., **6**, 1-9, 2010.

Sokoloff D. R., & Thornton, R. K., *Interactive Lecture Demonstrations*, Hoboken, NJ, Wiley, 2004.

Sokoloff, D. R., & Thornton, R. K., Using interactive lecture demonstrations to create an active learning environment, *The Physics Teacher*, **36**, 340-347, 1997.

Tanahoung, C., Chitaree, R., Soankwan, C., Sharma, M. D., & Johnston, I. D., The effect of interactive lecture demonstrations on students' understanding of heat and temperature: a study from Thailand, *Res. Sci. Technol. Educ*., **27**, 61-71, 2009.

Tipler, P. A., *Física para la ciencia y la tecnología, volumen* 1, 4ª ed., Reverté, Barcelona, 1999, p. 112.

Thornton, R. K., & Sokoloff, D. R., Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture Curricula, *American Journal of Physics,* **66**, [4], 338-352, 1998.

Received 27-07-2014 /Approved 02 -05- 2015

Index volume 16, 2015

FORMATO DE SUSCRIPCIÓN

REVISTA DE EDUCACIÓN EN CIENCIAS
Journal of Science Education

Suscripción volumen 16, 2015 (2 números en CD)

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, vol. 14, 2013, vol. 15, 2014, vol. 16, 2015 (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, 13, 14 y 15 en Internet.

Suscripción: en Colombia: $ 98 000, en otros países: 120 US$.

a. para persona natural: $ 25.000.oo pesos colombian
b. para institución: $ 43 000.oo pesos colombiano

Pago en Colombia:

Consignar en la cuenta de ahorros N° 2021 3358355 de Bancolombia, Bogotá.

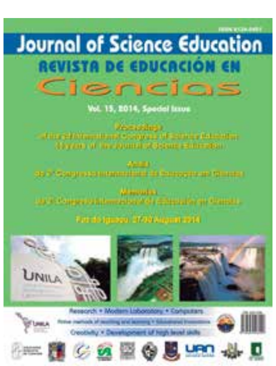
Pago para suscriptores fuera de Colombia:

A. Hacer transferencia bancaria o giro bancario de la suma correspondiente BANK INFORMATION: Bancolombia, Colombia, Bogota, cuenta de ahorros 2021 3358355 name: Y. Orlik, JSE
SWIFT BANCOLOMBIA COLOCOMB, ABA 021000089 SWIFT BANCO INTERMEDIARIO CITIUS33, ACREDITAR A LA CUENTA DE BANCOLOMBIA 360066658

B. Hacer el giro por Western Union, WU, a nombre de Y. Orlik, Director JSE, Brasil. Colombia

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



Proceedings (Memorias /Anais)

of the 2d International Congress of Science Education, 15 years of the Journal of Science Education, ISBN 978-958-99070-3-0 ,

Journal of Science Education. Special issue, vol. 15, 2014, 240 pp.

To get these Proceedings is necessary to send email to : oen85@yahoo.com