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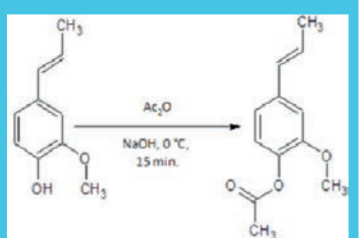

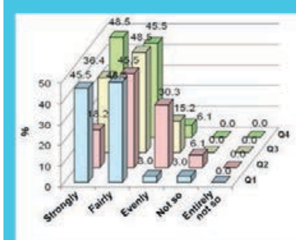

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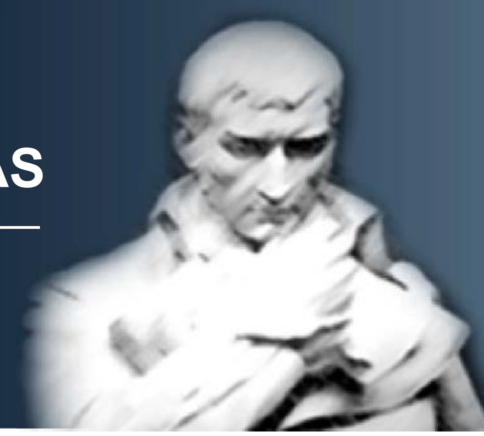

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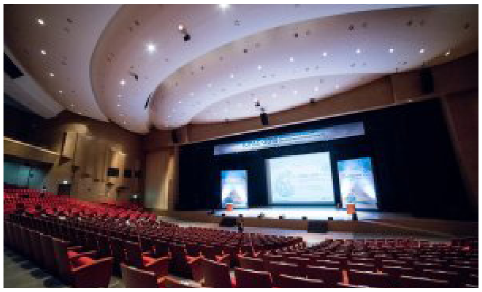
CONTENTS

Chemistry and science education in the 45th IUPAC World Chemistry Congress (IUPAC-2015)



The 45th IUPAC World Chemistry Congress (IUPAC-2015) was held in Busan, Korea on August 9-14, 2015 under the theme of **“Smart Chemistry, Better Life”** . The agenda of IUPAC-2015 was to emphasize the central role of chemistry as a multidisciplinary science to promote the quality of life and welfare through innovative scientific achievements and to discuss current issues of mutual interest. Very interesting Congress activities were centered in questions of how to solve problems related to energy, food, water, and environment and other crucial topics of human life. In this regard IUPAC-2015 provided a variety of opportunities to exchange ideas and expertise as well as network with worldwide research groups.

One of the biggest conferences in the World, IUPAC-2015 welcomed 3,787 participants from 79 countries.

The congress proposed a rich scientific program that allowed participants to deepen their knowledge and have discussions with each other. It included plenary/keynote/invited lectures, session talks, poster presentations, and workshops under 12 major themes and over 116 symposia. The many high-quality lectures, the Organizing Committee invited 437 speakers from 31 countries including 4 Nobel laureates, made the Congress all the more fruitful.

The themes of chemistry and science education were well represented in the Congress too. For example, Prof. N. Tarasova (Russia) delivered an interesting lecture *Chemistry: Meeting the Worlds’ Needs?*

The plenary lecture of the Nobel laureate in Physics, 2010 Prof. A. Geim (UK*), Van der Waals Heterostructures and Beyond* was not about an educational theme, but stressed important details of modern nanochemistry and nanophysics, which had a lot of educational applications too.

In the educational area some interesting Symposia were organized*: Curriculum and Evaluation , Chemistry Education for the Future: A Global Perspective, Best Practices in the Teaching and Learning of Chemistry, Sustainable Chemistry Education, Research and Practice.* There were many important works presented in poster sessions too.

Our JSE was well represented in the Congress too and Members of JSE Committee delivered very engaging presentations : professors I. Maciejowska (Poland), M. Kamata (Japan), P. Mimero (France) , Mei-Hung Chiu (Taiwan), and others.

A lot of new works of chemistry and science education were well met with great interest by presenters . Some of them are:

Materials Based Science Education (MBSE) (M. Kamata, Japan), Promoting Global Chemistry Education via the Development of International Standards of Chemistry Education (Mei-Hung Chiu, Taiwan), Research on Learning in the Academic Laboratory in Tertiary Education (S. Sandi-Urena, USA), Impact of Nanotechnology on Chemistry and Chemical Engineering Curricula (D. Benachour ,Algeria), What Happens During a Chemical Reaction? Students’ Perceptions (L. Mammino, South Africa), A comparative and analytic study of activities of science and Chemistry textbooks for secondary school between South Korea and North Korea (HyunJu Park, GeonHee Kim, DaHee Jung, Yoojin Cho, Korea), 3D-printed setups for demonstrating pollutants photo-degradation in liquid and gas-phase (B. Stefanov, et all, Sweden), Chemistry of Paintings: How to Involve 8-10 y.o. Children for Two-Hours Session without Breaks (D. Zhilin, M. Tokareva, Russia), Project-based learning as a way to cover the gap between school curriculum and contemporary chemistry (O. Koliasnikov, et all, Russia), Teacher Training at Chemistry Faculties – Mutual Benefits? A Case Study Based on the Example of the IRRESISTIBLE Project (I. Maciejowska, et all. Poland), ECTN and EC2E2N: 19 years of a successful European Chemistry Thematic Network story (P. Mimero, A. Smith, R. Whewell, France, UK) and many other works.

The social and cultural program was very well organized too. There were various activities of Korea Chemical Society, Royal Chemical Society (RCS), interesting excursions in Busan and other parts of the country.

The next IUPAC 2017 will be held in Brazil.

Yuri Orlik

Characterizing scientific inquiry found in science core high schools (SCHS) in Republic of Korea

Caracterización de indagación científica encontrada en las escuelas secundarias con educación profundizada en ciencias en la República de Corea

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Abstract

The government of the Republic of Korea established a new type of school where students are provided with science research labs and field experiences in 2009. Rather than memorizing scientific knowledge and taking written tests without true understanding and applications the Science Core High School (SCHS) was designed to help students experience scientific inquiry and practice to enhance their scientific process skills and to develop better scientific minds. This study intended to find evidence of changes in the science classrooms in the SCHS as scientific practices are infused in teaching. The focus of the study was on identifying the characteristics of science teaching and learning in the newly built school system focusing on scientific inquiry.

Key words: *science education, Science Core High School, scientific inquiry, Republic of Korea*

Resumen

El gobierno de la República de Corea estableció en 2009 un nuevo tipo de escuela donde los estudiantes cuentan con laboratorios de investigación de la ciencia con la metodología de experimentación científica. En lugar de memorizar los conocimientos científicos y tomando pruebas escritas sin una verdadera comprensión y aplicaciones, las escuelas secundarias con educación profundizada en ciencias fueron diseñadas para ayudar a los estudiantes a experimentar, investigar y tener las prácticas científicas para mejorar sus habilidades indagativas y desarrollar mejor las capacidades científicas. Este estudio pretende encontrar evidencia de los cambios en las clases de ciencias en estas escuelas y sus influencias en las prácticas científicas en la enseñanza. El objetivo del estudio fue la identificación de las características de la enseñanza de las ciencias y el aprendizaje en el sistema escolar de nuevo tipo con énfasis en la indagación científica.

Palabras clave: *escuelas, educación profundizada, ciencias, indagación científica, República de Corea*

INTRODUCTION

The extent to which reform efforts framed by constructivism and promoted in the national standards documents have taken hold has been a topic of discussion in many countries. In Korea, Lee and Fraser (2000) argued, “while constructivist principles have been consistently emphasized in the science curriculum since 1982, actual practices in the classrooms in Korea have been dominated by teacher-centered, lecture-type instruction” (Lee & Fraser, 2000, p. 1). As evidence for this claim, in a study by Kim, Fisher, and Fraser (2000) investigating students’ perceptions of their learning environment and teacher interpersonal behaviors in Korean science classrooms, 543 grade eight students rated the level of support they received from their teachers as relatively low. In addition, these same students reported a minimal amount of involvement in their class, as well as a limited amount of cooperation with other students (Campbell, et al, 2010).

The goals of inquiry, based on the National Science Education Standards (NSES), are summarized as: Through school science students should: (1) learn to do scientific inquiry, and (2) develop an understanding of scientific inquiry (National Research Council, 1996). The emphasis on scientific inquiry is also consistent with the Next Generation Science Standards, (National Research Council, 2013). In current school science practice, it is easily found that these two goals could be separately undertaken. As students perceive scientific knowledge to be the results or outcomes of doing science, they make efforts to memorize abstract science jargon without undergoing scientific practice or inquiry process. Understanding of scientific knowledge is, however, gained by using it. Better understanding scientific knowledge must involve students in participating in doing inquiry and scientific testing. Doing science is indeed correlated with cognitive processes that include scientific reasoning, students asking their own questions and formulating their own explanations. Students construct their own meaning through doing science. Such cognitive process and skills that involve scientific reasoning cannot be achieved by memorizing.

Unfortunately, school sciences in Korea have not been successful in involving students in their own inquiry where they are challenged with the cognitive processes involved with doing science. Recently, however, the Korean government has started to emphasize developing a strong science curriculum in high schools. The Science Core High Schools (SCHS), established in 2009, were designed to provide students with opportunities to practice authentic scientific inquiry. In Korea there are about 2282 high schools and 100 SCHSs. The proportion of SCHS is 4.4%. The SCHS is two year program for 11th and 12th graders that occurs in normal high schools nominated as SCHS. The government funded the development of the new science curriculum that included a special science program where students worked on scientific inquiry projects and studied history and philosophy of science as they were engaged in active science learning. The SCHS is a type of science immersion program in Korea.

In this study, we had two research goals:

- Explore qualitatively the features of scientific inquiry found in classes.
- Rethink what school science inquiry means as related to the educational purpose of school science.

After reviewing the theoretical framework for involving students in scientific inquiry these goals will be developed in the methodology and further analyzed and discussed in the results.

THEORETICAL FRAMEWORK

In science education, characteristics and features of school scientific inquiry have been searched and explored in many ways by researchers. At the international symposium (Abd-El-Khalick et al. 2004), researchers in science education made a list of processes for describing science inquiry (Grandy & Duschl, 2007): posing questions, refining questions, evaluating questions, designing experiments, refining experiments, interpreting experiments, making observations, collecting data, representing data, analyzing data, relating data to hypotheses/models/theories, formulating hypotheses, comparing alternative theories/models with data, proving explanations, giving arguments for/against models and theories, comparing alternative models, making predictions, recording data, organizing data, discussing data, discussing theories/models, explaining and refining theories/models, writing about data, writing about theories/models, reading about data, and reading about theories/models.

This list interestingly included cognitive, social, and epistemological elements (Grandy & Duschl, 2007). For instance, writing about scientific theory is a cognitive task and at the same time it can ask students to make societal judgments (Norris 2005). It is because writing means that student authors need to possess delicate beliefs about the cognitive tasks of readers and at the same time ask students to make societal judgments. As students are making predictions, recording data, and organizing data, they may not concentrate on the writings. Therefore writing tasks need to require different points of view and the epistemological judgment and reasoning of students. In summary, judgment and reasoning should be included in school science connected to the real world. Whether authentic inquiry is feasible in school science classes is a question that is hardly answered. However, as explained in the “Inquiry and the National Science Education Standards: A Guide for Teaching and Learning” (NRC, 2000), teaching approaches and instructional features in scientific inquiry can be varied.

What experiences provided for learners through inquiry occur in school science? Grandy and Duschl (2007) presented a list similar to the above but focused on what learners should learn in school science inquiry. It involved learners being engaged with scientifically oriented questions, giving priority to evidence, formulating explanations and communicating and justifying their proposed explanations.

This list can be considered when designing immersion programs of long-term inquiry curriculum from the viewpoint of learner -centered classroom environments.

Considering the limitations of the physical environments in schools and the task of covering the whole national curriculum in Korea found in school science, it is a challenge to implement authentic inquiry in schools. Still we can try to find a way of overcoming such impediments and propose feasible ways of doing science. In that context, school scientific inquiry provides students with opportunities to formulate and evaluate explanations from evidence and actively participate in scientific practice and discourse (NRC, 1996, 2003; McNeill, 2011). Science for students is more than explaining concepts and facts; scientific understanding also includes thinking and reasoning. It is essential for students to provide concrete illustrations and experiential evidence to show authentic practice and reality of school scientific inquiry.

METHOD

Target Science Classes

During this study, thirteen Science Core High Schools were observed and videotaped from April to June of 2012. Fifteen classes were videotaped for this study: 8 from 10th, 6 from 11th, and 1 from 12th grades. The demographic information of the 15 classes is described in Table 1. Students in SCHS must take eight science courses including biology, chemistry, physics and earth science as well as science literacy, integrated science, and two out of physics experiment, chemistry experiment, biology experiment and earth science experiment.

Teaching strategies of fifteen classes in thirteen different SCHSs were as follows: three classes designing and inventing some devices (e.g. toy wagon using the principle of action and reaction law); five with active discourses by using student presentation and discussion; five with laboratory style investigation; one with a long term group investigation project; one with Prediction-Observation-Explanation (POE) teaching strategy where teachers allowed students to predict before observing something happening and explain after observing the actual demonstration (see Table 1).

Data Collection

Two researchers participated in observing and videotaping 15 classes. Two focus group discussions among students were videotaped. These videotaped classes were transcribed. After observation of classes, the researchers interviewed teachers and students to find their understanding of lesson goals and procedures. Lesson plans and students' work sheets were collected as well.

Data Analysis

The data analysis was conducted in three steps. In the first step, videotapes and their transcripts were examined. Discourse segments of student-student and students-teacher were extracted as well. The exemplary cases of showing active interactions were selected. Secondly, according to cognitive processes of inquiry (Chinn & Malhotra, 2002), each segment was analyzed and interpreted. Chinn & Malhotra (2002) categorized inquiry into authentic inquiry, simple experiment, simple observation, and simple illustration. They defined the cognitive process for each category and developed the framework to apply for analyzing textbooks. In the third step, exemplary cases were extracted to show essential features of school science inquiry.

Table 1. Summary of 15 class information from 13 SCHSs.

SCHS School Name Initial	Grade (number of observed classes)	Course Name	Features of Student Activity in Observed Classes	Activity Type
JA	11th (2)	Science Study	Student Science Long-term investigation	Group investigation project
KN	10th(1)	Science Literacy	POE, Student Inferences and Presentation	Prediction-Observation-Explanation(POE) /Student Inference and Presentation
SER	12th (1)	Chemistry Experiment	Experiment on measuring molecular weight using Ideal Gas Law	Laboratory style investigation
WA	10th (1)	Science Literacy	Experiment related to the topic of Health: antioxidants and reduction-oxidization Experiment	Laboratory style investigation
YJ	10th (1)	Science Literacy	Inventing 'Slowest moving slide'	Designing and Inventing
ICW	10th (1)	Integrated Science	Inventing 'Pendulum of Foucault'	Designing and Inventing
JI	11th (1)	Earth Science	-Big-Bang Theory -Student making film presentation on Big-Bang Theory	Student Presentation and Discussion
PCID	11th(1)	Biology	-Student Presentation and Discussion -Teacher Summary and Instruction	Student Presentation and Discussion
WJA	10th (1)	Science Literacy	Student Presentation on the topics of Advertisement and Caseins	Student Presentation and Discussion
BEJ	11th (2)	Chemistry Experiment '	Various student lab. Work	Laboratory style investigation
KR	10th (1)	Science Literacy	-Force and Momentum –Inventing a toy wagon which can make a longer trip	Designing and Inventing
BH	11th (1)	Earth Science	Student investigation and presentation on astronomy related topic	Student Presentation and Discussion
MS	10th (1)	Creative Science Experiencing	-Activity to make a water filtering machine -How to integrate music and physics	Laboratory style investigation

RESULTS

This study found four distinctive cases that demonstrated the cognitive processes of scientific inquiry: features of controlling variables-improving devices, designing studies, formulating explanations from observations, and reasoning to formulate explanations from evidence.

Case 1: Controlling variables-improving devices

Students in 10th grade class of SCHS KR took the course of "Science Literacy". Students, as found in the videotaped class, were asked to invent a "far going toy wagon" using the law of action–reaction in physics. Students tried to design a toy wagon which could move farther only with one finger push by using plastic straws, rubber bands and erasers (see Figure 1). The purpose of this class was mainly that students had a chance to design a science experiment including controlling variables. Students came up with numbers of strategies using different number of rubber bands, varying weight of erasers, and changing places of plastic straws. Controlling variables and the relationship between variables were considered including the height of placing rubber strings, how to set up erasers, and the placement of wagon on straws. In the school science classes, a full sequence of authentic inquiry was observed. Students formulated and structured their own questions, proceeded to experiments for solving their questions and they evaluated their explanations by identifying evidence. In the limited condition of full inquiry, partial features of inquiry activity were experienced. In this case, questions were provided for students, but the instruction was primarily learner-centered..

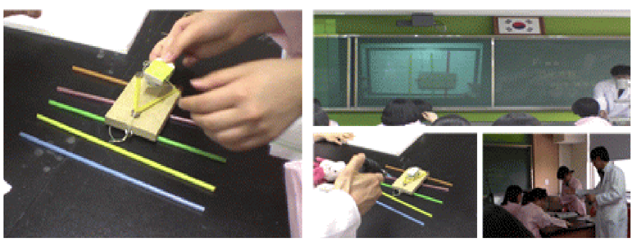


Figure 1. Students' activity of inventing 'far going' toy wagon

Case 2: Designing studies (defining variables, planning procedures, controlling variables, and planning measures)

This case took place in two class periods with 11th graders in SCHS JA participating in a group investigation project. This is a sort of independent science study or science immersion program. In one semester student group worked on their own science investigation topic for two hours every week. In the observed independent study group, students proposed to investigate on how to control the escape velocity of a variety of beads in a magnetic field. The escape velocity was dependent on the interactions and collisions of a variety of beads (including iron and glass beads). For example, given an initial velocity of an iron bead, the escape velocity was controlled by variables such as the: strength of magnets, diameter of iron beads and magnifying intensity. It was found that a group of three students designed their own study.

Figure 2. Students working on group investigation project

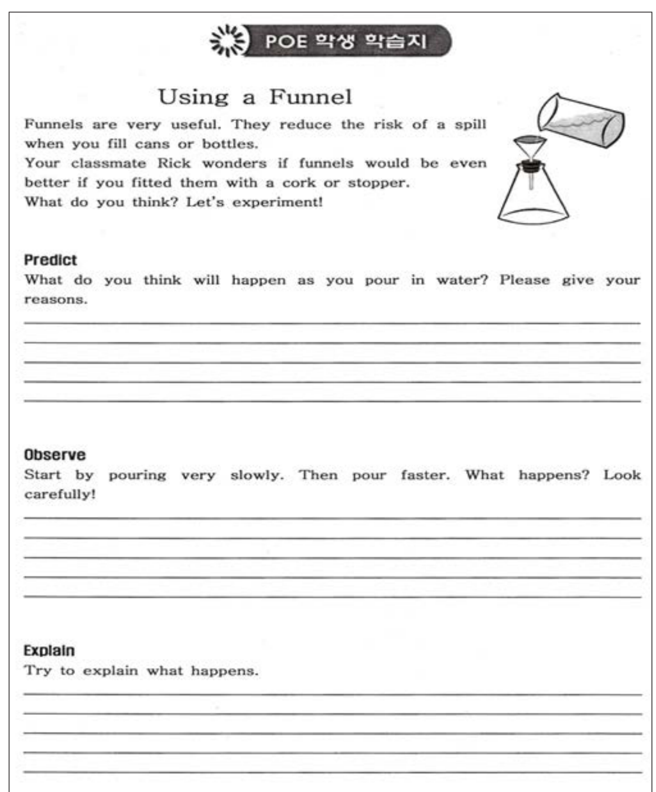
In this case, teachers did not tell the students the research question. Rather, the student groups made their own questions such as how to control escape velocity of moving beads in magnetic field. They tried to design the best experiment to solve their questions. They needed to define the variables related to their questions and make their own device. They interacted with each other in a group during the procedure of investigation. Students spent most of their time deciding distances and the time-duration of not-detecting laser light in order to calculate the escape velocity of beads. Students' exchange of ideas focusd on selecting critical variables for their own design of experimental devices in Figure 2.

Case 3: Formulating Explanations from Observations

This case was collected from a 11th 'Chemistry Experiment' class of SCHS BEJ during two consecutive periods. In this activity, students were asked to "design their own experiment using liquid nitrogen". Before starting this activity, a group of two students were assigned as a pre lab group and explained to the rest of students the purpose, contents, safety issues, and methods. The lab content found in this class were freezing roses, freezing a puffing snack, making liquid oxygen, twisting rubber balloons, and pouring liquid nitrogen into drinks.

Figure 3. Student works in chemistry experiment by using liquid nitrogen

Using liquid nitrogen, students observed a variety of phenomena and explained their observations. They tried to identify materials found during their experiments. When they explained something from their observations, it was found that they connected their observations with theoretical knowledge about phase change. Observational evidences from a simple experiment were simply matched with scientific knowledge and vice versa. This case showed two aspects of inquiry. First, students explained what they observed and linked to theory by means of active verbal interactions of students and teachers. During the interactions, they transferred their everyday words to scientific terms to explain their observations with scientific knowledge. Second, students tried to reason about the causes of what they observed and extended their investigation to explore various concepts, including differences between gases and liquids using appropriate materials.



POE 학생 학습지

Using a Funnel

Funnels are very useful. They reduce the risk of a spill when you fill cans or bottles.
Your classmate Rick wonders if funnels would be even better if you fitted them with a cork or stopper.
What do you think? Let's experiment!

Predict

What do you think will happen as you pour in water? Please give your reasons.

Observe

Start by pouring very slowly. Then pour faster. What happens? Look carefully!

Explain

Try to explain what happens.

Figure 4. POE instruction working sheet(above) and students in action(below)

Case 4. Reasoning to formulate explanations from evidence

This case was collected from the POE (prediction-observation-explanation) teaching strategy used in the 12th grade class. The topic of this class was "understanding pressure: using funnel, both air and a column of water can exert pressure". This case demonstrated students' reasoning process following by the given working sheet in Figure 4. Whenever they predicted what happened, they actively participated in the discourses with their colleagues.

Even when they explained their own observations, they tried to use scientific terms including equilibrium, pressure, Boyle's law, and air pressure. It was found that by using observations as evidence, the students interacted very actively in making meaning out of their observations.

DISCUSSION AND CONCLUSIONS

This study found four distinctive cases to show cognitive processes of scientific inquiry in the classes of SCHS. These processes included: features of controlling variables-improving devices, designing studies, formulating explanations from observations, and reasoning to formulate explanations from evidence. These processes on scientific thinking are consistent with recommendation from the Next Generation Science Standards (National Research Council, 2013). In the four cases, it was commonly found that student-teachers and student-student interactions were active and features of scientific inquiry were clearly present. Each case of exemplary lessons showed parts of elements of authentic inquiry rather than demonstrating its full sequences. Further analyses of each class, describing what happening in real classes collectively, led to in-depth discussion on the purposes and directions for improved school science inquiry. The new school system of SCHS showed some possibilities for providing other normal schools with benchmarks of how to facilitate student inquiry in school science based on this study.

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Una revisión sistemática sobre e-mentoring: tendencias y perspectivas

A systematic review of e-mentoring: trends and perspectives

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Resumen

La mentoría es una forma de apoyo que hace posible establecer relaciones de ayuda en muy diversos contextos, ya sean escolares o universitarios, de formación profesional e incluso en el ámbito de las organizaciones, en procesos de inducción a la profesión, de mejora y desarrollo profesional así como de desarrollo de competencias laborales específicas. Este artículo desarrolla una revisión sistemática con el objetivo de buscar información de manera ordenada, estructurada y metódica en torno a la mentoría electrónica para descubrir las tendencias y tópicos que la literatura científica muestra. La revisión se llevó a cabo desde una búsqueda sistemática, fundamentalmente en inglés, en la base ISI Web Of Science (WOS), empleando el descriptor "e-mentoring" y filtrando la búsqueda en función del criterio temporal (2009-2013) para los tipos de documento "article" en el área "Education and Educational Research". Se obtuvo un total de 20 artículos que cumplían los parámetros fijados. Los resultados se presentan desde dos parámetros. Por un lado, datos generales (autores, revistas, distribución por años y tópicos) y, en segundo lugar, se destacan los tópicos fundamentales. Esta investigación ha permitido apuntar hacia los beneficios, impacto y perspectivas de este tipo de programas.

Palabras clave: *e-mentoring, mentoría electrónica, tendencias, revisión sistemática, estado del arte*

Summary

Mentoring is a way to support that makes it possible to establish helping relationships in a variety of contexts, whether school or university, vocational training and even in the field of organizations, processes of induction into the profession, improvement and professional growth and development of specific competences. This article develops a systematic review in order to searching information in an orderly, structured and methodical way about the e-mentoring, to discover trends and topics that develops the scientific literature. The review was carried out from a systematic search in English, based on ISI Web of Science (WOS), using the descriptor "e-mentoring" *and filtering the search by time criterion (2009-2013) for document "article" in the "Education and Educational Research", obtaining a total of 20 articles that met the criteria set. Results are presented from two parameters. On the one hand, general data (authors, journals, yearly distribution and topical), and second, highlights the key topics. This research has allowed the benefits point to the benefits, impact and prospects of such programs.*

Key words: *e-mentoring, electronic mentoring, trends, systematic review, review of research*

INTRODUCCIÓN

La mentoría es una forma de apoyo que hace posible establecer relaciones de ayuda en muy diversos contextos, ya sean escolares o universitarios, de formación profesional e incluso en el ámbito de las organizaciones, en procesos de inducción a la profesión, de mejora y desarrollo profesional así como de desarrollo de competencias laborales específicas (Allen & Eby, 2007; Casado, Lezcano y Colomer, 2015; Hooley, Hutchinson & Neary, 2015).

En la literatura es muy frecuente encontrar palabras como mentoría y tutoría que se empleen de modo indistinto. Esto es debido a que en su esencia representan significados afines, dado que podría decirse que la mentoría es una forma de tutoría, pero a su vez presentan claras diferencias. En efecto, aunque mentoría y tutoría refieran a relaciones de apoyo y ayuda, tienen distintos objetivos y metodologías. Así, una de las distinciones más importantes entre tutoría y mentoría se centra en el rol del que aprende. En la tutoría, el problema se define y delimita de entrada, y el tutor es el principal responsable de cómo lo explora la persona tutelada, por ello la tutoría es una forma de acompañamiento y orientación más propia de la relación profesor-estudiante (Lázaro, 2010; López Gómez, 2013, 2015; Fernández Salinero, 2014). En el caso de la mentoría, la relación es más simétrica, se da inter-pares y el grado de estructuración y programación de la actuación del mentor es menor que en la tutoría, pues aunque esta actuación ha de ser proactiva, intencional y planificada, el mentorizado marca en mayor medida el ritmo y contenido del proceso de apoyo que co-protagoniza y co-dirige con su mentor (Velaz de Medrano, 2009, 213).

Centrando la atención en la mentoría, la investigación internacional es abundante en cuanto al número de trabajos, diversa respecto a los objetivos de investigación y plural en tanto que son muy variados los contextos en los que los procesos de mentoría se llevan a cabo.

Aunque el eje de este trabajo tiene que ver con la *e-mentoría* o mentoría electrónica, parece necesario traer a colación algunos trabajos que con lucidez han actualizado distintos elementos de la mentoría (concepto, finalidades, funciones, beneficios y tendencias) en la pluralidad de escenarios en los que se desarrolla, apuntando también hacía la mentoría electrónica como una modalidad de gran impacto y actualidad.

Así, son tres los trabajos que revisaremos en lo que sigue (Crisp y Cruz, 2009; Colvin y Ashman, 2010; Haggard, y cols., 2011). En el primero de ellos, Cris y Cruz (2009) desarrollan una investigación acerca de la relación entre mentoría y éxito académico en la universidad (1990-2007), actualizando la revisión previa realizada por Jacobi (1991). En su trabajo analizaron los documentos desde dos parámetros: las definiciones y características del mentoring y la evaluación de la calidad de los trabajos empíricos. Atendiendo al primero de ellos, muchos trabajos revisados señalan que las relaciones de mentoría se centran en el crecimiento y en los logros de los individuos e incluyen varias formas de apoyo (desarrollo profesional, psicológico y personal). Igualmente, en la revisión de la literatura se distinguen diversos tipos de relaciones de mentoría (formal o informal, planificada o espontánea, a largo plazo o de corta duración) así como distintas etapas del mentoring: iniciación (*iniciation*), cultivo (*cultivation*), separación (*separation*) y redefinición (*redefinition*) (Crisp y Cruz, 2009, 529). Estas mismas autoras apuntan que algunas publicaciones incluyen un componente tecnológico como tendencia novedosa para la mentoría.

En el segundo trabajo, Colvin y Ashman (2010) trataron de entender las relaciones de mentoría a través de una investigación que involucró a más de 15000 estudiantes y 400 estudiantes-mentores. A través de un complejo diseño cualitativo (observaciones, diarios de reflexión semanales y entrevistas) identificaron funciones, beneficios y riesgos de la mentoría.

Por su parte, Haggard, y cols. (2011) presentan una revisión de la literatura acerca de la mentoría (1980-2009) con dos objetivos. El primero de ellos fue analizar el concepto de mentor y, tras encontrar más de 40 definiciones diferentes concluyeron que la falta de consenso teórico era notable. El segundo objetivo se centró en conocer la disposición por fechas de los temas de investigación en torno a la mentoría, siendo los principales tópicos en la década de los 1980: la construcción de la mentoría y sus dimensiones clave, las barreras para ser mentor, los costos y beneficios de la mentoría, las diadas en función de variables culturales, entre otras. En cambio, en los años 1990-2004, la investigación en torno a la mentoría abordó aspectos como las fases y los criterios para finalizar el proceso de mentoría, resultados en el desarrollo personal, la calidad de las relaciones y la elección del mentor y telémacos. Finalmente, en el último lustro revisado (2005-2009), destacan los trabajos sobre el éxito del mentoring, *what works* y *best evidence* en mentoría, los procesos de mediación y el emergente *e-mentoring* (Haggard, y cols., 2011, 292). A modo de síntesis, se presentan en la Tabla 1 las principales conclusiones de estos trabajos de revisión.

Tabla 1: ***Elementos fundamentales de la mentoría. Fuente: adaptado de Crisp y Cruz, 2009; Colvin y Ashman, 2010; Haggard, y cols., 2011.***

Elementos fundamentales de la mentoría		
Concepto		Las relaciones de mentoría se centran en el crecimiento y en los logros de los individuos e incluyen varias formas de apoyo (desarrollo profesional, psicológico y personal). Pluralidad de definiciones (más de 40).
Funciones/ roles		*Nexo de unión* (connecting link), en el sentido que apoya a los estudiantes a conectar con la vida académica y del campus universitario.
		Líder de grupo (peer leader), al motivar y animar a implicarse en diversas iniciativas universitarias.
		Entrenador de aprendizaje (learning coach), que ayuda a descubrir a los estudiantes sus fortalezas que permitan desarrollar su potencial.
		Defensor del estudiante (student advocate), al atender sus necesidades y solucionar las diversas problemáticas académicas y personales.
		Amigo de confianza (trusted friend), dada la disposición al apoyo continuo del mentor y los lazos relacionales que se gestan.
Tipos de relaciones		Formal o informal/ planificada o espontánea/ a largo plazo o de corta duración.
Etapas		Iniciación (iniciation)/ cultivo (cultivation)/ separación (separation) y redefinición (redefinition).
Beneficios	*Para el mentor*	La posibilidad de apoyar a los estudiantes.
		El impacto personal de sentirse capaz de ayudar a otros.
		Participar con los estudiantes y estimular vínculos sociales.
		Conexión e implicación en el campus y la vida universitaria.
		La mentoría les permite volver a aplicar los conceptos en sus propias vidas y les ayuda a ser mejores estudiantes.
	Para los estudiantes	De las relaciones que se establecen.
		En las calificaciones y en el rendimiento académico.
Riesgos	*Percepción del mentor*	La gestión del tiempo.
		Las dificultades de ansiedad.
		El apego emocional con los estudiantes para luego tener que separarse de ellos al final del semestre.
		Los desafíos en la interacción con los estudiantes hacen que estos puedan ser demasiado dependientes del mentor o, por el contrario, no aceptarlo como tal.
	Percepción del estudiante	El mentor les molestase demasiado cuando no necesitaban ayuda.
		La falta de compromiso e implicación en su función.
		Las relaciones del mentor basadas en el formalismo.
Evolución en el tiempo: Tendencias	*1980-1990*	La construcción de la mentoría y sus dimensiones clave, las barreras para ser un mentor, los costos y beneficios de la mentoría, las diadas en función de variables culturales.
	1990-2004	Las fases y los criterios para finalizar el proceso de mentoría, resultados en el desarrollo personal, la calidad de las relaciones, la elección del mentor y telémacos.
	2004-2009	El éxito del mentoring, what works y best evidence en mentoría, los procesos de mediación, el emergente e-mentoring.

Como apuntan las tendencias identificadas por Haggard y cols. (2011), el *e-mentoring* representa un espacio de interés dentro de los estudios sobre mentoría, especialmente en los años 2004-2009. Es por ello que el trabajo que aquí se desarrolla pretende ser continuidad al interés constatado en la literatura. Para ello, se desarrolla una revisión sistemática sobre e-mentoring, para los años 2009-2013.

Se entiende que el e-mentoring tiene la virtualidad de combinar procesos de apoyo y mentoría con las potencialidades de la comunicación electrónica y virtual. Se ha denominado también *telementoring*, *cybermentoring* o simplemente, mentoría virtual.

Desde parámetros generales, el *e-mentoring* es la relación que establecen mentor y *telémaco* utilizando la comunicación virtual, caracterizado este por tener menos experiencia, conocimientos o habilidades que aquel. Así para Bierema y Merriam (2002, 219) "es una relación de beneficio mutuo entre un mentor y un protegido a través de un ordenador, el cual provee aprendizaje, mejora, motivación, estímulo diferente que la tradicional mentoría cara a cara (*face-to-face*)".

Por tanto, su principal pretensión es la de facilitar el desarrollo de habilidades, la adquisición de conocimientos o simplemente la incorporación de valores, de apoyo afectivo, confianza, socialización, etc. que dependerán de la pretensión del programa formativo. Por ejemplo, para el contexto universitario, la finalidad debería ser la de "facilitar a los alumnos todas las herramientas y ayuda necesaria para que puedan conseguir con éxito tanto las metas académicas como personales y profesionales que les plantea la universidad" (Sogués, Gisbert e Isus, 2007, 45).

Así, la mentoría electrónica ofrece oportunidades nuevas de apoyo a partir de diversos medios, muchos de ellos asincrónicos que se construyen desde la comunicación mediada por ordenador (*computer-mediated communication*, CMC), lo que permite superar las limitaciones de espacio y tiempo para lograr relaciones de mentoría exitosas (Ensher y cols., 2003). De hecho, este tipo de apoyo podría hacer que las relaciones de mentoría estén más disponibles para los grupos que previamente han tenido un acceso limitado a la modalidad presencial. Es un modelo que permite enriquecer o complementar, en algunos casos sustituir, a los programas de mentoría cara a cara si bien, como concluye Rísquez (2006), la *e-mentoría* ha de ser considerada en su propio derecho y no en comparación con su versión tradicional presencial.

Sin embargo, es necesario controlar algunas de las variables que son fundamentales para su eficacia como la planificación, la formación de los participantes, el seguimiento y los recursos para que estos programas sean realmente exitosos (Colvin y Ashman, 2010).

Tabla 2: ***Resultados de la revisión sistemática sobre e-mentoring. Fuente: Elaboración propia.***

Autores	Año	Revista	Temática
Schichtel, M.	2009	*Education for Primary Care*	A conceptual description of potential scenarios of e-mentoring in GP specialist training
Cothran, D., McCaughtry, N., Faust, R., Garn, A., Kulinna, P. H., & Martin, J.	2009	*Research quarterly for exercise and sport*	E-mentoring in physical education: Promises and pitfalls
An, S. & Lipscomb, R.	2010	*Journal of the American Dietetic Association*	Sharing wisdom and getting advice online with e-mentoring
Cantrell, K., Fischer, A., Bouzaher, A., & Bers, M.	2010	*Journal of Pediatric Oncology Nursing*	The role of E-mentorship in a virtual world for youth transplant recipients.
Schichtel, M.	2010	*Medical Teacher*	Core-competence skills in e-mentoring for medical educators: a conceptual exploration
Thompson, L., Jeffries, M., & Topping, K.	2010	*Innovations in Education and Teaching International*	E-mentoring for e-learning development
Loureiro-Koechlin, C., & Allan, B.	2010	*British Journal of Educational Technology*	Time, space and structure in an e-learning and e-mentoring project
Li, Q., Moorman, L., & Dyjur, P.	2010	*Educational Technology Research and Development*	Inquiry-based learning and e-mentoring via videoconference: a study of mathematics and science learning of Canadian rural students
Sánchez, M., Manzano, N., Rísquez, A., & Suárez, M.	2011	*Revista de Educación*	Evaluación de un modelo de orientación tutorial y mentoría en la educación superior a distancia.
McAleer, D. y Bangert, A.	2011	*Journal of Educational Computing Research*	Professional growth through online mentoring: a study of mathematics mentor teachers.
O'Neill, D. K.	2011	*Learning, Media and Technology*	Local social capital through e-mentoring: an agenda for new research
Obura, T., Brant, W. E., Miller, F., & Parboosingh, I. J.	2011	*BMC Medical Education*	Participating in a Community of Learners enhances resident perceptions of learning in an e-mentoring program: proof of concept
Murphy, W. M.	2011	*Academy of Management Learning & Education*	From e-mentoring to blended mentoring: increasing students' developmental initiation and mentors' satisfaction
Risquez, A., & Sánchez, M.	2012	*The Internet and Higher Education,*	The jury is still out: Psychoemotional support in peer e-mentoring for transition to university
McCarthy, J.	2012	*Australasian Journal of Educational Technology*	International design collaboration and mentoring for tertiary students through Facebook.
Schrum, L., English, M. C., & Galizio, L. M.	2012	*The Internet and Higher Education*	Project DAVES: An exploratory study of social presence, e-mentoring, and vocational counseling support in community college courses
Pietsch, T. M.	2012	*Computers Informatics Nursing*	A Transition to E-Mentoring: Factors That Influence Nurse Engagement.
Shpigelman, C. N., & Gill, C. J.	2013	*Qualitative Health Research*	The Characteristics of Unsuccessful E-Mentoring Relationships for Youth With Disabilities
Smith, S., Alexander, A., Dubb, S., Murphy, K., & Laycock, J.	2013	*The Clinical Teacher*	Opening doors and minds: a path for widening access
Lamb, P., & Aldous, D.	2013	*Physical Education and Sport Pedagogy*	The role of E-Mentoring in distinguishing pedagogic experiences of gifted and talented pupils in physical education

OBJETIVO Y MÉTODO

Con el objetivo de avanzar en el conocimiento sobre esta realidad formativa se presenta en esta contribución una investigación exploratoria y exhaustiva sobre la e-mentoría. El trabajo que se presenta es el resultado de una revisión sistemática, con el objetivo de "buscar información de manera ordenada, estructurada y metódica (...) para superar las limitaciones de las revisiones narrativas porque localizan e incluyen de manera sistemática los estudios y resumen el gran número de publicaciones científicas" (Camilli, López y Barceló, 2012, 90).

Los criterios de búsqueda e inclusión para la selección, revisión y análisis siguieron los parámetros de este tipo de método (Sánchez Meca, 2010; Sánchez Meca y Botella, 2010):

(a) *Preguntas que se desean resolver*: ¿Cuál es la tendencia actual sobre e-mentoring?, ¿Qué tópicos se desarrollan en la literatura? ¿Cuáles son las revistas que acogen esta temática y los autores más relevantes?
(b) *Descriptor empleado*: e-mentoring.
(c) *Periodo de tiempo*: 2009-2013, por considerar el intervalo que se revela como más pertinente para mostrar tendencias actuales y perspectivas futuras, en continuidad con el trabajo de Colvin y Ashman (2010).
(d) *Fuentes de información*: la base de datos ISI Web Of Science (WOS) para el área "*Education and Educational Research"* y atendiendo al tipo de documento *"article"*.

RESULTADOS

Parámetros generales

Los resultados de la búsqueda en los parámetros delimitados ofrecieron un total de 21 artículos, si bien, al revisar los trabajos, uno de ellos (Rots, Aelterman y Devos, 2013) no incluía referencia alguna a la *e-mentoría* por lo que se optó por excluirlo de la investigación, quedando un total de 20 artículos (Tabla 2). Para su mejor identificación, los trabajos que forman parte del resultado de la revisión se incorporan en la lista de referencias con asterisco al comienzo (*) siguiendo la práctica que la literatura sobre revisiones sistemáticas desarrollan.

Como se observa (Tabla 2), la mayoría de los artículos (14) aparecen desarrollados en colaboración, siete de ellos elaborados por dos autores y otros siete por tres o más. Los seis artículos restantes son de autoría única. Con todo, se obtiene un índice de colaboración de 2,45 como cociente entre autores firmantes (49) y trabajos (20). Se constata de igual forma una amplia variedad de autores, concretamente 46 autores distintos, si bien un autor aparece en dos trabajos (Schichtel, 2009 y 2010) y dos autoras aparecen en otros dos (Sánchez, Manzano, Rísquez y Suarez, 2011; Rísquez y Sánchez, 2012).

Se aprecia también la distribución temporal durante el espacio temporal delimitado (2009-2013), destacando que es probable que la escasa representatividad que se observa para el año 2013 se justifique porque algunos trabajos que pudieran aparecer no se encuentren aún indexados en la base de datos.

Otra cuestión interesante es la pluralidad de revistas encontradas entre las que destacan dos grandes bloques: de educación y de salud (Tabla 3). Dentro de las primeras encontramos dos categorías definidas, aquellas revistas *generalistas* y otras que tienen que ver con *tecnología educativa* y afines. Las otras dos categorías, *educación física y educación médica*, se han incorporado al bloque de revistas de educación si bien tienen tópicos muy cercanos al área de salud por lo que podrían ser categorías transversales. Dentro del bloque de salud destacamos dos categorías, las que refieren propiamente a *alimentación* y otro bloque referido a *pediatría y enfermería*.

En cuanto al objeto de estudio de los trabajos, cabe destacarse que los tópicos fundamentales que abordan los artículos son *e-mentoring*: *for medical educators, for medical residence, for young transplant recipients, for nurse engagement; for e-learning enviroment, in a e-learning project; in mathematics and sciences learning of Canadian rural context, in physical education, for youth with disabilities*; *for tertiary students, in community colleges,* fundamentalmente.

Síntesis narrativa de las investigaciones: tendencias y perspectivas

Un análisis más riguroso y ajustado de los trabajos permite hacer las siguientes apreciaciones en forma de síntesis narrativa, agrupando sus resultados en cuatro grandes ejes: relaciones sociales, comunidades formativas, beneficios y desafíos de la mentoría electrónica (Figura 1).

Tabla 3: ***Agrupación de las revistas encontradas en la revisión sistemática sobre e-mentoring. Fuente: Elaboración propia***.

Revistas que publican artículos sobre e-mentoría		
Revistas de Educación	**Generalistas**	*Innovations in Education and Teaching International*
		Revista de Educación
		Academy of Management Learning & Education
	Tecnología Educativa y afines	*British Journal of Educational Technology*
		Educational Technology Research and Development
		Journal of Educational Computing Research
		Learning, Media and Technology
		The Internet and Higher Education
		Australasian Journal of Educational Technology
	Educación Física	*Physical Education and Sport Pedagogy*
	Educación Medica	*Medical Teacher*
		BMC Medical Education
		The Clinical Teacher
		Education for Primary Care
Revistas de Salud	**Revistas de Salud y Alimentación**	*Journal of the American Dietetic Association*
		Research quarterly for exercise and sport
	Pediatría y Enfermería	*Journal of Pediatric Oncology Nursing*
		Computers Informatics Nursing
		Qualitative Health Research

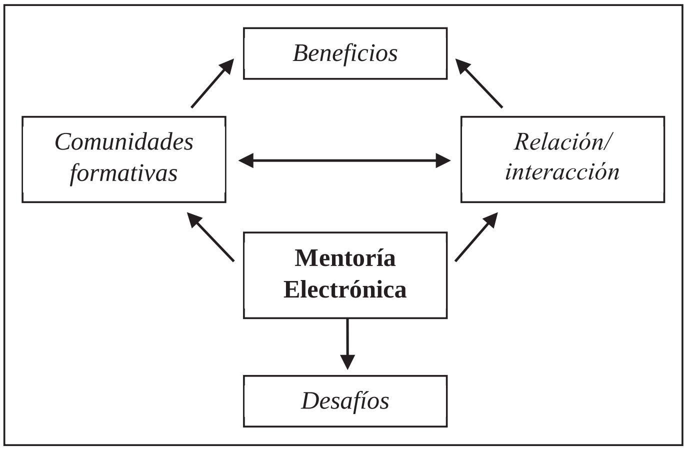

Figura 1: Tendencias y perspectivas de la mentoría electrónica..

Las relaciones e interacciones, clave del proceso de mentoría electrónica

Un primer grupo de trabajos se centran en la naturaleza de las relaciones que se establecen en los procesos de mentoría electrónica. Así, por ejemplo, Pietsch (2012) explora en un estudio cuantitativo las actitudes de los profesionales de enfermería en las interacciones entre mentor y telémaco en relación con el compromiso y la edad.

También Lamb y Aldous (2013) presentan los resultados de un programa de mentoría electrónica entre estudiantes de secundaria y el segundo curso de universidad teniendo como particularidad todos ellos sus altas capacidades para la educación física. La pretensión de este trabajo fue comprender los procesos que subyacen a las interacciones entre estudiantes en un contexto de comunicación mediada por ordenador durante seis meses. Los resultados apuntaron hacia el impacto del intercambio de las experiencias entre los estudiantes, acentuando la voz del alumno que comparte una realidad vivida, y al apoyo para una mejor gestión de la práctica deportiva con el desarrollo académico, así como intercambio en temáticas propias de lesiones deportivas.

Ya Cothran y cols. (2009) presentaron un trabajo cuyo objetivo fue lograr una mayor interacción en el proceso de mentoría cara a cara a través de un programa de e-mentoring con treinta profesores de educación física de escuela primaria, quienes se implicaron en talleres, visitas escolares, lecciones grabadas en video y mentoría electrónica a través del chat, fundamentalmente. Concluye este autor que los maestros apenas participaron en los chat, poniendo de manifiesto en las entrevistas un uso limitado debido a algunos aspectos técnicos y humanos del proceso virtual.

De igual forma, en una investigación con estudiantes de nuevo ingreso encontramos el trabajo de Rísquez y Sánchez (2012). En él se investiga, a través de la comunicación mediada por ordenador (CMC) las relaciones de e-mentoría entre iguales. Sus resultados muestran que los estudiantes de primer año que participaron experimentaron mayores necesidades psicoemocionales que la población estudiantil en general, destacando las interacciones personales y emocionalmente enriquecedoras que a menudo se desarrollan. Sin embargo, es bastante frecuente el conflicto que se sucede cuando los mentores esperan desarrollar relaciones de apoyo con un alto grado de intimidad de forma duradera en el tiempo mientras que los telémacos no siempre comparten esta expectativa.

En este sentido, Murphy (2011) destaca en sus hallazgos que cuando los estudiantes y mentores tenían un rol definido y cercano entre sí los estudiantes percibían un apoyo más profesional y psicosocial y los mentores sentían que apoyaban más a sus telémacos. Una interacción entre ambos frecuente se asocio con un mayor apoyo, satisfacción en el proceso y las intenciones de ambos de continuar la relación. De hecho, Loureiro-Koechlin y Allan (2010) sugieren que el factor (ausencia-presencia) en los entornos en línea ha influido en la forma en que los participantes del proyecto llevan a cabo sus actividades de aprendizaje.

La mentoría electrónica como comunidad formativa en entornos virtuales

Además de las interacciones, un buen número de artículos han profundizado en el impacto de la mentoría electrónica en las comunidades de aprendizaje que se generan en los entornos virtuales.

Sirva de ejemplo el trabajo de Obura y cols. (2011) al evidenciar tras una investigación con encuestas y entrevistas los altos niveles de aceptación de las experiencias de aprendizaje a través de la web. Su trabajo demostró la aceptación de los participantes (médicos residentes) para construir una comunidad de aprendizaje colaborativo como experiencia formativa.

Profundamente innovador es el trabajo de McCarthy (2012), al explorar la eficacia de la red social en línea Facebook, a través de la experiencia de colaboración entre la *University of Adelaide* en Australia, y la *Penn State University* en los Estados Unidos. Durante un semestre, doce estudiantes de posgrado en Australia y diez estudiantes de pregrado en los Estados Unidos participaron en un programa de orientación en línea organizada por Facebook. La interacción entre los estudiantes fue consistente durante todo el semestre y todas las partes se beneficiaron de la colaboración: (1) Estudiantes de la *Penn State* fueron capaces de recibir orientación y apoyo de sus compañeros con experiencia respondiendo positivamente a la retroalimentación continua durante el semestre y (2) Los estudiantes de la *Universidad de Adelaida* recibieron el apoyo de grupos diferentes: personal de *Penn State*, profesionales asociados y los profesionales de la industria local y recién graduados.

El aporte de Schrum, English y Galizio (2012) conceptualiza al e-mentoring como una estrategia interactiva innovadora para satisfacer las necesidades académicas y profesionales de los estudiantes-telémacos a través de una comunidad de aprendizaje para todos desde los parámetros de la teoría de la presencia social (*social presence theory*). Los datos recogidos incluyen los registros semanales de mentores, encuestas y grupos focales bimensuales, cuyo análisis se orientó cualitativamente mediante codificación abierta y axial. Estos resultados indican que la creación de la presencia social puede depender, en parte, de tener un papel auténtico, claramente definido e identificado para mentores y estudiantes-telémacos.

Profundizando en esta línea en dimensión social, O'Neill (2011) sintetiza la investigación sobre el capital social, los resultados escolares, el uso de internet y el voluntariado para argumentar que la e-mentoría, que se practica comúnmente a través de largas distancias, podría convertirse en una poderosa manera de construir una mayor cohesión en las comunidades locales.

Beneficios del e-mentoring

Otro grupo relevante de trabajos se centra propiamente en los beneficios de los programas de e-mentoring mostrando los hallazgos del desarrollo de estos programas en diversos contextos. Así, An y Libscom (2010, 1151-1152) exploran los beneficios de un programa de mentoría en el área de alimentación y salud en el que a través del empleo del correo electrónico, grupos de discusión online (*online discussion groups*), mensajería instantátea y chat (*instant messaging and chat*), videoconferencias (*video conferencing*), blogs y wikis se ha desarrollado una experiencia fructífera de ayuda y consejo, haciendo posible conectar teoría y práctica. Por su parte, Schichtel (2009) sitúa su propuesta en el contexto de la formación de médicos especialistas en enfermedades crónicas (*general practitioner*) concluyendo que la mentoría electrónica es eficaz, mejora la interacción cara a cara y debe ser impulsada en un marco de aprendizaje continuo y desarrollo profesional. De igual forma, el trabajo de Shpigelman y Gill (2013) desarrolla los beneficios del *e-mentoring,* en este caso para jóvenes con discapacidad. Sus hallazgos permiten comprender las razones del éxito en la relación de e-mentoría, mostrando que las parejas no exitosas desarrollan un estilo comunicativo más formal y un tono más distante mientras que las parejas exitosas utilizan un estilo informal y de apoyo. En el trabajo de Smith y cols. (2013) se desarrolla una investigación que ha hecho posible el acceso de estudiantes de entornos socioeconómicos desfavorables de Reino Unido a las facultades de medicina, a través de una estrategia sostenible que ofrece apoyo, asesoramiento y experiencia con un programa de mentoría electrónica con los estudiantes de medicina, concluyendo parcialmente que este enfoque puede haber ayudado a superar la desventaja social de este colectivo.

También sobre los beneficios cabe destacarse los resultados del estudio de McAleer y Bangert (2011), quienes indican que el nivel de actividad de un mentor se relaciona positivamente con la percepción de crecimiento profesional y que gran parte del crecimiento se produce entre bastidores (*behind the scenes*) y puede no ser evidente en los mensajes o diálogo en línea de los participantes. Los profesores de matemáticas (mentores) reportaron crecimiento en todos los dominios evaluados, particularidad en sus prácticas de reflexión atribuyendo su crecimiento a la participación en el *foro de discusión* más que las otras áreas evaluadas.

También sobre las virtualidades de este tipo de iniciativas encontramos el trabajo de Sánchez y cols. (2011), donde presentan el modelo de mentoría que se ha implementado en la *Universidad Nacional de Educación a Distancia* durante dos años académicos, con el fin de dar la bienvenida a los nuevos estudiantes y proporcionarles orientación, mejorando así la calidad de su transición académica y ajuste temprano. El modelo permite demostrar la idoneidad de esta metodología para el logro de una relación flexible y adaptada a las necesidades de cada estudiante.

Finalmente, Li, Moorman y Dyjur (2010) desarrollan un entorno de aprendizaje basado en la investigación con la mentoría electrónica (*inquiry-based learning with e-mentoring*, IBLE) para examinar su impacto en el aprendizaje de los estudiantes rurales. Los resultados mostraron que IBLE había mejorado el aprendizaje de los estudiantes y quizá lo más importante, un claro avance en el desarrollo afectivo, incluido el aumento de la motivación, entendimiento del proceso de enseñanza y una mayor toma de conciencia como aprendiz.

Desafíos del e-mentoring: limitaciones a superar para una mayor efectividad

Finalmente, un último bloque de trabajos hace referencia a los desafíos que ha de enfrentar la mentoría electrónica, si bien, muchos de los trabajos ya referidos en esta revisión han reflexionado también acerca de los desafíos y sus limitaciones. Destacaremos tres por encima del resto. Así, Schichtel (2010) indica que el *e-mentoring* tiene un gran potencial de mejorar la formación médica y el desarrollo profesional continuo, como complemento de la mentoría cara a cara, pero tras su revisión teórica indican que los hallazgos parecían ser inconsistente, fragmentados y con limitaciones significativas en el rigor metodológico. Por ejemplo, Cantrell y cols. (2010) se plantearon la siguiente pregunta de investigación: ¿Qué hace que un modelo de e-mentoring sea exitoso en los mundos virtuales para niños con enfermedades graves? Para ello encontraron de gran valor observar patrones como: el tiempo pasado en línea, el análisis del discurso, el inicio de la conversación, el inicio de las actividades y el contacto fuera del espacio del chat.

También Thompson, Jeffries y Topping (2010) concluyen que la mentoría electrónica ofrece una solución socio-técnica prometedora, pero no es sencillo desarrollar módulos de aprendizaje a distancia que la incorporen. Sugieren que su efectividad debe implicar la inducción sistemática, la cartografía de todos los canales de apoyo, una rigurosa evaluación de necesidades así como diversidad y variedad en las formas de comunicación.

CONCLUSIONES

La *e-mentoría* representa un campo de estudio flexible y abierto que requiere fundamentarse desde investigaciones valiosas que muestren evidencias y, especialmente, el impacto real en las prácticas de apoyo y supervisión a estudiantes, profesionales en ejercicio y *colectivos diana*, todos ellos diversos en función de la finalidad del programa.

Los resultados de esta investigación han ofrecido un conocimiento actual de las últimas investigaciones sobre mentoría electrónica, evidenciando un horizonte de pluralidad temática dentro de la investigación educativa, si bien es cierto, se constata en los trabajos revisados que las áreas de salud y formación médica tienen un espacio significativo de desarrollo.

De igual modo, las investigaciones sobre mentoría electrónica han tratado de comprender las relaciones e interacciones de los procesos de mentoría, así como profundizar en la comunidad formativa que se genera en entornos virtuales dejando patente los beneficios de esta forma de apoyo a la vez que se identifican algunos desafíos a afrontar para lograr una mayor efectividad de estos programas.

Así, se destacan a continuación cuatro líneas básicas de desarrollo a corto y medio plazo:

- Este trabajo ha constatado la ausencia de consenso teórico en torno a la mentoría electrónica, quizá por transferencia de la indefinición conceptual sobre mentoría (Jacobi, 1991; Crisp y Cruz, 2009). Es por ello, que una línea futura inmediata ha de centrarse en identificar los parámetros conceptuales básicos de aquello que se entiende por mentoría electrónica.
- Una línea de desarrollo prioritaria tendrá que ver, desde nuestro punto de vista, con el estudio de los roles, beneficios y riesgos del proceso de mentoría en entornos virtuales; más aún cuando está constatado que el éxito de estos programas toman como referencia el resultado de las relaciones que se establecen entre mentor y telémaco (Haggard, y cols., 2011; Colvin y Ashman, 2010).
- Un reto clave es cómo diseñar y desarrollar la formación interactiva en línea (*interactive on-line training*) para la e-mentoría, por su alto impacto en los resultados de este tipo de programas, en la línea del trabajo de Kasprisin y cols. (2003).
- Finalmente, queda patente la necesidad de establecer procesos rigurosos de evaluación que permitan regular la propia práctica de los programas de mentoría (de Janasz, Ensher y Heun, 2008). Para ello es fundamental asumir parámetros investigadores que ofrezcan una amplia información sobre la validez y fiabilidad de los instrumentos empleados, superar la mera información descriptiva, desarrollar estudios con muestras representativas, aumentar la validez externa, entre otros, son elementos que podrán aumentar la validez externa de las investigaciones sobre mentoría electrónica.

Además, la propia revisión ha permitido identificar a aquellos autores que están desarrollando proyectos sobre *e-mentoring*, siendo una referencia a la que acudir para avanzar en el estudio del tema, y se han identificado aquellas revistas que consultar y a las que poder dirigirse si se desea publicar los hallazgos de investigaciones sobre temáticas afines, que podrán encontrar en la que aquí se ofrece puntos de intercambio y discusión para seguir haciendo camino en la investigación sobre mentoría electrónica.

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The museum of chemistry, from the past to the future through the laboratory
El museo de la química, desde el pasado hasta el futuro mediante el laboratorio

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Abstract
During the last several years, the Chemistry and Industrial Chemistry Department of the University of Genova (DCCI) has developed a few projects with the specific target of helping younger generations approach science in a correct and fascinating way, to contribute fostering the future scientific and technological development of society. In this paper the project, we describe a visit to the Museum of Chemistry of the DCCI followed by a laboratory activity, where the students are provided an opportunity to appreciate chemistry from a more complete point of view. At the end of the activities, a questionnaire is distributed to the teachers, to evaluate their appreciation of both the museum and how the laboratory contributes to the project. An analysis of the results is also reported.

Key words: *education, scientific museum, school laboratory activities*

Resumen
Durante los últimos años, el Departamento de Química y de Química Industrial de la Universidad de Génova (DCCI en el siguiente), ha desarrollado algunos proyectos con el objetivo específico de hacer que las generaciones jóvenes se acerquen a la ciencia de una manera correcta y fascinante, con el fin de contribuir fomentando el futuro desarrollo científico y tecnológico de la sociedad. En este trabajo el proyecto "EL MUSEO DE QUÍMICA: DEL PASADO AL FUTURO A TRAVÉS DEL LAB" consiste en una visita al Museo de Química de la DCCI seguida de una actividad de laboratorio, donde los estudiantes visitantes puedan apreciar la química desde un punto de vista más completo. Al final de las actividades se distribuye un cuestionario a los profesores, para evaluar su apreciacion, por tanto el museo como laboratorio contribuye al proyecto. También se presenta un análisis de los resultados.

Palabras clave: *educación, museo científico, actividades de laboratorio de la escuela*

INTRODUCTION

This article illustrates the aims and the communication strategy adopted in the project "THE MUSEUM OF CHEMISTRY: FROM THE PAST TO THE FUTURE THROUGH THE LAB", a scientific culture dissemination project dedicated to consolidate collaboration and exchanges among schools, general community and the museum of chemistry of the Genoa University. The project began from a collaboration between the DCCI, engaged for years in scientific activities for the schools (from the primary to the high school level) and Green Modeling Italia (GMI), a cooperative society, spin-off of the Genoa University, whose members have many years of experience in training, and scientific research. The project aims at developing new forms of scientific presentation and new methodologies to achieve a more effective exchange between the scientific research world and the community. Specific attention has been devoted to the schools of all levels, providing teachers with effective tools for their work, offering a wide range of educational services (laboratory activities and scientific visits within the museum of chemistry) with a rigorous but appealing scientific approach, stimulating the interest to chemical sciences and biotechnology through a direct involvement of the participants. The belief that scientific museums represent an opportunity to offer culture and education is now widely shared but, especially in our country, this practice is usually underdeveloped. The impact of chemistry museums on the general public in Italy is quite low, mainly because of the relatively small number of visitors **(**Domenici, 2008**).** One of the immediate challenges of these museums is to change their image to get more in touch with the society (O'Brien, 1999) (Gupta, et at, 2010) and to demonstrate (rather than obscuring) the role and impact of chemistry in everyday life, in both its negative and positive outcomes (Morris, 2006).

Recently, several initiatives have been developed that link a visit to a museum of chemistry (or more generally a scientific museum) to laboratory activities, but often without the characteristic of continuity that allows museums to become part of the educational experience. In Italy, the Museo di Chimica of the Università la Sapienza, Rome proposes a numbers of laboratory activities related to specific museum itineraries for schools (http://www.officineapogeo.com). In Widnes, Great Britain the scientific museum "Catalyst" (http://www.catalyst.org.uk), visited by over 40,000 visitors every year, can be summarized by the words of its director, Christine Allison, "Catalyst is a place where science fuses with fun, and of course, chemistry is most fun when it is hands-on."

METHODOLOGY

The guided visit to the Museum of Chemistry of DCCI - University of Genoa

The museum is located in the old Chemistry Institute premises, as a typical example of the chemical laboratory of the early twentieth century with original furniture and tools. It contains hundreds of objects, most of which dating back to the second half of '800 and the first half of '900. Inside the museum, the visitors can appreciate numerous apparatuses and instruments pertaining to different scientific fields (thermodynamics, mechanics, metrology, electromagnetism, electrochemistry, optics and spectroscopy). Two groups of tools are of specific interest, the first includes items from the age of Stanislao Cannizzaro (fig.1).

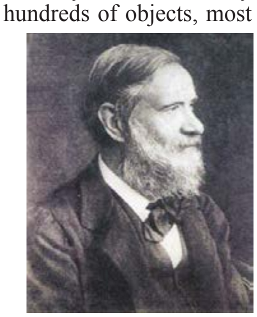

Fig.1. S. Cannizzaro portrait (http://www.chimica.unige.it/museo/Canizzaro.htm)

Cannizzaro, the son of a magistrate, studied medicine at the universities in Palermo and Naples and then proceeded to Pisa to study organic chemistry with Raffaele Piria, the finest chemist then working in Italy. In 1849 Cannizzaro traveled to Paris, where he joined Michel Chevreul in his laboratory at the Muséum National d'Histoire Naturelle. Two years later, Cannizzaro was appointed professor of physics and chemistry at the Collegio Nazionale in Alessandria, Piemonte (now part of Italy). Then, in 1855, he was called to a professorship in Genoa, where he taught chemistry from 1855 to 1861. During that time he published the "Summary of a course of chemical philosophy" that was presented in Karlsruhe in September 1860 at a conference of the major chemical existing at the time; they are still debating issues such as the distinction between the concepts of atom and molecule. Cannizzaro, developed a method to measure the atomic weight of the elements contained in a compound, clarified these two concepts with irrefutable arguments accompanied by experimental confirmation. Mendeleev, who was in attendance at the convention, took advantage of his views in order to proceed to the drafting of the periodic classification of the elements, completed in 1869. The second group of tools, dating back to the 1930's consists of equipment and tools used to process and characterize the rare earths. The museum also preserves equipments and teaching boards of historical value, and has a store of historical material and numerous paper items yet to be restored. In figure 2 the main room of the museum is shown, while figure 3 shows three images related to three of the main topics accessible at the museum.

Fig.2. The main room of the Museo di Chimica

a) b) c)

Fig.3. Three reports pertaining to the museum: a) filtering apparatus for the separation and crystallization of the rare earth elements. b) original ancient pigments and the Chevreuil chromatic circle. c) eudiometer: tool used to analyze the gas and to measure the purity of air. The instrument shown is an evolution of the one invented by Alessandro Volta in the 1770s.

To make science museums more proactive in school education new communication strategies need to be developed. Visitors need to be directly involved in the scientific phenomena inducing curiosity, wonder, motivation, understanding and interest in learning more. This can be achieved by highlighting the human aspects of chemistry, while exhibits can stimulate memories linked to biographies of scientists, to their human stories and to famous scientific discoveries.

An effective communication strategy should allow the visitors to identify the objects accessing easy information as name, function and historical origins. People should be encouraged to ask questions about the subject involved, receiving answers that enable a deeper understanding about why a tool was constructed, in which cultural and economic context, and what other tool it can be compared with now.

The visit to the museum of chemistry of DCCI directly involves the participants. The guides keep the visitors interest high through the description of the tools and the narration of some anecdotes, related to illustrious personalities of the past who made a strong contribution to the development of chemistry. The visits offered to the schools consist in selected museum routes, each related to a specific laboratory activity, which takes place in a scientific laboratory, located next to the museum. The visit starts with a brief description of the main pieces of laboratory glassware and of their specific uses. School children are encouraged by the guide with a series of questions related to the purpose of use of the different tools, sharing examples from daily life or knowledge arising from their study pathways. The second step of the visit accompanies the visitors into the "room of the gases", where are stored the devices that allowed the determination of the chemical composition of air, and where is available a reconstruction of the system used by Lavoisier to discover the composition of water. In this room, there are also Dewar vessels and several pieces of Kipp equipment, the latter usually collecting a lot of success and admiration by the younger participants. The tour ends in the main room of the museum, which collects most of the scientific instruments of the past. Here, particular emphasis is put on the color theory of Chevreuil, showing the tables created by the researcher to explain the genesis of the different hues and shades of colors, as well as on the discovery history of the colors, both of natural and synthetic origin.

Laboratory activities

Hands-on experiences in laboratories have long been recognized for their importance in science education (Krajcic, 2001). Laboratory investigations offer important learning opportunities for students to link theory and science concepts with concrete events.

The educational goals of the scientific experimentations proposed are a phenomenological–inductive approach to the scientific topic proposed, the introduction of elements for a critical approach to the results, the successful achievement of the learning objectives planned and the creation of new situations that are more open and dynamic, but having a greater emphasis on individual formation pathways. Science educators increasingly perceive the science laboratory as a learning environment in which students have the opportunities to observe scientific phenomena. A privileged place to verify the scientific laws, to build experimental and reasoning skills by learning to apply the theoretical knowledge to practical experimentation by means of hands-on activities. Furthermore, the laboratory is a source of experiences, highlighting the social dimension of the school, improving the ability to work in a team to achieve shared results; through a critical approach to their work, the students develop awareness of their own potential and learn to grow their self-esteem.

A series of thematic labs is offered, in order to develop the interdisciplinary nature of chemistry, whose themes are represented by the biogeochemical cycle of one element (C, N and P). The periodic table is thus the starting point of all the labs and from there the participants discover by significant experiments the path that the chosen chemical element follows within the biosphere and the continuous interactions between living (biotic) and nonliving (abiotic) environments. The proposed experiences, set up ad hoc on the age of students, are listed in the following with the related literature references. During the activities the students are supervised by PhDs who guide them during the experimentation.

A. For classes III, IV and V of the primary school and the lower secondary school level

- Element carbon: The experimental activities involving the element carbon cover such topics as photosynthesis and cellular respiration, alcoholic fermentation carried out by yeast and the production of CO_2, the research of sugars in foods and beverages, using a colorimetric reaction, and the determination of fats. (Reinking, at al, 1994; Yurkiewicz, et al, 1989; Tatina, 1989) (Detecting starch in food, Practical chemistry www.practicalchemistry.org/experiments/detecting-starch-infood.223.EX.html - Science and Plants).
- Element phosphorus: The experiments focus on the structure and function of DNA with its extraction from an array of vegetal origin.
- (Curtis, 1989) (Genetic Science Learning Center, University of Utah; http://gslc.genetics.utah.edu/units/activities/extraction/)
- Element nitrogen: The workshops focus on experiences relevant to the nitrogen-fixing organisms such as microalgae, emphasizing the properties and functions of proteins with enzymatic action and understanding the mechanism of action and the importance of these molecules with particular reference to metabolic processes. (Marini 2005, Inhelder, et al, 1958; Voet , 2004; Van der Maarel, et al, 2002).

B. For the high school students the laboratory activities proposed are:

- Fantastic plastic (in Italian this title sounds like a joke)

  The goal of the laboratory is to accompany the students in a short but significant journey into the world of plastic, to learn more about this material, appreciating its great versatility and assessing its strengths and weaknesses. The journey into the world of plastic starts with its birth, experiencing the synthesis of macromolecules such as special

Nylon® and 'foam' and showing how their properties can be different from those of the starting materials, mostly coming from petrol. At the end, the students are introduced to environmental education, talking about recycling, energy recovery and experiencing the possibility or not to transform an artifact in another according to the type of plastic of which it is composed.

- The natural pigments: extraction and analysis

The activity focuses on extraction, isolation, and spectroscopic analysis of natural pigments. Pigments are initially extracted (from spinaches) into an organic solvent. The extracted mixture, essentially consisting of chlorophyll (green) and carotene (yellow-orange), is then subjected to a separation process using silica. The formation of two "bands" differently colored fully justifies the name given to the technique used: "chromatography", or "write the color". Finally, the two pigments are separately subjected to spectroscopic analysis in the visible, leading to a discussion about the interaction between matter and light.

- Synthesis of colored glasses

The glassy state is that of a solid stuck in the disordered structure of a liquid, the main glass component being the silica of sand. It is possible to impart a color to the glass by adding secondary constituents such as Cu^{2+} (light bleu), Co^{3+} (bleu), Ce^{2+} (yellow), Nd^{3+} (violet); the combined addition of Fe^{2+} and Fe^{3+}, bleu and yellow respectively, cause the well known green color of bottles. Students weigh and mix the powders of the reagents and introduce them in crucibles for heat treatment, which will take place in an oven at high temperature (1000 C). After treatment, the crucible is extracted from the oven and the liquid is poured onto a sheet of aluminum or graphite molds to favor a rapid cooling.

- Properties of the elements: metals

This laboratory experience aims at defining a metal through a series of experimental observations. Students are initially stimulated to make some sensorial remarks on various elements, more or less known; then they compare the behavior of the same elements with respect to certain properties, such as heat and electricity conduction, melting temperature, the chemical behavior in water, air, and solutions of acids and bases. From the observation and processing of the experimental results the students try to define the concept of metallic element and will also be able to order the different elements analyzed according to the degree of metallic behavior.

RESULTS AND DISCUSSION

One of the main goals of the project is to use the Museum as a special resource to address the historical dimension of chemistry, its evolution and the scientific and technical ideas that have been established over time, enabling the discovery of the "current" version of the "historical" equipments displayed in the Museum of Chemistry. This approach also provides a starting point for a series of practical laboratory activities that link different scientific areas with current issues, such as health, environment, food safety and biotechnology. This approach allows to create interdisciplinary experiences through practical laboratory activities, relying on the "hands–on" method. The project would also provide a new tool for science teaching in general and chemistry in particular. In this way, it will be possible to communicate the importance of interdisciplinary science through a trail that includes the use of the Museum of Chemistry as a place of acquiring knowledge not only of the past but also of the present.

The communication strategy used was chosen to provide concrete tools for making up an objective opinion on chemistry and other disciplines often demonized, such as biotechnology. During the experimental work, teachers are supplied with material (Power Point presentations) to deepen the study of topics that can be analyzed in an interdisciplinary way. In Table 1 the activities selected vs the different classes are reported.

The children learn about their own abilities to perform scientific experiments, and have the opportunity to compare their approach with that of a 'real' scientist. In addition, the inquiry-based approach allows children to enjoy teamwork as well as the experimental activities themselves: this is a real source of motivation and shared joy. The opportunity for schools to have free access to interactive educational experiences, that might not otherwise be made use of, favored a copious participation of students and teachers to the proposed activities. This report includes the three school years, 2012-2013, 2013-2014 and 2014-2015 during which 116 classes (almost 3,500 students and over 250 teachers) joined the project. Figure 4 reports the distribution of the students as mirrored by the school level.

Table1. Laboratory activity selected by the different classes.

Laboratory activity	primary school	lower secondary school	high school	TOTAL
The plants and the chlorophyll	8	-	-	8
water: marvelous solvent	4	3	-	7
How much colors with the vegetable!	3	2	-	5
The gases and their properties: the air	1	-	-	1
The carbon pathway	4	-	-	4
phisycal and chemical transformations	-	10	-	10
solid, liquid or gas?	-	3	-	3
Capillarity and surface tension	-	1	-	1
The carbohydrates and the lipids	-	3	-	3
nitrogengetter organisms	-	3	-	3
The proteins:buikldinq block of life	-	1	-	1
The Dna: the molecule of life	-	1	-	1
Metals	-	-	11	11
Glasses	-	-	26	26

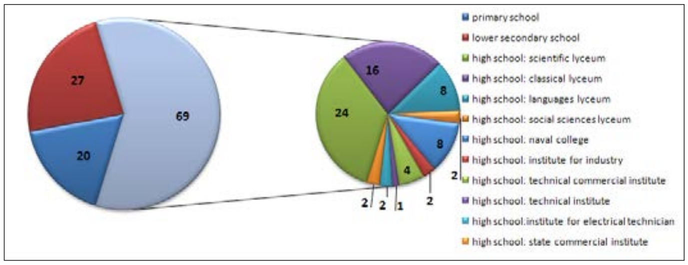

Fig.4. Distribution of the students as the school level (elementary: primary school, media: lower secondary school, superior: high school)

A questionnaire was distributed to the teachers of each group of students to evaluate the effectiveness of the communication strategy both for the visit at the museum and for the lab activities. The first two questions addressed the general satisfaction of the teachers and of the students. The results indicated a favorable attitude towards the project (4.9/5 and 4.7/5, respectively). Additional specific questions were reported, regarding the quality of communication skills and teaching approach of the "guides" during the visits and of the "tutors" during the laboratory activities (more than 95% of the teachers considered both of them "very effective") and the duration of visits and activities and the space available to students (all of the teachers judged both of them adequate). The final questions were related to the materials and equipments used in the laboratory activities and the possibility to reproduce the experiments at school.

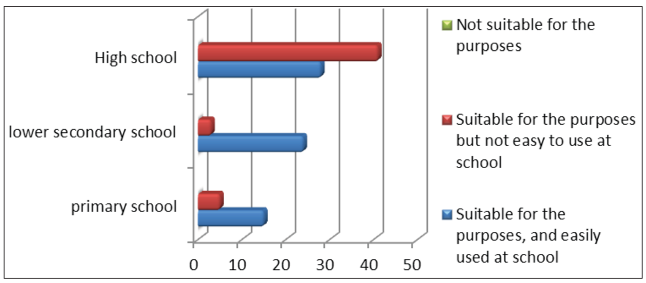

Fig.5: Results related to the two questions: a) the materials used, in your opinion, have proved to be suitable for the purposes and easily used at school, suitable for the purposes but not easy to use at school, not suitable for the purposes; b) in your opinion the teaching approach has been: successful, quite successful or not successful.

In figure 5, results are reported related to the two questions: A) the materials used, in your opinion, have proved to be a) suitable for the purposes and of easy use at school, b) suitable for the purposes but not easy to use at school, c) not suitable for the purposes; B) in your opinion the teaching approach has been a) successful, b) quite successful or c) not successful. The teaching approach was consistently considered successful and interesting, as it was for the materials and equipments used in the laboratory activities. Different opinions were gathered about the possibility to repeat, continue or implement the attended experiments at school. On this point, different answers are probably due to the different complexity of the activities proposed depending on the school level. Thus, Primary school: more than 75% of the teachers thought that the lab activity could be repeated at school. Lower secondary school: practically all of the teachers found the experiments (and related materials) suitable to be proposed again at school by themselves. High school: here the opinions overturn, the teachers found the lab activities not easy to reproduce at school on their own forces.

CONCLUSIONS

The communicative approach used during visits to the museum, based on the engagement of the visitors in the construction of an interactive contest, has proved very satisfactory, particularly for young audiences. This is probably due to their natural curiosity and to their power of observation thanks to an age at which the acquisition of new knowledge is done with enthusiasm and active participation. On the other hand, it proves to be somehow more difficult to raise interest and curiosity about scientific historical exhibitions when the audience consists of high-school students, who usually better appreciate practical laboratory activities. That is why, altogether, a degree of satisfaction even higher has occurred in the evaluation of laboratory activities.

Nevertheless, it remains an important goal, the possibility for students of attending some experimental activities they usually do not have the opportunity to do at school, though in the context of the so-called informal science education (Orlik, 2003).

In summary, we can say that the strengths of this project, which will be further improved in the future, are essentially the following:

-*Adapting to a young audience the exhibition routes*, making them more attractive and interactive.

-*Making easily accessible the interesting collections* in the Museum, conveying concepts of high scientific and historical value to a wide audience.

-*Linking each selected museal tour to specific activities* to be carried out in a real scientific laboratory.

-*Increasing the development of multimedia resources*, such as online renew database, virtual interactive visits to the museum.

- *Developing an application that allows to play online with the "museum memory game"* with which students can enjoy in the recognition of objects and tools seen at the museum, associating the photo of the instrument to its name and to its description.

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Learning in a community of practice: the case of pre-service chemistry teachers

El aprendizaje en una comunidad de práctica: el caso de los profesores de química en formación

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Abstract

What makes the teaching of chemistry a challenge for teachers. In this paper, we have explored communities of practice (CoP) as a viable alternative for teacher training of chemistry. The power of CoPs is through the interactions within the group, and the opportunity to share experiences, so that teachers can learn about new trends in chemistry education and practice in class. This work shows the contributions of a CoPs designed in the project PIBID of the University of São Paulo for the learning of pre-service chemistry teachers. The results show that, in the CoP, the pre-service chemistry teachers have learned about the teaching practice and working effectively in groups; the connection of the practice of teaching; and group engagement on sharing experiences as main factors that favored learning.

Key words: *community of practice, teaching knowledge, pre-service teachers training.*

Resumen

La química es una asignatura difícil de aprender, lo que hace que la enseñanza de la química un reto para los profesores. En este contexto, las comunidades de práctica podría ser un buen ambiente para la formación de profesores. Intercambiando la experiencia en las comunidades de práctica, los profesores pueden aprender acerca de las nuevas tendencias en la enseñanza de la química y practicar clase. Este trabajo muestra las contribuciones de una comunidad de práctica diseñada en el PIBID, proyecto de la Universidad de São Paulo para el aprendizaje de los profesores de química en formación. Los resultados muestran que, en la comunidad de práctica, los estudiantes de licenciatura de química aprenden sobre la práctica docente y el trabajo en grupo, la conexión con la práctica de la enseñanza. El intercambio de experiencias fue el principal factor que favoreció su aprendizaje.

Palabras clave*: comunidad de práctica, enseñanza de química , formación de profesores en formación.*

INTRODUCTION

Chemistry is an important part of science; because it enables learners to understand the world around them. The learning of chemical concepts and explanations of chemical phenomena rely on understanding the microscopic world that is connected with the phenomenological world, both of which are communicated with symbols (Jhonstone, 1991). Thus, the conceptual understanding in chemistry includes the ability to represent and translate chemical problems using macroscopic (observable), molecular (particulate), and symbolic forms of representation (Gabel & Bunce, 1994). The abstract concepts and the difficulty in translate these concepts for macroscopic and symbolic representations is what makes chemistry a difficult subject for many students.

According to Johnstone (2000), integrating these forms of representations is an important process needed for a comprehensive understanding of chemistry. Although this ability is an essential tool in the full appreciation of natural phenomena, the acquisition of this ability remains a significant challenge for the teaching of chemistry.

Sirhan (2007) shares the areas of difficulties in chemistry, which include: selection of the curriculum content; cognitive overload of students' working memory; language and communication; and motivation. According to the author, the key lies in visualizing chemistry from the point of view of the student learner. Is vital for teachers to know what learners already know, how they gains knowledge and what motivates them.

Teachers are constantly having difficulties helping students understand the abstract concepts of chemistry and asking them to translate the macroscopic observations from microscopic phenomenon. Moreover, teachers need to be in constant attention to know students' difficulties and what motivates them to learn.

Communities of practice (CoP) have been shown to be effective learning environments. Communities of practice is described by Wenger, McDermott and Snyder (2002) as a group of people who share a concern, a set of problems, or a passion about a topic, and deepen their knowledge in this area by interacting among them, developing personal relationships and practicing. According to Wenger (2008) the participation in a CoP results in the process of learning, by the process of doing practice, belonging communities, experience meanings and becoming a member.

In teacher training, prior research has showed that the involvement of teachers in CoP leads to positive outcomes, since they provide support for teachers to implement their instruction, professional growth and the opportunity to practice their knowledge and share experiences with other members (Akerson et al., 2012; McDonald et al., 2008; Santos & Arroio, 2013).

Wenger (2008) defines learning in a CoP as result of the community members' engagement, the sharing of ideas and the work towards a joint enterprise. According to the author, in a professional group the learning could be related to the training of individuals for their profession. Thus, in a CoP, chemistry teachers can learn about the teaching of chemistry for a better appreciation of their students.

An example of a CoP is the Project PIBID (Programa Institucional de Bolsas de Iniciação à Docência – Institutional Program of Grants to Initiation to Teach) developed at the University of São Paulo, Brazil. The PIBID is a Brazilian program that offer grants for undergraduate students to participate of projects in several areas of teaching. These students have the opportunity to experience teaching practice, being inserted in public schools to develop activities of teaching.

The project PIBID of chemistry aims to promote training for pre-service chemistry teachers, preparing them to build teaching methodologies using visual tools for teach chemistry and promote students' understanding of chemistry in the microscopic and macroscopic levels, making links between them.

In a previous work (Santos & Arroio, 2013), the group of pre-service chemistry teachers, participating of the PIBID project, was characterized as a CoP, since it presented three dimensions proposed by Wenger (2008) that characterizes a CoP: mutual engagement, joint enterprise, and a shared repertoire.

This work aims to show the contributions of the CoP designed in the project PIBID for the learning of participating pre-service chemistry teachers.

METHODOLOGY

The project PIBID of chemistry carried its activities aiming to improve the training of teachers to teach chemistry using visual tools. In a partnership with a public school, the project included 14 pre-service chemistry teachers of different years in the chemistry undergraduate program.

The activities of the project included weekly meeting where the pre-service teachers were provided theoretical training on topics related to visualization, chemistry teaching and teacher's practice. Coupled with these trainings, the pre-service teachers produced, in groups, didactic sequences supported by visual tools and applied these sequences to high school students. The group of pre-service teachers were divided in seven groups of two people each, called work groups. In these groups, pre-service teachers planed the sequences of activities and applied them at the school. Chemistry and science teachers from the public school supervised the groups.

For this research, the group was accompanied during their discussions and preparation of didactic sequences at the weekly meetings. Notes were taken and the discussions were recorded with an audio recorder. At the end of the year, a questionnaire was applied with questions about what they have learned through the project, as showed in Table 1.

Table 1. Questionnaire applied to the pre-service teachers

What have you learned during the project?	In what situations?	Who helped you in this learning?

Interviews were also performed with questions about the development of the group and of the individual. These interviews helped to understand the pre-service teachers learning during their participation in the project. From the data obtained at the questionnaires and interviews, categories of responses and possible explanations were identified.

The work was analyzed for what the pre-service teachers have learned at the activities in the PIBID and how this CoP have assisted their learning about the teaching profession. Of the 14 pre-service teachers participants, only ten answered the questionnaire, and all participated in the interviews. The research was completed with the permission of the pre-service teachers.

RESULTS AND DISCUSSION

The answers obtained at the questionnaire were divided in categories and the percentage of answers obtained in each category is displayed in Table 2. Many answers were placed in more than one category. Each category will be discussed separately.

What have you learned during the project?

The pre-service chemistry teachers' responses are summarized in two main categories: learning for the teaching practice and learning for the work in group. The results show that a significant portion of the students' learning was related to the teaching practice, that is, issues related to how to prepare class plans and reports, as well as, the methodology and didactic for teaching chemistry. Most pre-service teachers reported that they learned how to plan classes, in order to have autonomy to modify the activities planned according to the students' necessities, avoid lectures and increase dialogue with students. On questionnaires and interviews, the pre-service teachers reported:

> *"I've learned how to plan a class, analyze the results and discuss changes. I also have learned how to appropriating-me of information from scientific papers for improve my class plan".*

Table 2. Percentage of answers obtained in the questionnaire

What have you learned during the project?		In what situations?		Who helped you in this learning?	
Learning for the teaching practice	Learning to work in groups	During the meeting with the group	During the classes at the public school	The group of participants of the program	Students from the school
90	10	63	58	96	23

"Learning how to teach avoiding lectures was good to improve the students' learning and I think that it could help me in the future, when I become a teacher".

Many pre-service teachers have also reported that they have learned how to deal with some situations in class, as well as, lack of discipline, teaching a heterogeneous group, and modify languages and examples for everyone to understand.

"One important thing that I have learned was how to conduct a class (...). I learned to plan me for unforeseen, to think in the next step, think in alternative ways of explanations (...)".

A large part of the pre-service teachers stated that they have learned about different tools to improve the teaching and learning of chemistry. They have essentially learned about the use of visual tool in the teaching of chemistry, as models, experiences, movies and pictures. They have also learned how to teach chemistry in a multimodal way, involving interaction of visual and linguistic tools, aiming to improve learning of chemistry, as stated by some science education researchers (Jewitt et al., 2001; Lemke, 2006).

"I always thought that chemistry must have this visual tools (...) and I thought it was cool the project propose this. The experiments we made, the models with adapted materials, as Lego and play dough, made the difference on the students' learning".

About the work in groups, the pre-service teachers stated that at first, many of them faced difficulties in the work in pairs, mainly because of the differences between pre-service teachers. At the end of the year, some pre-service teachers stated that they have learned to work in groups, to discuss and listen to others aiming to create a good job.

"I've learned to respect other people's opinion, but also show my opinion according to correct arguments".

"With the discussions at the meetings, I learned to listen to criticism and use them in constructive way".

In what situations?

The main answers provided by the pre-service teachers to this question are related to learning in the group's meetings or at the classes, teaching chemistry. Most of them gave both answers, showing that the learnings at that community of practice were guided by the involvement in the group, listening to the other's opinion, and the involvement in the practice of teaching. However, when questioned about this answers at the interviews, the pre-service teachers showed that although the group discussions were constructive, the learning obtained at these moments were simply consolidated in the practical work, as stated by one pre-service teacher:

"When people told me, in the meetings, that our class plan looked as a lecture, that we should change it, for me it had no effect, I thought that in the class I could change. However, when I gave the class, I saw that it was not good for the students. So then, I have learned that I have to change".

"A set of factors helped me to learn about teaching chemistry. The discussions about the papers, the theories, the action of thinking about what to do, the group's help in my classes planning..."

Who helped you in this learning?

In this question, most pre-service teachers answered that the group of participants in the project was the primarily responsible for their learning. Some of them stated that the students from the public school also helped them in their learnings.

The group's influence on learning occurred not only during the meetings, but was also perceived during the classes at school, since the group helped the pre-service teachers in their chemistry classes at school. The learning with the group occurred in a directly way, with advices during the meetings, and in an indirectly way, observing other groups in their classes.

"My partner helped me a lot in my learning. And in the classes, observing the other pre-service teachers in their classes".

The results presented here show that the involvement in a community of practice helps pre-service teachers learn about the teacher practice. By the pre-service teachers' statements is possible to see that the work in group, the possibility to share experiences, discuss ideas and practice what they have learned were essential to their learning.

Despite the learning is not the embodied goal of the pre-service teachers when participating of the project (many of them related that their aim was the experience of teaching), their experience led to learning. In this sense, the pre-service teachers learning is not static, but a process of being engaged, participating in a CoP.

To not trivialize the concept of learning by saying that everything people do is learning, Wenger (2008) stated that a significant learning in CoP includes three process: evolving forms of mutual engagement; understanding and tuning their enterprise; developing their repertoire, styles; and discourses. Thus, learning in CoPs is related to the development of a mutual relationship, aligning the engagement with the community enterprise and negotiating the meaning of various elements.

By examining the results, it is possible to conclude that the pre-service teachers have learned many things related to the teaching of chemistry and their work in groups. The outcomes were developed by the mutual relationship with the other pre-service teachers and by the engagement in the practice of teaching. In many moments it was possible to observe that the pre-service teachers were concerned to the group enterprise of teaching chemistry using different visual tolls to promote a dialogued class. This concern led them to learn about minimizing lectures and the use of visual tools to teach chemistry. Ultimately, the pre-service teachers have stated that the other pre-service teachers helped them in their learning, by sharing of repertoire and discourses, and negotiating meaning.

Thus, learning is connected with the practice, in the sense that it sets the learning, but learning is also connected to the group engagement, the support of other community member. According to Wenger (2008), CoPs should not be reduced to purely instrumental purposes. They are about knowing, but also about being together, living meaningfully and developing a satisfying identity.

CONCLUSIONS

This work showed the learning of pre-service teachers by the involvement in a CoP. A significant aspect of the students' learning was related to the teaching practice, that is, issues related how to prepare class plans and reports, as well as, the methodology and didactic for teaching chemistry. The students reported that beyond the learning in practice, in the relationship with students, they also have learned substantial concepts at the meetings, interacting with other pre-service chemistry teachers. The results show that the CoP contributed for the learning of pre-service chemistry teachers since their learning was connected with the practice and with the group engagement.

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Methodological conditions for learning biology through writing and arguing: university students' perspectives

Condiciones didácticas para aprender biología escribiendo y argumentando: perspectivas de estudiantes universitarios

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Abstract

During recent years, research has tried to establish the role that argumentation and writing play in learning different disciplines. This attempt has been particularly relevant in the field of Science Education. Therefore, this work presents preliminary results of a research aimed to identify and characterize the methodological conditions for learning Biology by means of arguing and writing at university. This research has been carried out since 2012 in an introductory Biology course belonging to the "Ciclo Básico Común" of the University of Buenos Aires. Focusing on the analysis of interviews, we try to establish how students in one Biology course perceive the activities of argumentation and writing proposed by their professors. In this regard, we find that, in this class, students appreciate five conditions under which writing and arguing would function as epistemic tools for learning Biology. In this vein, the systematic work with writing and arguing help students think differently about the subject and, consequently, this allows them to participate and use the disciplinary concepts in practical matters and real life situations.

Key words: *science education, university, practices of written argumentation.*

Resumen

Durante los últimos años, muchas investigaciones trataron de establecer el papel que juegan la argumentación y la escritura en el aprendizaje de diferentes disciplinas. Este intento ha sido particularmente relevante en el campo de la educación científica. Por lo tanto, este trabajo avanza los primeros resultados de una investigación en curso encaminada a identificar y caracterizar las condiciones didácticas que permiten aprender Biología escribiendo y argumentando en la universidad. Esta investigación se ha realizado desde el año 2012 en un curso introductorio de Biología perteneciente al "Ciclo Básico Común" de la Universidad de Buenos Aires. Focalizando el análisis de entrevistas, tratamos de establecer cómo los estudiantes de este curso de Biología conciben las actividades de argumentación y escritura propuestas por sus profesores. Así, encontramos que, en esta clase, los estudiantes aprecian cinco condiciones didácticas bajo las que escribir y argumentar funcionarían como herramientas epistémicas para aprender Biología. Además, consideramos que este trabajo sistemático con escritura y argumentación ayuda a los estudiantes a pensar de manera diferente los contenidos de la materia y, en consecuencia, esto les permite participar y utilizar los conceptos disciplinares en casos prácticos.

Palabras clave: *educación científica, universidad, prácticas de argumentación escrita.*

INTRODUCTION

During recent years, research has established the role that argumentation and writing play in the learning of different disciplines (e.g. Padilla & Carlino, 2012; Padilla, 2012). In the field of Science Education (Physics, Chemistry, Biology, Oceanography, etc.), for example, argumentation -understood as "the ability of linking data and conclusions and of assessing theoretical statements in the light of empirical data" (Jimenez-Aleixandre & Diaz de Bustamante, 2007, p. 361)- has gained particular relevance, both at secondary and university levels (Buty & Plantin, 2008; Jimenez-Aleixandre & Diaz de Bustamante, 2007, 2008; Jimenez-Aleixandre & Puig, 2010; Kelly & Bazerman, 2003; Orange, Lhoste, & Orange-Ravachol, 2008).

In response to the need for deepening these inquiries, our work takes into account some basic background on argumentation and writing in Natural Sciences, particularly in Biology classes, and focuses on the students' perspectives in this regard. In this sense, students' views from an introductory Biology course belonging to the University of Buenos Aires (UBA) are analyzed.

This article's objectives, then, can be stated as follow: (1) to understand students' perspectives about the practices of argumentation and writing in science classrooms, especially at University and in Biology; and (2) to establish didactic conditions for working with writing and arguing in order to learn appreciated by an Argentine group of Biology students.

This work is framed in the WAC (*Writing Across the Curriculum*) and the WID (*Writing in the Disciplines*) lines of research (Bazerman, 1981, 1988; Carlino, 2005; Emig, 1977; Young & Fulwiler, 1986). These research lines propose that the ways of writing and arguing differ from one discipline to another. Consequently, and particularly at the undergraduate level where students are trying to enter in new discursive communities (Bazerman, 1988; Swales, 1998), professors of each discipline should take care of teaching these disciplinary ways of writing and arguing (Carlino, 2012).

METHODOLOGY

The data presented in this article are part of a wider doctoral research focused on the practices of argumentation and writing in two university disciplines (Biology and Linguistics). This wider research aims to answer the question about which are the didactic conditions for writing and arguing to learn at university. In other words, we wonder under which conditions writing and arguing could be transformed into epistemic tools for learning contents and disciplinary logics at the first year of higher education. In this paper, our case study, an introductory Biology class of the University of Buenos Aires (Argentina), was chosen precisely because their teachers incorporate argumentation and writing in their daily classroom activities. In this sense, we have what Patton (2002) calls *purposeful sampling*, i.e. a case that illustrates some points that are deemed to be relevant (and crucial) in order to think argumentation and writing in science classrooms at university.

Additionally, from a qualitative and interactive approach (Maxwell, 2013), the fieldwork techniques used in this investigation carried out during a semester in 2012, were collection of classroom documents (exams, written assignments, students' notes, etc.), semi-structured interviews with students and teachers, questionnaires and participant observation. Here, we primarily use the views of students about writing and arguing in order to learn Biology in college. It is worth mentioning that these standpoints or perspectives were gathered through 12 semi-structured interviews carried out individually, with an average duration of 20 minutes each. For the analysis of these interviews we used *coding* and *contextualization* (Maxwell & Miller, 2008). Thus, so far, some categories were identified and we could advantageously triangulate them (Maxwell, 2013) with participant observation records and with theoretical approaches.

RESULTS AND DISCUSSION

Regarding the course which is the case study here, Carlino (2012) and De Micheli and Iglesia (2012) state that it provides an unusual illustration of a model of writing interwoven in a Biology course. In this case, teachers not only assign topics from which students must establish relationships with disciplinary contents, but they also invest time for collectively planning and revising the texts produced by students. In effect, teachers give students many opportunities to practice and receive feedback about the kind of writing that then they will be required to produce in the exams (for example, explaining practical situations relating key concepts, using real cases in order to explain and describe processes, etc.).

Carlino (2012) underscores that this kind of experience promotes interactions between teachers and students and among peers, constituting an example of what Dysthe (1996) called *Dialogic teaching strategies*. The notion of *Dialogic teaching* (Bajtin, 2004; Dysthe, 1996) conceives the classroom as a space that involves multiple voices that need to dialogue in order to generate new meanings. In dialogic teaching, teaching involves integrating speech and writing; it requires teachers to formulate authentic questions and exercises that help students connect their writing tasks and assignments with their personal experiences. The writing is transformed into a key-learning tool. Students, whose voices are appreciated in the classroom, can consider themselves as valid interlocutors within their disciplinary community. Moreover, in our case, in this interwoven model, writing assignments not only help students learn the disciplinary contents but also help them develop the specific practices of reading and writing in Biology as a scientific field of knowledge (Toulmin, 2001). Furthermore, writing and arguing about scientific issues contribute to avoid classes focused only on the teacher's voice and encourage students to play a more active role in their own learning processes. To some extent, these practices of written argumentation undermine the monological classes, in which the teacher stands as the only legitimate voice, and lead the path to dialogue and to the joint construction of knowledge (Duschl & Osborne, 2002).

In this article, we add to the reflections of Carlino (2012) and De Micheli and Iglesia (2012), the idea that the work carried out with argumentation and writing in this course, besides promoting the learning of disciplinary contents, allows students to go into certain disciplinary logics. In this vein, by means of fieldwork, we postulate that in this seminar, beyond this model of disciplinary contents interwoven with writing assignments, teachers introduce students to the ways of *thinking* and *reasoning* in Biology. This form of reasoning inherent to the discipline of Biology involves, first, reasoning in a relational, dialectic, dialogic, process-focused way. It requires, essentially, not to memorize names of enzymes, proteins, systems, etc., but to think of the origins of biological processes and their interrelationships. In addition, it encourages students to do this through the use of concepts and by means of the exercise of argumentation and writing.

Thus, according to the perspectives of the students of the Biology course studied, five didactic conditions allow them to learn Biology developing and employing this kind of disciplinary way of thinking:

1. Writing tasks focused on justifications and relationships between processes

The majority of the interviewed students (11/12) declared that the writing tasks, including activities of justification and active use of disciplinary contents, help them learn to think in Biology. A student, for example, argues:

> *L[1]: Writing in this Biology course is different; because you have to integrate everything, link all the concepts. I mean it's not something repetitive as a response learned by heart for each question, but it's an integration of content, so to speak. Everything has a purpose. It's as if you understand that you have to give reasons because there is a reason to do it, not only because they ask you to do that in order to check if you know or not, am I being clear? (...) You have to keep in mind all that when you write here in Biology: why you are writing, for whom, and for what.*

These writing assignments with tasks of justification and relationships are then modeled by rhetorical concerns about why, with what purposes and for whom one is writing. Students reflect on the organization of their activity and their communicative goals (Bazerman, 1981, 1988; Swales, 1998), while learning the disciplinary contents (Britton, 1975; Chain & Hilgers, 2000; Emig, 1977; MacDonald & Cooper, 1992; Prain & Hand, 1999; Rivard & Straw, 2000; Walvoord & McCarthy, 1990; Young & Fulwiler, 1986). Even those students, who -for different reasons- have not written during the entire semester, support *a priori* the opinion that this kind of writing assignments and tasks are useful when it comes to learn disciplinary contents and their underlying logics.

> *A: I, eh [hesitation], particularly have not written many texts because I don't have the time… because I work and I come here, and it's all 100% my time. So I don't do them, but it seems to me that they are very positive because they help my classmates. These texts make them improve, that's for sure. I don't know, I think writing could help me too [laughs]. These texts and the comments the teachers give point you out what parts or concepts you have to reinforce. And that I think is extremely good.*

These writing assignments, then, propose students not only to articulate and relate what they are learning with their own personal experiences, but also to exercise a different way of thinking. These tasks are one of the keys to developing a biological thinking, since they allow students to take advantage of the epistemic potentials of writing and arguing (Carlino, 2005, 2012; Leitão, 2000). In this sense, these writing assignments are closely linked with other didactic condition that enables the development, improvement and employ of this particular way of thinking to learn Biology: participation and use of concepts.

2. Participation and use of the concepts

Bisault (2008) underlines that, in science classes, it is not a matter of thinking how we could materialize the characteristics of scientific reasoning, but how we analyze and implement our daily scholar practices in reference to the social practices of researchers, the real producers of scientific knowledge. In the same vein, Rebière et al. (2008) also considered advantageous to carry out a parallel between the activities of the professional scientists and those deployed within the class.

Indeed, this emphasis on the use and appropriation of concepts stands as one of the fundamental pillars of the didactic initiative in the Biology course studied. And that is how students (10/12) perceive it:

> *N: The key is to write because it is in that process where you realize if you have understood the lesson. If you can use the concepts and explain the processes, it is because you know and own them.*

Another student explores the underlying purposes to this use and appropriation of concepts:

> *J: Biology is different, because you write in the assignments and in the exams with a purpose. You should never throw up what you have studied by heart. They always give you a case study, some issue concerning real life, and from there you have to think about what you have studied. You can't memorize, not at all! Because if you don't know how to apply the contents studied or how to think in this case they give you, that's all, you fail. I think it's really interesting. For example, now after studying digestion I understand everything that is happening when I eat, and that's awesome! I can't explain it, what it feels to really know something, you know? In addition, I'm going to study veterinary medicine and this helps me a lot, because it makes me understand that all living beings have points in common. This Biology course gives me the tools to explain that.*

In relation to the use and appropriation of concepts, it becomes relevant the notion of *epistemic practices.* This notion, coined by Kelly and Duschul (2002) and used by Jiménez Aleixandre and Diaz de Bustamante (2008), conceives the *epistemic practices* as a set of activities associated with the production, communication and evaluation of knowledge. In this case, Biology students, through these practices of writing and arguing, must not only produce knowledge from specific cases, but also exercise the epistemic practices of articulating their own knowledge with the knowledge of others. The recognition of the epistemic dimensions of argumentation and writing lies in this use and appropriation of concepts through the practices of writing and arguing. These epistemic dimensions are understood by Leitão (2000) as the confrontation with the knowledge of others that requires to review our own knowledge.

In addition, this involvement and this use of concepts in Biology, as Kuhn (1991) suggests, can only be acquired through practice. Indeed, writing and arguing promote learning in science classroom as long as students have the opportunity to discuss explicitly contents and concepts, by means of meaningful activities and constant teachers' feedback. In the Biology course studied, teachers underpin the essential features to develop the students' scientific thinking: coordinating multiple causal influences, understanding epistemological positions and developing the ability to engage students with the contents and with the learning process itself (Kuhn, Iordanau, Pease, & Wirkala, 2008).

3. On-time feedback (frequent and before exams)

Buty and Plantin (2008) ensure that argumentation and writing, thrown in the science classroom without being integrated with the disciplinary contents, entail no epistemic potentials. Arguing and writing only help students learn when certain classroom conditions are generated, granted and guaranteed. "On-time Feedback" constitute one of these didactic conditions, since it allows Biology students to corroborate the assumptions they have made during the study of the subjects, to incorporate their teachers' suggestions in subsequent writings, to correct misconceptions, to rethink hierarchies and causality *in* and *between* processes, etc. However, the most important thing at this point, perhaps, is that this feedback precisely helps students learn because it is made "on-time", i. e. before exams, and not later, when -for the students- it would have been too late. In fact, several students

(11/12) refer to the "on-time feedback" as major criterion when it comes to think and learn Biology.

> *Interviewer: Your exam was very well! Do you think there is a reason for your success?*
>
> *T: Yes, I got an A, I can't believe it yet [laughs]. I think I did well because I basically follow the classes every day, continuity, I write and that's important. For example, in the exam when I had written assignments similar to those we have here everyday, it was easy. It is as if you could do that automatically, as you already have the structure in your head. You can relate concepts. I think that it is a straightforward consequence of having exercised that structure, that way of thinking, when I write in this course. Another important thing is that teachers comment your pieces of writing on time, I mean, the same class or the next class, and that helps you think class to class and to learn how to incorporate the subjects. They point you out what you did wrong and what you did well. Teachers guide you in every text. Well, they are consistent and constant, basically. And we, as students, have to be constant too, above all.*

Furthermore, for learning by means of arguing, Buty and Plantin (2008) affirm that students need not only sufficient knowledge about conceptual and practical issues but also about argumentative methods in order to argue in a legitimate, autonomous and not manipulated way. However, acquiring such knowledge and methods takes time. In this regard, the on-time feedback gave by the teachers in our case study understands the complexity of this learning process and tries to deal with it. And that is reflected in students' standpoints. This early, frequent, oral and written feedback (before the exams) promotes, from students' perspectives, the dialogue between teachers and students as well as among peers. This feedback allows the exchange of points of view and the co-construction of knowledge in the classroom.

4. Teacher's interventions oriented to constant maieutic (during class and in written feedback)

Maieutics is the well-known technique that involves questioning a person in order to make him reach knowledge through his own conclusions and not as mere transmission of knowledge learned and preconceptualized. In the Biology course that constitutes our case study, maieutics seems to be a key teaching tool when it comes to support students' learning processes. Indeed, the students (11/12) acknowledge this:

> *Interviewer: what other things that your teachers do, as well as the texts, do you think that they help you learn Biology? I mean in the dynamics of the class.*
>
> *C: I find the pictures and graphics in the keyboard very helpful. The last class they draw a giant scheme relating several things. Furthermore, they always ask us if we have questions. And each question we pose, they don't answer it punctual, precisely. Instead, they return you the problem with another question or they contextualize your question in a real case, in an example. That's something awesome. I have never experienced something like that in a class.*

In this course, conducted within a didactic intervention based both on immersion and on reflection of socio-scientific issues (Cavagnetto, 2010), maieutics is constant. In fact, argumentation and writing as ways of reflection are used as integrated components into the everyday activities and tasks of the students. Teachers, in the brousseaunian sense of the term (Brousseau, 2007), return the problem to the students and face them with their own questions. Professors, in the first instance, do not "institutionalized" (Brousseau, 2007), but they regulate and guide students through questions about rationale. In this context, students can find themselves the answers to their own questions. In this sense, the contextualization and provision of aims and objectives to the arguments not only allow students to assume, reflect and discuss their very own doubts and certainties, but also allow them to reconstruct the biological knowledge through their own conclusions.

5. *Clinical* (next to the student) and graphic explanations (use of models, magnetic chalkboards and generous use of analogies)

We use the adjective "clinical" here in its etymological sense. From the Greek κλινικός (κλίνη, bedding), originally the word referred to the person who accompanied and cared for the sick alongside the bed. Then, the term served to name the doctor who diagnoses from the foot of the patient's bed. In this paper, we refer to "clinical explanations" as those in which teachers accompany constantly students in their learning processes. We do not return to the second meaning of this word, which refers to the doctor who diagnoses, since we believe that that there is nothing to diagnose in the classroom. In classroom, students only need to be accompanied, guided and steadily helped by their teachers.

Finally, in this Biology course, students (12/12) positively value personalized explanations of their teachers during class. They also appreciate that these explanations are oral and written. A student, consulted about why she believes the she has obtained good mark in one of the tests, responds:

> *L: I think that, well, first because I studied, but the following work that the teachers made on each of us is wonderful. They [the teachers] take into account all our activities and texts. The class is always oriented, guided by the teacher, but for us. I like that.*

Moreover, in addition to these clinic explanations, another highly appreciated feature of these classes highlighted by the students is the use of graphics, models, magnetic chalkboards and analogies.

> *T: I think that, apart from writing, the pictures that the teachers show on the chalkboard are very graphic and help me understand what they are explaining. Looking at the pictures, one can understand the processes. They serve as diagrams pictures. And then I find useful what they do with the models and slates, I do not know how to call them, because it is more visual, something that it's not so easy to graph mentally, what happens with the nucleotide in the cell, for example. One sees it as something more concrete, less abstract, when we have the models. All these examples and models applied in cases of daily life, Biology becomes interesting [laughs].*

Concretize what otherwise would be impossible to see seems to be the cornerstone of the teachers' educational interventions for this course. Students positively valued the efforts of their professors relating to this point. It is not trivial that this theme is recurrent in all the interviews conducted.

In sum, in this Biology course of the University of Buenos Aires, the five didactic conditions set forth in this section configure the classroom space. Above all, they enable students not only to work with writing and arguing to learn contents, but also to develop a different way of reasoning..

CONCLUSIONS

In the introduction of this paper, we have presented two objectives: (1) to understand students' perspectives about the practices of argumentation and writing in science classrooms, especially at University and in Biology; and (2) to establish the didactic conditions for working with writing and arguing to learn appreciated by an Argentine group of Biology students. Regarding the first objective, we have found out that Biology students value positively the opportunity to learn through writing and arguing. In fact, they assure that this kind of written tasks not only helps them learn the disciplinary contents, but also enables them to think *biologically*, i.e. in a relational, dialogic, dialectic and process-focused way. In connection with the second objective, we have stated that a group of Biology students from the university of Buenos Aires appreciates five didactic conditions for learning by means of writing and arguing: (1) writing tasks focused on justifications and relationships between processes; (2) participation and use of the concepts; (3) on-time feedback (frequent and before exams); (4) interventions oriented to constant maieutic (during the classes and by means of written feedback); (5) clinical (next to the students) and graphic explanations (use of models, magnetic chalkboards, analogies, etc.).

In sum, this paper contributes to rethink the role that argumentation and arguing could play in university science classrooms. Students appreciate to be treated as legitimate interlocutors and they want to (re)discover and (re) construct the contents they are learning. In this process of (re)discovery and (re)construction of the disciplinary contents, teachers' interventions seem to be vital. They configure and create the didactic conditions necessary to learn through writing and arguing.

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A step-based learning methodology applied to veterinary science students in biochemistry classes

Una metodología de enseñanza basada en pasos y aplicada a estudiantes de ciencias veterinarias en clases de bioquímica

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Abstract

In an attempt to improve engagement and performance of first year veterinary science students in biochemistry issues, we applied a teaching strategy as follows: the subject was separated into four steps breaking down each one of the topics. Each step was a prerequisite for the next one and at the end of a step, the students had to answer questions and discuss the studied step enabling them to go on to the next step or review. In this way, knowledge was built throughout the classes and both students and the professor were able to point out some misunderstandings, knowledge deficiencies, and pedagogic problems, solving these class issues more effectively. In the work, we focused on studying Enzymes, an interdisciplinary subject that involves thermodynamic and kinetic concepts applied to a biological context. According to the students, they were able to define their learning deficiencies more specifically and become more committed to the class. Additionally, this teaching strategy was clearly effective in maximizing the progress of students.

Key words: *biochemistry, teaching methodology, veterinary science students*

Resumen

En un intento de mejorar la participación y el rendimiento de los estudiantes de primer año de ciencias veterinarias en bioquímica, hemos aplicado una estrategia de enseñanza de la siguiente manera: el asunto se separó en cuatro pasos para descomponer cada uno de los temas. Cada paso era un requisito previo para el siguiente y al final de una etapa, los estudiantes tenían que responder preguntas y discutir el paso estudiado lo que les permite pasar a la siguiente etapa o revisión. De esta manera, el conocimiento se construye a través de las clases y los estudiantes y el profesor fueron capaces de señalar algunos malentendidos, las deficiencias de conocimientos, y los problemas pedagógicos, para resolver estas cuestiones de clase de manera más efectiva. En el trabajo, nos centramos en el estudio de enzimas, una materia interdisciplinaria que involucra la termodinámica y conceptos cinéticos aplicados a un contexto biológico. Según los estudiantes, ellos fueron capaces de definir específicamente sus deficiencias en el aprendizaje y ser más comprometido con la clase. Además, esta estrategia de enseñanza fue claramente eficaz para maximizar el progreso de los estudiantes.

***Palabras clave**: bioquímica, metodología de enseñanza, estudiantes de ciencias veterinarias.*

INTRODUCTION

In veterinary education, biochemistry is highly relevant since it will enable students to study applied sciences, such as animal nutrition, physiology, and genetics (Krishnaraj, 1979). Biochemistry is taught to graduate students generally by didactic lectures in the first year. A professor is very often seen as imparting information and knowledge to students, where their role in the teaching-learning process is largely unconsidered and the information is absorbed in a passive way. However, even this way the process efficiency is deeply related to the presentation or organization of the material used for the class (Åkerlind, 2004). In addition, substantial loss of basic science knowledge and the ability to make use of it in medical school has been observed (Wilhelmsson *et al.*, 2013).

The professor finds it very difficult to teach students who are unhappy. S/he believes the subject is interesting and relevant, but the students may be less than enthusiastic due to the difficulties they face. Furthermore, they are interested in exploring and learning about modern exciting discoveries but are less keen to learn basic principles (Wood, 1990).

Students, especially entrant students, often report misconceptions and learning difficulties associated with various concepts, especially those invisible and untouchable ones (Barak and Hussein-Farraj, 2009; Mnguni, 2015).

Students learn more effectively if they are active during the learning process. Active participation can stimulate deep learning and high-level engagement (Marton and Säljö, 1976). Science courses consisting of traditional lectures and cookbook laboratory exercises need to be changed to scientific teaching, based on evidence (Handelsman *et al*., 2004). Problem-based learning in a veterinary medical education is an effective pedagogy that can often employ constructivist theory to achieve its curricular and pedagogical goals (Maza, 2013).

Our goal in this study was to describe an alternative teaching approach applied to the Biochemistry discipline of first year Veterinary Science Course students from the "Instituto Federal Catarinense" - Brazil, in an attempt to improve teaching-learning process and engagement of the students in biochemistry studies.

METHODOLOGY

The study was conducted on 54 first-year students enrolled in an introductory biochemistry course at a Brazilian public higher education institution. Enzymes were the subject used in this study, commonly covered in a chapter in classical Biochemistry textbooks. The topics related to enzyme study were organized in a knowledge gradient, separated into four steps. The first one was a conceptual step, providing a background. The next steps involved enzyme application as enzymatic reactions and how they work (step 2), enzymatic kinetic and inhibition (step 3), and examples applied to veterinary studies, including the main veterinary clinical enzymes and the units used to measure their activity (step 4).

The teaching-learning process was evaluated at the end of each step by asking students five questions. The questions involved conceptual, taught and applied knowledge. The students were also questioned about their opinion on the methodology, concerning its efficiency in learning compared to classical methodologies.

RESULTS AND DISCUSSION

In order to become enrolled in Brazilian Higher Education Institutions, students must have graduated from the secondary education level and to pass an entrance examination called "*vestibular*". A decade ago, the Brazilian government launched ENEM (Secondary Education Evaluation Exam). Since then, some institutions accept ENEM as part of the admission process. In addition, there is a law to reserve admission slots in public universities for students who attended public primary and secondary schools and for some racial and ethnic groups.

This work was developed in the first year of the veterinary curriculum in the "Instituto Federal Catarinense", a public higher education institution, located in Santa Catarina State, in southern Brazil. However, most students do not have sufficient background in organic chemistry to be prepared for adequate learning. Low performance and apparent lack of ability have been observed in past years among most students.

Biochemistry is introduced in the first year of the veterinary curriculum and according to Nelson and COX (2008), students who face biochemistry consider two key aspects to be difficult, approaching quantitative problems and drawing on what they had learned in organic chemistry to improve their understanding of biochemistry.

According to the scope of the Biochemistry curriculum, we aim to produce not only students who are prepared with knowledge on the modern aspects of the discipline, but also to help them make connections and apply the knowledge to the needs of the veterinary professional practice.

Among the diversity of the teaching methods, the lecturer should choose the method that makes teaching more efficient, more informative, more varied and more interesting in order to achieve the goals and teaching objectives.

This work studied a way to test a learning methodology on enzyme biochemistry. In general, it is a difficult subject to learn, since it requires thermodynamics and a kinetic knowledge background for proper learning. It employed visual models, such as pictures and diagrams, due to the complex nature of the concepts.

Effective learning is a process and not an event. The subject of the class (enzymes) was presented as a menu divided into four steps (Appendix 1). The four-step methodology broke this subject down, in a rationale way, so that the students could have a general overview. It was first presented to them following a discussion on these steps. The general concepts of enzyme structures and functions, and the importance of studying how fast the enzymatic reactions take place and how these are applied to veterinary science. These concepts were discussed to help prepare students to begin their classes. The idea is to begin on the whole and expand that to individual parts. This way, students improve their mental organization on the subject and this helps them to identify what they do not understand without missing the idea of the entire subject and then, they become more confident in their learning. They become part of the process and decrease their discontentment. It has been observed and, even reported, by some students that they were satisfied because they have developed their own goals and assessments on the subject studied. On this issue, one student stated:

> *"I think the methodology of dividing the subject into steps is interesting because it defines the subject and helps the students to have an idea on the range of the subject" (Student 1).*

During the process, the professor helped students to question their preconceptions and motivated them to further their learning, by asking some questions at the end of each step. At this point, the students needed to answer about five questions on a piece of paper for the professor to gather feedback from the students, and then they were allowed to discuss with other classmates and review their notes. There were different approaches to the questions, conceptual, reasoning, and applied knowledge. Regarding step 2, as an example, students were asked to explain why activation energy is not considered in the Gibbs energy reaction ($\Delta G'°$), as a conceptual question. This way, it was possible to review that enzymes, as catalysts, do not affect reaction equilibrium, but just increase reaction rates. As a reasoning question, we asked them why enzyme complementary to substrate model is not accepted, if part of the energy used for enzymatic rate enhancement is derived from weak interactions between the substrate and enzyme. On this question, students were able to discuss and compare the enzyme complementary to substrate and transition state models, respectively. They compared the weak interaction pattern and the relationship to activation energy in both models. Additionally, for applied knowledge questions, they needed to interpret a reaction coordinate diagram comparing enzyme-catalyzed and uncatalyzed reaction.

Concerning the questions, one student stated:

> *"This method was valid, as we were required to pay attention during the class so that we could answer the questions correctly and this helped the subject absorption" (Student 2).*

Moreover, there was another opinion given:

> *"I enjoyed this method because learning became easier. The subject was divided into steps and that helped me to understand better. The questions at the end of each step made us think about what we had just learned and identified our doubts so that we could solve them" (Student 3).*

The students' discussions were important because they tested their learning by explaining to each other and it was a way to involve all the students in a constructive discussion, even those who were quiet or apparently not interested in the class.

This way, the questions worked as refresher shots and they were part of the strategy for long-term memory retention. This habit of frequent review added to the discussion among students, which also helped in the comprehension of the topics and for self-evaluation. Furthermore, discussion among students contributes to learning and creates strategies for collaborative knowledge construction.

Additionally, note taking helps to both recall the subject of the lecture, synthesis and application of new knowledge in class or afterwards (Bligh, 2000).

Analysis of the answers clearly revealed some misunderstandings, misconceptions, basic knowledge deficiency and didactic failures. Therefore, at the beginning of each new step, the pedagogical strategies were reoriented to solve the identified learning problems, sometimes working on specific students after class. Students were encouraged to clarify their doubts in and after class, in order to progress and keep up with the rest of the class. At the beginning of the program, we highlighted the importance of self-commitment, working hard, and the challenge of achieving knowledge and overcoming learning handicaps before starting the next step in the program. This way, there was no need for any students to repeat any step and both of them progressed at the same pace in this study. It is even possible that some students who have serious basic knowledge handicaps will require extra work in order to make progress, and probably, they will progress at a different pace as compared to the rest of the class.

The questions worked as a thermometer for the professor's pedagogic skills and they helped in identifying basic concepts of deficiencies (from high school) that should be worked on or used to design the curriculum of a basic chemistry course for first year veterinary science students. At this moment, it was possible to intervene specifically on the critical points and avoided the identification of delayed learning problems and low performance. On this issue, one student stated:

> *"I believe the methodology is useful, because it tests me to verify what I understood about the subject. And it helps me to discover my doubts and this way I have time to clarify them with my professor" (Student 4).*

The subject was also worked on in two practical lab classes related to general enzyme proprieties and enzymatic kinetics. At these classes, the students followed a script and the professor conducted the class putting the theoretical concepts into practice in the laboratory; thereby creating new understanding.

The activities were evaluated by the students through written questionnaires and informal conversations, demonstrating good acceptance and approval of this method. In general, most students thought the step methodology and questions were effective and helped them to know what was more important and what they did not understand. This way, the doubts became clear enabling them to go on to the next step.

CONCLUSIONS

In conclusion, the findings presented in this paper reveal the step-based learning methodology applied to veterinary students. This helped them to have a clear understanding on individual parts of the entire subject, which they had not understood, preventing cumulative misunderstandings, low performance and missed knowledge. The methodology was also important to evaluate the didactic practices used in class. Good student scores in biochemistry exams indicated that these activities are also working as valid educational tools.

Additionally, this methodology could be part of the repertoire of pedagogical skills that are effective in meeting the developmental and learning needs of all students.

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Appendix 1

Schematic representation of the class subject presented as a menu divided into four steps. Step 1, introduction of the enzymes study and some general aspects of its structure and classification; Step 2, thermodynamics of the enzyme-catalyzed reactions; Step 3, enzymatic kinetics and inhibition, and Step 4, enzymes applied to Veterinary science and concentration units.

STEP #1	STEP #2	STEP #3	STEP #4
- Introduction - General concepts - Catalytic efficiency - Location - General characteristics - Structure - Classification	- How enzymes work -Reaction mechanism -Thermodynamics of enzymatic reactions - Catalysis models	-Enzymatic kinetics -General aspects -Michaelis-Menten kinetics -Lineweaver-Burk linearization -Enzymatic inhibition	- Examples of enzymes applied to Veterinary science - Concentration units

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The synthesis of vanillin - learning about aspects of sustainable chemistry by comparing different syntheses

La síntesis de la vainilla - aprendiendo sobre aspectos de química sostenible mediante la comparación de diferentes síntesis

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Abstract

This paper discusses one way of integrating the aspects of sustainable chemistry into secondary and undergraduate chemistry education. Two different synthesis reactions for vanillin are presented, which both use isoeugenol as the starting reagent. Whereas the first synthesis is performed using conventional chemistry techniques, second approach employs strategies inspired by sustainable chemistry. The discussion covers how comparison of these two experiments can aid in learning about selected sustainable chemistry principles.

Key words: *education for sustainable development, chemistry education, green chemistry, vanillin*

Resumen

Este artículo analiza una manera de integrar los aspectos de la química sostenible en la escuela secundaria y en bachillerato. Dos diferentes síntesis son presentadas, las dos usan isoeugenol como reactivo principiante (starting reagent). Mientras la primera síntesis se efectúa usando técnicas químicas convencionales, el segundo enfoque usa estrategias inspiradas por la química sostenible. La discusión abarca como la comparación de estos dos experimentos puede fomentar el aprendizaje sobre principios escogidos de química sostenible en la escuela secundaria y en bachillerato.

Palabras clave: *educación, desarrollo sostenible , educación química, química verde, vainilla*

INTRODUCTION

Economic prosperity and human welfare are challenges faced by every society. Economic prosperity has often been suggested as one of the key prerequisites for improving the quality of life. Chemistry plays a central role in this (Bradley, 2005). But economic growth can also cause environmental problems. The idea of sustainable development was born in response to limited resources and growing environmental problems. It was defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (World Commission on Environment and Development, 1987, p. 11). In 1992, the United Nations defined sustainability and sustainable development as normative, guiding principles for the international community, the world economy, global civil society, and politics (UNCED, 1992).

Chemical research and industry are heavily involved in the development of modern technologies and economies (Fisher, 2012). The chemical industry has contributed significantly to economic prosperity in the past, but all too often results in problems with overall resource consumption and environmental pollution. It is clear today that chemical research and industry bear the responsibility of addressing these problems. Emissions need to be reduced and the efficient use of both energy and raw materials must be maximized. One answer offered to these challenges by the field of chemistry is embodied by the ideas of *Green Chemistry* as a guiding framework for contemporary chemistry research, development, and industrial practice (Centi & Perathoner, 2009). Anastas and Warner in 1998 defined twelve principles for chemical processes, which are intended to reduce the impact of chemistry on the environment and resource consumption (Figure 1). Today, chemical research institutes and companies worldwide are looking for new synthesis pathways that incorporate the principles of Green Chemistry and sustainable development (Braun et al., 2006).

- Prevention
- Atom Economy
- Less Hazardous Chemical Syntheses
- Designing Safer Chemicals
- Safer Solvents and Auxiliaries
- Design for Energy Efficiency
- Use of Renewable Feedstocks
- Reduce Derivatives
- Catalysis
- Design for Degradation
- Real-time Analysis for Pollution Prevention
- Inherently Safer Chemistry for Accident Prevention

Figure 1: Short overview of the principles of green chemistry (Anastas & Warner, 1998)

In any case, sustainable development is not exclusively a task for chemistry, but is rather a challenge for all citizens. In a democratic society everyone is asked to contribute to sustainable development and to participate in the corresponding debates. For education this means that Education for Sustainable Development (ESD) is needed (Burmeister, Rauch & Eilks, 2012). Knowledge about sustainability is essential, because it enables students to assess information about new chemistry-based products and technologies in their lives and society at large. Development of corresponding skills is also unavoidable if we want our students to act appropriately and be able to effectively participate in societal debates today and in the future (van Eijck & Roth, 2007; Karpudewan, Ismail & Roth, 2012).

Chemistry education has different aims. Among them is learning about the societal dimension of science to prepare the next generation for future life and for participation in society (Hofstein, Eilks & Bybee, 2011). This perspective makes the societal dimension an essential component of all relevant science education (Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013). Society-oriented science education is relevant for students and the environment. It ensures that pupils can live as responsible citizens and react appropriately to challenges caused by science and technology (Fensham, 2004; Holbrook & Rannikmäe, 2007). Learning chemistry from an environmental and sustainability viewpoint makes chemistry teaching more meaningful and motivating, while at the same time increasing its value for general skills development in the sense of ESD (Burmeister & Eilks, 2012; Mandler et al., 2012; Robelia, McNeil, Wammer & Lawrenz, 2010).

Different ways have been suggested in the past to integrate sustainability into chemistry education at the secondary and undergraduate levels (Burmeister et al., 2012; Andraos & Dicks, 2012). However, implementation of ESD in chemistry education has still not been fully completed (Burmeister et al., 2012). Even though teachers' attitudes are generally promising, educators still feel that there is a continuing lack of appropriate teaching materials, learning scenarios and possible school experiments (Burmeister, Schmidt-Jacob & Eilks, 2013). This paper wants to contribute to closing this gap. It presents a case study discussing several different routes to synthesize vanillin. It also looks at how to learn from comparisons of the essential ideas behind green, more sustainable chemistry.

BACKGROUND

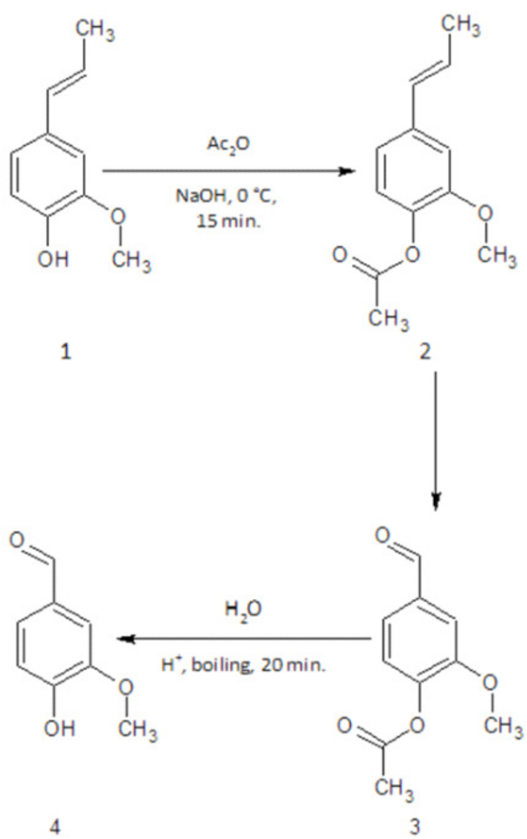
Vanilla belongs to the most oft-used food flavoring agents today. It is used in a wide variety of daily products. The main flavoring compound in natural vanilla is the compound vanillin (4-hydroxy-3-methoxybenzaldehyde). However, natural vanilla also contains only about 1-3% vanillin (Hocking, 1997), with the rest made up of over 130 various other organic compounds, which ensure the unique flavour of natural vanilla (Pérez-Silva et al., 2006).

Natural vanilla beans are grown mainly in Madagascar, the Comoros, and Reunion. About three-quarters of the annual harvest of about 2,000 tons are derived from these three islands and exported to the whole world (etcGroup, 2012). Worldwide demand of vanilla flavoring is, however, much higher than the supply. This is why many products include artificial vanillin instead of natural vanilla extracted from beans. Today, about 16,000 tons of synthetic vanillin are produced each year. It is not only a question of availability but also of price. Synthetic vanillin can be produced and purchased at a cost of about $10-$20 per kilogram, while natural vanilla extract reach prices of up to $1,500 per kilo (Evolva, 2013).

Synthetic vanillin can be produced in various ways using different starting materials, mainly guaiacol, lignin and eugenol. Currently, the major commercial route for synthesizing vanillin is the condensation of guaiacol with glyoxylic acid, followed oxidation in an alkaline environment then decarboxylation (Kalikar, Deshpande & Chandalia, 1986; Huang, Du, Jiang & Ji, 2013). Another industrial process synthesizes vanillin from eugenol, a substance isolated from clove oil. Eugenol is isomerized and then oxidized by potassium permanganate or ozone (Lampman & Sharpe, 1983; Branan, Butcher & Olsen, 2007).

TWO SYNTHESIS ROUTES FOR VANILLIN

This paper will discuss two experiments inspired by well-known syntheses pathways for vanillin. The first is a synthesis of vanillin using conventional strategies by Lampman and Sharpe (1983). The second is a microwave approach used by Luu, Lam, Le and Duus (2009). These two pathways have been modified so that they can be conducted by upper secondary and undergraduate students in the classroom. The experiments can be carried out in a maximum of 4-5 hours. They can also be split up and carried out in a succession of shorter experimental phases. To save time, the isomerization of eugenol to isoeugenol was omitted and isoeugenol substituted as the starting material. The process involves acetylation, oxidative cleavage and hydrolysis. It employs no harmful chemicals. The entire procedure is summarized in Scheme 1.



Scheme 1: The Synthesis of vanillin from isoeugenol

Conventional synthesis of vanillin

Step 1- Acetylation of isoeugenol: Using protective groups is a fundamental concept in organic synthesis. Protective groups allow producers to achieve higher product yields and aid in avoiding unwanted by-products (Schelhaas & Waldmann, 1996). Addition of an acetyl group protects the hydroxyl group from oxidation in step 2. The protecting group is easy to introduce onto the molecule, quite stable, and easy to remove at the necessary time. A mixture of 3ml of isoeugenol **(1)** and 100ml of 1M sodium hydroxide solution are thoroughly combined in a beaker. After two minutes, crushed ice and 5ml of acetic anhydride are added to the solution drop for drop. The mixture is then stirred for 15 minutes, with the solids being separated at the end of this period. Purification of the crude isoeugenol acetate **(2)** is achieved by recrystallizing the solids in a 1:1 ethanol-water mixture. Typical student yields are generally 75-90%.

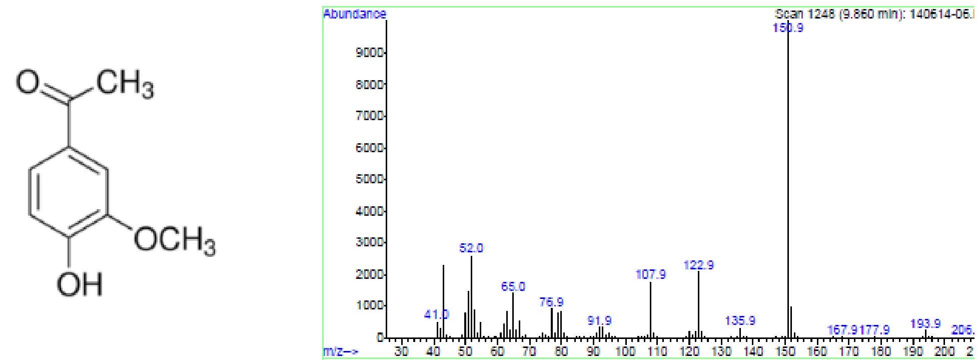
Step 2 - Oxidation of isoeugenol acetate: Oxidative cleavage is introduced by the addition of potassium permanganate as an oxidizing agent. Phase transfer catalysis is used so that over-oxidation of the product is kept to a minimum. 3.8g of potassium permanganate, 3.8g of manganese sulfate, 0.2g of benzyltriethylammonium chloride, 75ml of water and 75ml of methyl tert-butyl ether are mixed together in an Erlenmeyer flask without being heated. Benzyltriethylammonium chloride works as the phase transfer catalyst. Manganese sulfate is added to maintain pH-neutrality and also to reduce the chances that the acetyl protective group might be randomly removed by hydrolysis. 2g of isoeugenol acetate are slowly added over a time span of 5 minutes. The mixture is then stirred for an additional 15 minutes. The brown solid is removed and rinsed twice using 20ml of methyl tert-butyl ether. The aqueous and organic phases are then separated and the aqueous phase is again washed twice with 20ml of methyl tert-butyl ether. All of the organic layers are combined and the solvent is removed. Vanillin acetate **(3)** is obtained as a yellow oil, with typical yields roughly reaching the 40–50% range. Phase transfer catalysis is used to minimize over-oxidation. Nevertheless, the organic layer contains low quantities of vanillic acid. This undesired by-product can be eliminated by adding 1g of sodium hydrogen carbonate to the aqueous layer. After the reaction is over, 20ml of water are subsequently added and the two layers separated. The sodium salt of vanillic acid is located in the aqueous phase. The vanillin acetate remains in the organic layer.

Step 3 - Hydrolysis of vanillin acetate and purification: The protective acetyl group needs to be removed to obtain vanillin. The vanillin acetate is boiled with 30ml of half-concentrated hydrochloric acid under reflux for at least 20 minutes. The mixture is then cooled down to room temperature and an extraction is performed twice using 15ml of methyl tert-butyl ether. The organic phases contain vanillin (4). After removal of the solvent, final purification can be achieved by recrystallization of the crude vanillin in cyclohexane or water. In some cases, it may be beneficial to decolorize the solution with the help of activated carbon before allowing the vanillin to crystallize. Typical student yields are 40%.

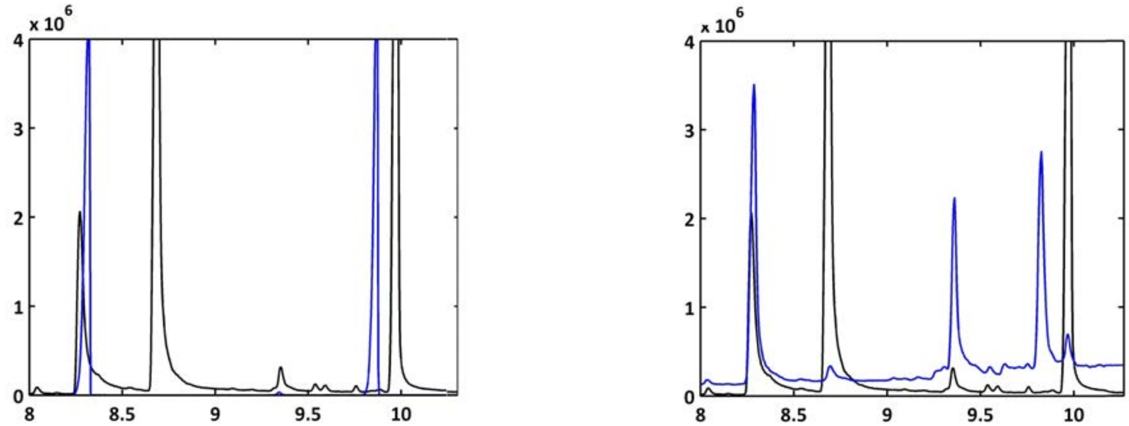
Synthesis of vanillin using microwave technology

For a more sustainable chemistry synthesis, steps 2 and 3 of the synthesis can be altered. In this procedure, microwave technology is used instead of phase transfer catalysis. For this experiment, a laboratory microwave from MLS (Ethos 1600) is used. A mortar is used to thoroughly mix 10,6g of dry copper sulfate, 2,63g of potassium permanganate and 0,41g of isoeugenol, before they are placed in a sealable, microwaveable digestion vessel (MPV-100 *HT high performance PTFE container*, d= 3.5cm; h= 10cm). The well-sealed vessel is first left in the microwave for 5 minutes at 120 watts, then for an additional 15 minutes at 450 watts. After cooling, the reaction mixture is extracted two times using 15ml of methyl tert-butyl ether to obtain vanillin acetate. The solid is filtered off and the organic phase is collected separately. After the solvent has been removed, vanillin acetate **(3)** is obtained as a yellow oil. Typical student yields are around 50%. This method may also lead to overoxidation. To remove any undesired by-products, sodium hydrogen sulfate is used as described above. In the last step, acidic ion exchangers can be used as replacements for the half-concentrated acid and are generally quite practicable from a sustainability viewpoint.

The syntheses products can be detected using GC-MSD (figure 2a and 2b) or thin layer chromatography.



2a



2b

Figure2. Results of GC-MSD

DISCUSSION AND CONCLUSIONS

In a recent review of Education for Sustainable Development in chemistry education, Burmeister, et al. (2012) suggested that students be more thoroughly confronted with the issues of sustainable development and Green Chemistry in chemistry lessons. The paper suggests using different strategies to connect chemistry teaching with learning about both of these topics. These strategies range from (1) applying Green Chemistry principles in the educational science laboratory to (2) using sustainability issues to contextualize chemistry content learning, (3) employing technological and environmental challenges in a socio-scientific issues-based curriculum, and (4) using innovations in school life to introduce sustainability principles. Learning about the different syntheses pathways for vanillin has the potential to highlight the above-mentioned strategies. Green Chemistry principles are applied to the educational chemistry laboratory. Learning about different synthesis routes for vanillin contextualizes the essential methods of organic synthesis. Finally, reflection on the synthetic production of food additives can also lead to a socio-scientific discussion about the quality and availability of food, as well as bring the benefits and risks of intensive agriculture for the economy, society and the environment into better focus.

To date about 70 upper secondary school and undergraduate students have carried out the syntheses reactions described in this paper in an educational chemistry laboratory environment. The experiments have proven themselves suitable for demonstrating differing synthesis strategies in modern organic chemistry. The students enjoyed experiencing how diverse the synthesis of everyday products can be thanks to the wide array of innovative ideas for organic syntheses, including the microwave-induced variant discussed above. In the learning environment the two experiments were used to reflect about selected issues of Green Chemistry (Table 1).

Table 1: Discussion of the syntheses taking into account aspects of Green Chemistry: Comparison of the oxidation of isoeugenol acetate

	conventional procedure	using microwave technology
	The waste can be collected and subsequently quantified.	
Principle 1 Waste production	There are about 100ml of heavy metal-containing aqueous solution as a waste product. During the cleaning process additional waste water is produced.	There will be no aqueous waste. Only the oxidant is obtained as solid waste. Cleaning is easy: No additional aqueous waste is produced
	Most by-products result from incomplete conversions in the reaction, which is necessary due to time constraints during school and undergraduate student experiments.	
Principle 2: Atom economy	Apocynin is produced as an additional undesired byproduct, which lowers the economy of the reaction. The effective yield is roughly 40–50%	No additional byproducts. The real yield of the reaction is higher than with conventional synthesis. It is around 50%.
Principle 5: Solvents	Within the PTC, 75ml of methyl tert-butyl ether are required. In addition, 60ml of the solvent are necessary for subsequent extraction.	In order to separate the product from the catalyst, a total of only 30ml of methyl tert-butyl ether are used.
Principle 6: Energy requirment	The reaction mixture is not heated. Only a magnetic stirrer and a rotary evaporator are needed. However, in the full laboratory synthesis by Luu et al. (2009) the mixture should be heated for 90 minutes under reflux to achieve better yields.	The reaction mixture is heated for 20 minutes with a laboratory microwave. After the reaction, a rotary evaporator is also required. Thus, energy consumption is higher than in the conventional method if the mix is not heated under reflux for 90 minutes. Generally, microwave syntheses have advantages over conventional syntheses employing heating. Shorter reaction times are the result and lower energy consumption is possible.
Conclusion	Aspects of the waste production, the atom economy and the solvent usage result in an advantage of microwave technology. The conventional method for the preparation of isoeugenol acetate only has an advantage over microwave technology with respect to energy expenditure if the reaction mixture is not heated to improve yield.	

The alternate synthesis of vanillin falls more in line with the principles of Green Chemistry. The amount of necessary solvents has been reduced, concentrated acid can be replaced with a heterogenic catalyst, and less byproducts and waste are produced. Based on the context of vanillin synthesis learners can also be introduced to discussions about the complexity of production of everyday products and the impacts that these processes have on the economy and the environment.

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A trial and evaluation of experimental kit of handy body-warmer through a model lesson on the rusting of iron

Un ensayo y evaluación de kit experimental a través de oxidación de hierro

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Abstract

Development and practice of a lesson model on the rusting of iron using an experimental kit of handy body-warmer through the principle of SEIC ("Special Emphasis on Imagination leading to Creation") and an evaluation of the use of the experimental kit were conducted. The lesson was carried out for undergraduate chemistry classes of junior (third year) level student in Tokyo Gakugei University (TGU). Students did an individual experiment actively and smoothly using the experimental kit with quite simple description of B6 size leaflet. Answers from students to questionnaire revealed that the individual experiment by use of the experimental kit was effective for realizing images of the phenomenon of rusting of iron and understanding the chemical reaction.

Key words: *experimental kit, individual experiment, imagination, SEIC, chemical education, lesson model*

Resumen

Se describe el desarrollo de la clase modelo de oxidación de hierro mediante el uso de un kit experimental a través del principio de la SEIC ("la imaginación que lleva a la creación") . Las clases se llevaron a cabo en el curso de química de pregrado (tercer año) en Tokio Gakugei University (TGU). Los estudiantes hicieron los ensayos individuales utilizando el kit experimental usando la simple descripción en un folleto especial. Las respuestas de los estudiantes en el *cuestionario revelaron que los experimentos individuales mediante el uso del kit experimental fueron exitosos para entender el fenómeno de oxidación de hierro y la comprensión de la reacción química.*

Palabras clave: *kit experimental, experimentos individuales, imaginación, educación química.*

INTRODUCTION

It is important for students to be thinking and behaving imaginatively, and finally to have an outcome which is of value to the original objective Wardle, 2009, Finke Ward, Smith, 1992). Promoting creativity in science has been also reported and discussed in papers (Child, 2009, Osborne at al, 2003, Jarvis, 2009, Höhn, Harsh, 2009, Longshaw, 2009, Ohshima, 1920). Actually, school education in this early part of the 21st century faces many challenges especially in Japan, such as bullying, truancy, and disordered classes apparently, in which students are kindled with placing too much emphasis on knowledge and competition in a class. These bring about i) students receding from intellectual activity (learning science) in the cramming system of education in Japan, ii) lack of teaching on highly motivated creativity, and iii) also lack of teaching on morality (ethics). Learning on the basis of students' enthusiastic activities using imaginative thinking and appropriate behaviour would be of great importance in understanding science and chemistry.

We have reported a survey of current textbooks for "Chemistry I" and "Chemistry II" (Keirin-kan, 2003, Tokyo-shoseki, 2003, Dainihon-tosho. 2003, 2004) in senior-high school, sometimes used in junior-high school and compiled based on the Japanese course of study (MEXT, 1999). Text as a representative of knowledge (Ogawa, Okada, Takehara, Ikuo, 2006), skills for experimental study (Ogawa, at all, 2009), and schemes as a representative of image (Ogawa, at all, 2008) were analyzed and ordered. Large numbers of text items, schemes, and skills were cited in the present textbooks in Japan in order to understand scientific concepts, phenomena, and methodology. Then we proposed a fundamental feature of school lesson in science and chemistry in which a **S**pecial **E**mphasis on **I**magination leads to **C**reation (**SEIC**) (Ogawa, Fujii, Sumida, 2009). Having imagination is emphasized with the hope of acquiring sufficient knowledge and skills toward promoting creativity in this SEIC program. Development of the lesson models of rusting of iron through the principle of SEIC has been reported and the model found to be effective for students to understand the chemical reaction of rusting of iron accompanied by an acquisition of sufficient knowledge (Ogawa, Fujii, 2010). Presenting the lesson through drawings was one of the influential methodologies for enhancing images of the chemical reaction. Students felt this helped their imagination through experiment, observation and application of schemes, and was an important contribution to their learning.. In this paper, further improvement of the lesson model with experimental kit and practice are reported.

DEVELOPMENT OF A TYPICAL LESSON MODEL THROUGH SEIC

SEIC policy

SEIC has the feature of student-initiative-activities such as brain-storming and their own operation, if need be, teacher's support. The lesson puts a special emphasis on enhancing the imagination and creativity by handwork operations with mainly drawing, sometime forming clay in three-dimension (3-D) and doing experiments themselves. This approach of SEIC is expected that appropriate images can enhance and foster creativity through making good use of thought, ability for expression, and reason. Thereby the strength of will for imagination and creativity will be raised through SEIC together with the acquisition of sufficient knowledge and skills as a tool.

Lesson models

Fifteen themes were selected for the lessons in chemistry (for teaching profession in primary school) to an undergraduate university student. Fundamental contents on the topics were chosen on the basis of basic chemistry; *i.e.* the chemistry is roughly composed of three frames of structure, equilibrium, and change. Fifteen lessons in the model covered them moderately. Above all, three lessons from lesson 4 to lesson 6 include fundamental concepts in chemistry, *i.e.* stoichiometry, free energy, and entropy from the standpoint of rusting of iron. The lessons proceed toward the theme of topics, *i.e.*, the lesson 4, 5, and 6 proceed toward the themes of stoichiometry, activating complex and entropy change of the chemical reaction of rusting of iron, respectively.

Timetable

The lesson is typically divided in five activities. For example, even in a lecture in about 45 minutes frequent discussions are performed with no students' memorization, and then students' own recollection of their thoughts in 10 minutes are explored. Students' drawings presenting images of chemical concepts, phenomena and self-explanation should be performed in 15 and 10 minutes, respectively.

Drawing rule

Drawings should be attractive for everybody to see once again. Drawing is regulated, *e.g.*, description of text, mark, line, arrow, and illustration with simile are not allowed in a drawing area. Explanations in text could be used outside the drawing area on the sheet using chemical terms and separated by solid parting-line.

Practice with experimental kit

Fig. 1 Kit of handy body-warmer

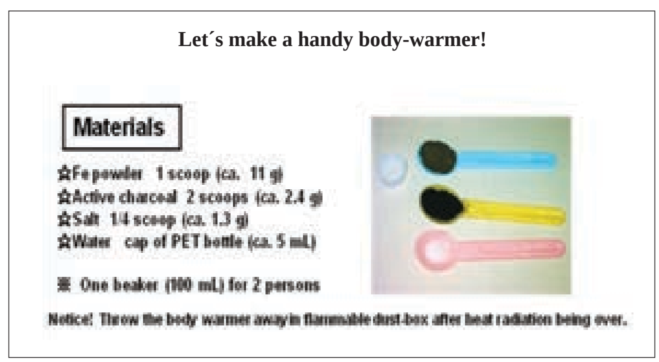

Fig. 2 Leaflet

The students' experiment was carried out in the classes in chemistry (for teaching profession in primary school) of 33 undergraduate students of junior (third year) level in Tokyo Gakugei University (TGU). This experiment was an additional program in 30 minutes over three lessons on rusting of iron described in the former section of 2.2 of "lesson models". The experiment proceeded by the use of an experimental kit (Fig. 1) composed by reagents, apparatus and leaflet (Fig. 2) with B6 size; *i.e.* reagents: iron powder, charcoal powder and sodium chloride were all regent grade commercially available. Apparatus: tall beaker, stirring bar, pin for hole punching, tissue paper, polyethylene wrap, Japanese paper for ornamentation, and plastic bag (about 15 cm x 15 cm) for the outside cover.

Students started the experiment individually by only using the experimental kit with the leaflet. There was no explanation or lecture about the experiment in advance. Students did an individual experiment actively and smoothly with the help of the experimental kit and the simple description in the leaflet. Students' were enthusiastic about the activities and imaginative thinking and scientific behaviour were seen everywhere through the experiment (Fig. 3). They showed not only of the heat generation but also the prevention of an exothermal reaction by separating the body-warmer chemicals with plastic bags.

Fig. 3 Lesson scenes

RESULTS

An appraisal of the lesson with the experimental kit was conducted through a questionnaire (Appendix 1) to students. The questions were set up to students from Q1 to Q4 of "Were you touched by heat generation from your own body-warmer?", "Did you have clear images about the substances accompanied by heat generation?", "Did you have clear images of overall reaction of rusting of iron by the experimental kit?", and "Was your knowledge more strongly coupled with facts of heat generation through making body-warmer?", respectively. Numbers of "yes" equivalent including "strongly" and "fairly" in a whole were quite large with the slight tendency on Q2 of "Did you have clear images about the substance accompanied by heat generation?" (Fig. 4). The questionnaire implied that students had i) the feeling of being emotional, ii) images about the substance accompanied by heat generation, iii) clear images of overall reaction, and iv) integration of knowledge and facts through their own experiment with the kit. A way of the lessons attached experimental kit could be one of the influential methodologies for enhancing images and understanding of the chemical reaction.

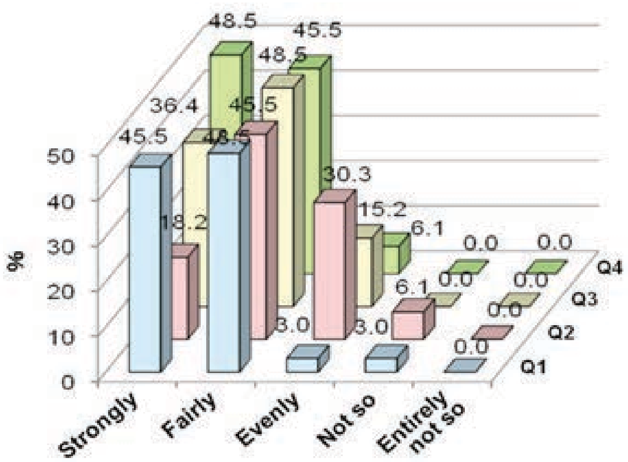

Fig. 4. Questionnaire (33 students). Q1: "Were you touched by heat generation from your own body-wormer?"; Q2: "Did you have clear images about the substance accompanied by heat generation?"; Q3: "Did you have clear images of overall reaction of rust of iron by the experimental kit?"; Q4: "Was your knowledge is strongly coupled with facts of heat generation through making body-wormer?"

The following questions in the questionnaire were conducted; Q5 of "Select two items from those described below which maintain contents uplifting your feelings through the experiment!" and Q6 of "Learning while making the experiment is important!" From the question of Q5 interest was signalled through the experiment for uplifting students' feelings (Fig. 5) while most of students thought the making was important for introducing in lesson from the answer of question of Q6 (Fig. 6). Feelings were uplifted through the making of body-warmer. Experimenting by the use of the experimental kit would be one methodology for motivating students' interest in the desired theme.

The questions in the questionnaire were conducted; Q7 of "Select two items among those described below which maintain an importance for understanding chemical concept and/or phenomenon" in Fig. 7 and Q8 of "Select three items among learning methodologies described below which enhance your images!" in Fig. 8. For comparison purposes data of the class without this experimental program was put in the back. Students had preference comparatively to the items of "Imaging," "Experiment & Observation", and "Knowledge" as an important item for understanding chemical concept and/or phenomenon (Fig. 7). Knowledge was slightly decreased, and then imaging and making were increased through the experiment. Drastic change of thought was appeared from the question of Q8.

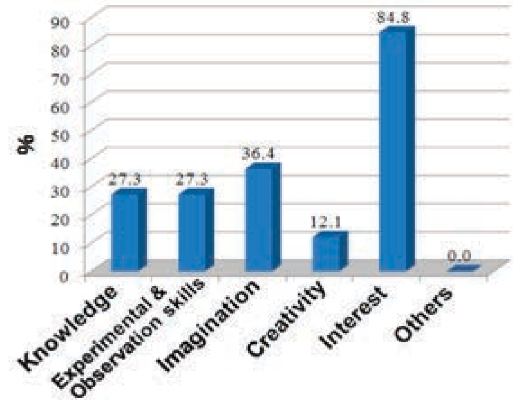

Fig. 5 Questionnaire (33 students). Q5: "Select two items from those described below which maintain contents uplifting your feelings through the experiment!" [Knowledge, Experimental & Observation skills, Imagination, Creativity, Interest, Others]

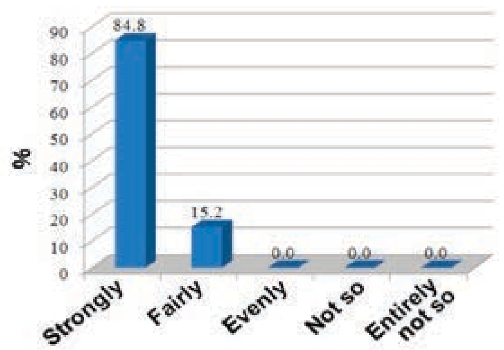

Fig. 6 Questionnaire (33 students, duplicate answer recognized). Q6: "Learning while making the experiment is important!"

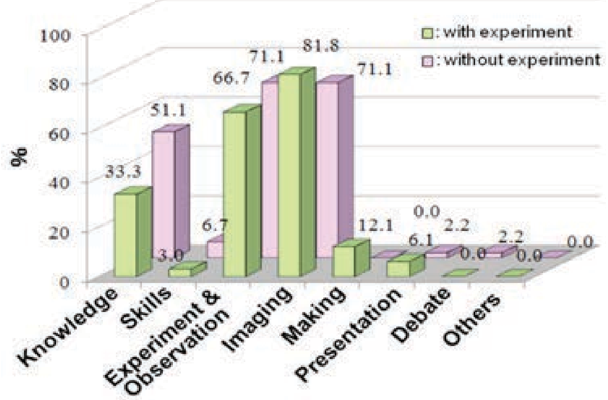

Fig. 7 Questionnaire (33 students with the experiment, 45 students without the experiment). Q7: "Select two items among those described below which maintain an importance for understanding chemical concept and/ or phenomenon!" [Knowledge, Skills, Experiment & Observation, Imaging, Making, Presentation, Debate, Others]

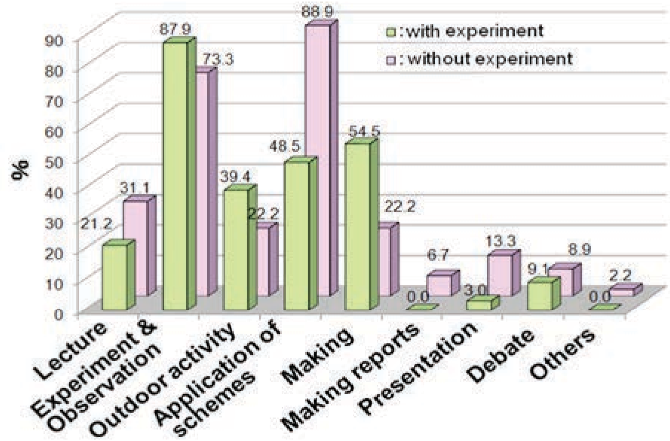

Fig. 8 Questionnaire (33 students with the experiment, 45 students without the experiment). Q8: "Select three items among learning methodologies described below which enhance your images!" [Lecture, Experiment & Observation, Outdoor activity, Application of schemes, Making, Making reports, Presentation, Debate, Others]

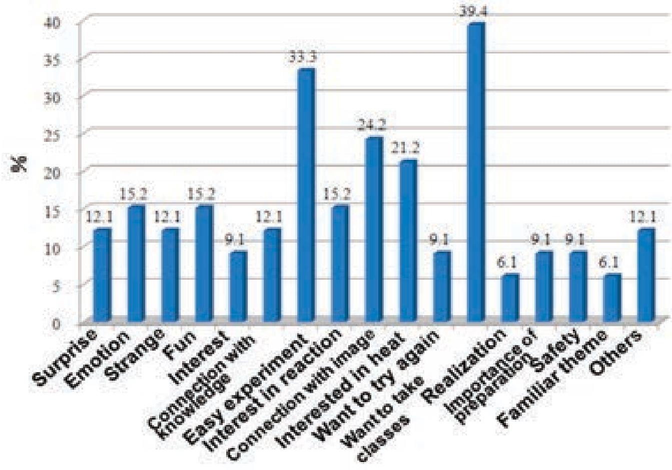

Fig. 10 Questionnaire of free description (33 students, duplicate answer recognized) Question of "Do you have any opinions through the experiment?"

While students without the experiment had the preference to "Application of schemes" and "Experiment & observation" as an important item for learning methodologies which enhances images, students through the experiment had the preference to "Experiment & Observation" and evenly to "Making", "Application of schemes", and "Outdoor activity" (Fig. 8). Especially, application of schemes halved and the making doubled in value. This indicates that learning methodologies accompanied by actual behaving such as the making and outdoor activity would be expected to enhance more of the images of objectives besides experiment & observation and application of schemes.

In addition, free description in a questionnaire was ordered from the stand point of mentioned items in Fig. 9 and Fig.10 based on questions of "What ideas come to mind when you try to make body-warmer once again?" and "Do you have any opinions through the experiment?" Students picked up items concerning "Quantity of materials" and "Temperature change" for a second challenge to make body-warmer which was expected to be as a candidate for students own teaching class with the feeling of easy experiment.

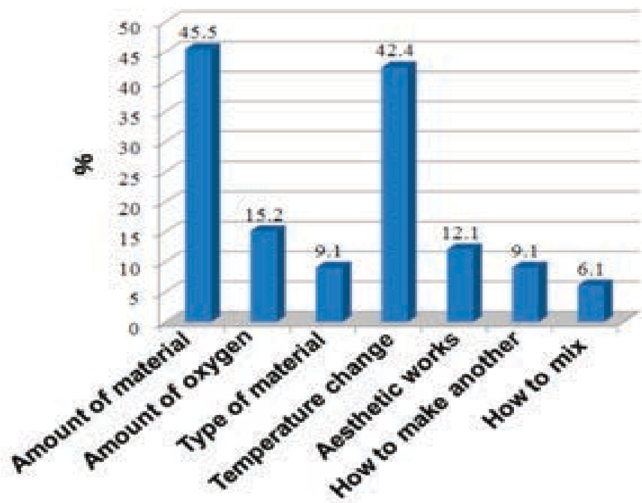

Fig. 9 Questionnaire of free description (33 students, duplicate answer recognized). Question of "What ideas come to mind when you try to make body-warmer once again?"

DISCUSSION AND CONCLUSIONS

Thinking and behaving imaginatively in science is important to promote creativity as an outcome with value to the original objective (Wardle, 2009, Finke, Ward, Smith, 1992, Ohshima, 1920). The answers to the questionnaire in this work showed that students felt the importance of actually doing the experiment and making observations for developing imagination, creativity and skills. These are important items for learning methodologies. Child and/or Osborne, *et al.* mentioned that students should appreciate that science is an activity that involves creativity and imagination as much as many other human activities and that some scientific ideas are enormous intellectual achievements Child, 2009, Osborne *et al*, 2003). Scientists, as much as any other profession, are passionate and involved humans whose work relies on inspiration and imagination. Domin has reported incorporation of the role of creativity plays in science into a problem-based laboratory activity of an undergraduate first-year chemistry curriculum (Domin, 2008). The learning on the basis of students' enthusiastic activities and imaginative thinking and behaving are of great importance to understanding science. Student's attitude being enthusiastic toward the possibilities of their own abilities with their own images would enhance the understanding of objectives.

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Appendix 1 Questionnaire

1: Strongly, 2: Fairty, 3: Evenly, 4: Not so, 5: Entirely not so

No.	Items	Scale
Q1.	Were you touched by heat generation from your own body-wormer?	**1-2-3-4-5**
Q2.	Did you have clear images about in and out of the substance accompanied by heat generation?	**1-2-3-4-5**
Q3.	Did you have clear images of overall reaction of rust of iron by the experimental kit?	**1-2-3-4-5**
Q4.	Was your knowledge is strongly coupled with facts of heat generation through making body-wormer?	**1-2-3-4-5**
Q5.	Select two items from those described below which maintain contents uplifting your feelings through the experiment! [Knowledge, Experimental & Observation Skills, Imagination, Creativity, Interest, Others]	
Q6.	Learning while bringing in making through is important !	**1-2-3-4-5**
Q7.	Select two items among those described below which maintain an importance for understanding chemical concept and/or phenomenon! [Knowledge, Skills, Experiment & Observation, Imaging, Making, Presentation, Debate, Others]	
Q8.	Select three items among learning methodologies described below which enhance your images! [Lecture, Experiment & Observation, Outdoor activity, Application of schemes, Making, Making reports, Presentation, Debate, Others]	
Free 1.	Free description; What ideas come to mind when you try to make body-wormer once again?	
Free 2.	Free description; Do you have any opinions through the experiment? [for example, want to take classes of yours, impressions actually made, relationship between knowledge and image and so on.]	

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The production of ecological paints as a contribution to the teaching of chemical concepts

La producción ecológica de pinturas como contribución a la enseñanza de los conceptos de química

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Abstract
This article aims to present the contributions of the subject's utility for the teaching of chemical concepts. The title of the project was "the production of paints from "soils" in the region of Ponta Grossa, in the State of Paraná – Brazil". The study was carried out with 16 students from the fourth-year of the Building Technician course at a state public school, in the discipline of Control and Environmental Protection. The methodological approach was qualitative with participant observation, whose techniques of data collection were images, testimonials, observation and notes of remembrance in field journal. The main results showed that there was a significant learning of chemical concepts worked in the production of paints from "soils". The analysis and interpretation of the values of density, and viscosity of each specimen resulted in acceptable values of standard deviation for most specimen. They also provided reflections on environmental implications in relation to the materials that are typically used in civil construction.

Key words: chemistry teaching, projects, ecological paint, viscosity.

Resumen

Este artículo tiene como objetivo presentar las contribuciones de los proyectos de utilización de la educación de los conceptos químicos. El título del proyecto es "La producción de pinturas del suelo " de la región de Ponta Grossa en el estado de Paraná - Brasil. El estudio se realizó con 16 estudiantes del cuarto periodo del curso de formación de Técnicos , como extensión del bachillerato en una escuela pública, en la disciplina de Control y Protección del Medio Ambiente. El enfoque metodológico fue de tipo cualitativo y observación sobre los participantes, la recolección de datos técnicas eran a través de imágenes, testimonios, notas de observación y en los diarios de campo. Los principales resultados mostraron que hubo un aprendizaje significativo de los conceptos químicos en la realización del proyecto de producción de pinturas con base en los suelos, mediante análisis y la interpretación de los valores de densidad y viscosidad de cada muestra producida. También se proporciona reflexiones de implicaciones ambientales en relación con los materiales que se utilizan comúnmente en la construcción.

Palabras clave: *enseñanza , química, proyecto, pintura ecológica, viscosidad.*

INTRODUCTION

Promotion of the construction of sustainable communities is the challenge of the 21st century (Capra, 2008), and consequently there is need for the training of professionals for civil construction, committed to the environment, aware that the city is the "nature transformed, an ecosystem, different, but not immune to its cycles" (Sirkis, 2008).

The work goals outlined here in the discipline of Control and Environmental Protection with the students of the 4th period of the Technical Course in Buildings subsequent to the high school level of a Public School aims to contribute to this training.

After the proposition of work for projects, carried out by the teacher, the students presented various topics with discussions and developed projects with alternative materials. One of these projects addressed the theme of the production of paints with less environmental impact and, after intensive research, produced paints from "soils" existing in the region. In this way it was possible to apply chemical concepts in the development of the project with "Ecological Paints", titled: "The production of paints from different types of "soils" that exist in the region of Ponta Grossa, in the State of Paraná - Brazil".

In the pursuit of knowledge of conventional paints the production paints based on "soil", it points out that the earliest records of the use of paints occurred in prehistory, in the form of rock paintings with pigments consisting of oxides of iron and manganese, carbon, micaceous iron oxide and carbonate chalk, mixed to water, bone marrow, animal fats, eggs, or plant sugars. Before the Christian era, linseed oil was already used, but was recognized in the 14th century and improved in the 18th century with new formulations, (Lambourne, 1999) and new characteristics (Bullett, 1999).

As Doroszkowski (1999) explains, paint is a colloidal dispersion of pigment in polymer solution (dispersant), i.e., a mixture containing binders, solvents and additives. The distribution of the particles, and the degree of dispersion influence on flocculation of pigment and its rheological dispersion (Strivers, 1999), the colored pigments absorb the light spectrum, increasing as the size of the particles is reduced, by intensifying the colors emitted (Bullett, 1999). The resin is the non volatile part, responsible for the formation of the pigment coat, strength and shine. Its generic purpose names the kind of paint, such as acrylic resins, epoxy, polyester, alchemical, vinyl and other (Abrafati, 2006; Farm, 2009). And, is embedded, forming a coat to preserve its dispersion (Bullett, 1999).

According to Adami (2002), other products are added to reduce its viscosity. As stated by Doroszkowski (1999) the amount of the solvent affects the amount of adsorbed polymer by the substrate and emphasizes the importance of the incorporation of electrolytes in emulsions and additives, as non agglomerate pigments tend to flocculate. Also used in the formulations are resins, solvents, pigments, dyes and other additives (Abrafati, 2006).

Pigments can be obtained from mineral, animal and plant sources and used for many applications. Experiments using pigments from different sources have shown good results in chemistry teaching. Lech and Dounin (2011), conducted activities with plant extracts and obtained different colors by changing the pH, helping students to understand the use of natural pigments and the interrelation between art and chemistry. A similar work was carried out by Jacobsen (2012). Experiments developed by Galloway, Bretz, Novak (2015), using anthocyanin extracts obtained from red fruits and grape vegetables were helpful to chemistry teaching in subjects like solid-liquid extraction, paper chromatography, characterization by UV/VIS spectroscopy and evaluation of antioxidant properties.

Activities in teaching chemistry concepts may be conducted using different methodologies, especially the perspective pedagogic projects. In this regard it is noteworthy that the pedagogy of projects sets the teaching/learning process: "Learning is no longer an act of memorization and teaching does not mean transmit ready digested content". (Leite, 1996). In this way, knowledge is constructed, becoming inseparable from the cognitive aspect, "You learn by living and interacting with the world. Not only answers are taught, but also experiences, and actions" (Leite, 1996).

Buck Institute for Education (1996) reinforces the understanding that learning through projects promotes learning, formulating questions that lead to the production of useful answers. The pedagogic mediation, in the cognitive universe, of clear intervention, ensuring the understanding of concepts and promoting interpersonal relationship is vital for learning from projects and it is a constant learning action (Prado, 2003) that can lead to significant learning that is understood as the result of the interaction between the new and the existing, resulting in a different cognitive structure (Ausubel, Novak, Hanesian, 1980).

As above, this study aimed to use in the teaching of chemical concepts projects producing paints based on "soils". The data presented are part of the dissertation research of professional master's in Teaching Science and Technology of the Federal Technological University of Paraná -Campus Ponta Grossa - Brazil.

METHODOLOGY

The methodological approach was qualitative with participant observation, data collection in notes on field journal started in 2013, with 16 students from the subsequent mode of the Building Technical Course of public school, using 10 classes of 50 minutes each. To preserve the anonymity of students, identification was made by letters (A, B, etc.) and the work was divided into three stages: 1) questioning, 2) development and 3) synthesis.

Stage 1: The questioning was the moment of planning and discussion in which we defined the production of paints and suggested the use of "soils" as pigment. Wood glue, water, and the "soils" were used, obtaining paints in the form of mixtures and colloidal dispersions probably with particles less than 1 micrometer.

Stage 2: The development of the project consisted in planning, collecting "soils", implementation and use. After collecting the "soils", they were dried in a flame and then crushed in a mortar with a pestle and sieved on nylon screens. After this, the paints were prepared using 11 different "soils", considering the stoichiometric calculation of 40 % of the formulation. 80 g of each of the dried and crushed samples were weighed in test tubes of 100 mL, using a digital scale accurate to one decimal place, and at the same time, the volume of each "soil" was measured to calculate the density ratio of each sample, then they were packed into beakers of 250 mL and solubilized with 100 mL of water, homogenized and added 20 mL of wood glue on base of polyvinyl acetate. After homogenization, and decanting a heterogeneous mixture was obtained with background body and supernatant solution for each type of "soil" and this led to different paints, ready for the evaluation of viscosity and application testing. Based on the characteristics of commercial paints and those produced in class, we addressed the chemical knowledge, mixtures, solute, solvent, colloidal dispersions, suspensions, solutions, mass, volume, stoichiometric calculation, density and viscosity, culminating in the analysis of viscosity using viscometers (Ford viscosity Cup).

The analyses were performed in triplicate, with number 2 viscometer and capacity of 100 mL of solution. The analysis consisted of completely fill each Cup Ford with the sample, leveled with the glass cane, keeping the hole in the cup covered. The outflow of each sample was released simultaneously with the activation of a stopwatch to record the time (Figure 1).

Stage 3: This way the synthesis stage which permeated the whole process until the completion and interpretation of the calculations using the outflow time of each paint for the determination of viscosities, standard deviations (SD) relative standard deviation (RSD). The approach of chemical concepts and the data obtained allow discussions about the sustainability and environmental issues.

RESULTS AND DISCUSSION

The paints produced showed different characteristics, with different colors related to the type of "soil", and arising from the physico-chemical composition of these materials as presented in Figure 1. According to Sá (2007), the "soil" of the region comprises of caolin, iron oxide and aluminum, with size less than 0,001 mm, clays with colloidal properties, and rocks named sandstones.

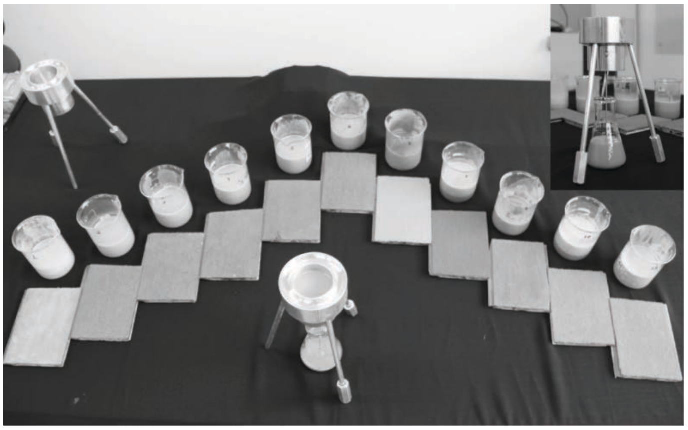

Figure 1. Viscosity analysis and application of paints obtained from different "soils"

The rock formations in the region are divided into sandstones: Furnas, Vila Velha, Lapa and Itararé Group rocks, of varied composition, being the main the quartz (silicon dioxide), iron-cement (oxide and hydroxide of iron), manganese iron sandstone (manganese oxide), and siliceous and clay minerals (caolin) (Melo, 2006).

The density of "soils" collected was determined using the values of mass and volume, and ranged from 888.88 $g.L^{-1}$ to 1333 g.L. It was observed that equal masses of "soil" resulted in a larger volume, influencing the characteristics of the formulations. It was inferred that the particle size correlated with the density of the "soil" as Strivers (1999).

In the statement of calculations of viscosity was used the sample number 4. The results of the viscosity values were calculated from the outflow time in seconds using formula 1, for the Ford Cup 2.

$V = 2{,}388 \cdot t - 0{,}007 \cdot (t)^2 - 57{,}008$ (Formula 1)

The outflow times of sample number 4 were, t_1 = 24"12 (twenty-four seconds and twelve hundredths), t_2 = 24"05 (twenty-four seconds and five hundredths) and t_3 = 24"12 (twenty-four seconds and twelve hundredths). Thus, using the formula 1, time 1 was obtained from 24"12 (twenty-four seconds and twelve hundredths), and the kinematic viscosity 1 (V_1 = 3,48 $mm^2.s^{-1}$).

Following the same criterion, were obtained times of 24"05 (twenty-four seconds and five hundredths), resulting in viscosity 2 (V_2 = 3,62 $mm^2.s^{-1}$), and for the time of 24"12 (twenty-four seconds and twelve hundredths), resulting in V_3 = 3,48 $mm^2.s^{-1}$. So, the average of the calculated viscosity was 3,52 mm^2/s.

The standard deviation was calculated and presented in Table 1, seeking an alternative so that the student use the reasoning of diagrammatic form.

The results of the calculations of the kinematic viscosity, standard deviation and relative standard deviation corresponding to each one of the formulations of paints are presented in Table 2. The viscosity of a suspension is dependent on interparticles forces, and Brownian motion, which increases as the particles approach, requiring greater time in relation to outflow (Strivers, 1999).

The viscosity values obtained ranged from 1.19 $mm^2.s^{-1}$ in sample 10 to 5,35 $mm^2.s^{-1}$ in sample 1, as a result of the different composition of each "soil" used, which gave specific characteristics to each solution as a consequence that the viscosity is related to the size of the ions and the electrolytic strength as Strivers (1999).

No *Ford Cups* were suitable for sample number 7, and that made it impossible for the evaluation of viscosity in this sample, however, all the other used the *Ford Cup* with the hole 2. The analysis of viscosity was important for assessing the quality of paints. The values of SD and RSD were acceptable for most, however, elevated to the samples 1, 8, 9 and 11.

Table 1 - Calculation of standard deviation for the paint sample number 4

Kinematic viscosity ($mm^2.s^{-1}$)	**Differences between average and Viscosities of samples**	**Differences between the high viscosities squared $(\neq)^2$**
$V_1 = 3{,}48$	- 0,046	0,002116
$V_2 = 3{,}62$	0,093	0,008649
$V_3 = 3{,}48$	-0,046	0,002116
Average = 3,52		$\sum(\neq)^2 = 0{,}012881$
	$SD = \sqrt{\frac{\Sigma(\neq)^2}{n-1}}$	

Source: Experimental data using the Ford Cup Nº 2

Standard deviation calculations were carried out using the following formula:

$$SD = \sqrt{\frac{\Sigma(\neq)^2}{n-1}} \qquad SD = \sqrt{\frac{0{,}012881}{2}}$$

$$SD = 0{,}08$$

The calculation of relative standard deviations were obtained using the formula:

$$RSD = \frac{DP * 100}{average\ viscosity} \qquad RSD = \frac{0{,}080 * 100}{3{,}52}$$

$$RSD = 2{,}27\%$$

So the result was obtained from Kinematic Viscosity equal to 3,52 $mm^2.s^{-1} \pm 0{,}08$.

Table 2 - Results of kinematic viscosity, standard deviation and relative standard deviation of the samples of ecological paints produced on base of "soil".

Paints	Kinematic viscosity ($mm^2.s^{-1}$)	Standard deviation	Relative standard deviation (%)
01	2,12	0,355	16,70
02	5,35	0,12	2,36
03	4,37	0,01	0,23
04	3,53	0,08	2,27
05	5,13	0,19	3,60
06	2,83	0,02	0,49
07*	________	________	________
08	3,48	0,315	9,06
09	3,49	0,33	9,46
10	1,19	0,02	1,32
11	1,73	0,20	11,63

Source: Experimental data
** Values not presented due to the viscosity be superior to Ford Cups available (time of outflow > to 100s)*

In the course of activities were included the chemical content (solute, solvent, solution, colloidal dispersion, mixtures, suspension, density and viscosity) occurring learning as noted on the statement of Student A: "In relation to [...] practices, were very good, because the achievement was a lot better than if we had just had theoretic classes". Learning and the importance of the work were also found in the statement of Student B "From my point of view it was great learning, because I will take for the rest of my life the knowledge gained, and whenever possible I will take all these techniques for my future works".

The students' reports portray considerations of Leite (1996) when considering that the teaching by projects allows the student to experience learning, in which the knowledge-building process is integrated to the practices. Such participation of students, developing the experiments, and making decisions provides the development of entrepreneurs. Dolabela (2003) corroborates with the understanding that the entrepreneurial attitude is not innate and depends on including democratic and cooperative attitudes in the program.

The application experiments of the paints on wooden surfaces resulted in a good fixation of colors (Figure 1), even with different viscosities. And, according to the student L "It was possible to learn how to prepare the paint for painting walls, houses, etc. using land(soil), water and white glue, with the exact percentage of each ingredient, we get paint ready for use." It confirms what Moreira (2008) argued that learning with meaning and understanding, takes place interactively and that it depends on the existence of previous knowledge.

The student P said "The preparation of land-based paint gave us a sense of how it can become cheap and easy painting of a building, making this property more beautiful, valued and ecologically correct in relation to the ones painted with common material".

It can be affirmed that the project provided several reflections about the availability of cheaper technologies not available to the population, about the possibility contamination of water bodies, the improper disposal of waste, the unpreparedness of the professionals, and the resistance in accepting civil construction as part of the environment by reducing the environmental impact and also keeping the quality.

It was noted that the teaching by projects encouraged the students to develop experiences and build their knowledge, as noted on the statement of Student E: "We had the opportunity to research and discuss endless possibilities for making a beautiful and comfortable building and at the same time sustainable, small attitudes that help preserve and conserve nature".

The students spoke of the difficulties encountered when developing a project, highlighting the student J, "But on top of all the work there are difficulties, as well as finding exhibition materials, having to move material from neighboring towns [..]" and the student M added, "despite the difficulties the team is to be congratulated for having chased new ideas and so managed to complete the work".

By observing the attitudes and words of the students, it was found that they showed motivation and initiative at all stages of the process. Also, it was a very significant learning-friendly activity besides generating environments conducive to collaboration and cooperation, as Menezes and Faria (2003) observed in their work.

CONCLUSIONS

The realization of the work using the pedagogy of projects in the production of paints from "soils" allowed the students to understand and differentiate the chemical concepts of solution, suspension, gel, colloidal dispersion, density, viscosity from the experimentation, of carrying out the calculations, and the practical application. Enabled the understanding that viscosity is responsible for the fluidity of the paint and, for that reason, exact proportions should be used in the formulation, in addition to promoting the use of alternative materials in construction.

In addition, the development of this study provided great debate regarding the use of environmental-friendly paint as a low-cost option that maintains quality. It was possible to realize the motivation, involvement and initiative of the students.

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Studying the importance of soil organic matter: an educational proposal for secondary education

Estudiando la importancia de la materia orgánica del suelo: una propuesta educativa para educación secundaria

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Abstract

Although the importance of including in the curriculum of all educational levels issues related to soil science has been strongly highlighted, the fact is that the importance that the quality and availability of organic matter in the quality of soil has received very little attention when it comes to considering educational practices in classrooms. This paper brings an educational proposal for teaching the transcendence of organic matter in soil at secondary level. The learning unit presented is based on essential chromatography techniques and allows the qualitative study of soil organic matter. The ultimate purpose is to offer basic educational tools for reflection on the implication that soil has in order to maintain biodiversity and food production.

Key words: *teaching methods, undergraduate education, soil science, K-12 education.*

Resumen

Aunque la importancia de incluir en el plan de estudios de todos los niveles educativos cuestiones relacionadas con la ciencia del suelo ha sido fuertemente resaltada, el hecho es que la importancia de la calidad y la disponibilidad de la materia orgánica en el suelo han recibido muy poca atención cuando se consideraran las prácticas educativas en las aulas. Este documento aporta una propuesta educativa para la enseñanza de la trascendencia de la materia orgánica en el suelo en el nivel secundario. La unidad de aprendizaje presentada se basa en las técnicas esenciales de la cromatografía y permite el estudio cualitativo de la materia orgánica del suelo. El objetivo final es ofrecer herramientas educativas básicas para la reflexión sobre la implicación que tiene el suelo a la hora de mantener la biodiversidad y la producción de alimentos.

Palabras clave: *métodos de enseñanza, pregrado, ciencia del suelo, educación secundaria.*

INTRODUCTION

Soil is a complex, non-renewable and essential natural resource in the maintenance of ecosystems and it is also key to ensuring the food, energy and fiber supply to humans.

Soil organic matter comes from either the remains of living things which were once alive or their waste products in a natural environment. Once on the ground, organic matter undergoes a set of complex chemical transformations conducted by living beings in soil (Trevors, 1998)). Thanks to these chemical changes, organic matter gradually achieves a quasi-equilibrium state known as *humus* which can remain stable over time (Schmidt, Torn, Abiven, Dittmar, Guggenberger, Janssens et al. 2011, Tan, 2014).

What makes humus so important for plant life is that it is rich in humic and fulvic acids. These substances produce organo-mineral associations with ions such as Mg^{2+}, Ca^{2+}, Fe^{2+} y Fe^{3+} (Tang, Zeng, Gong, Liang, Xu, Zhang, et al., 2014) resulting in an increase in the availability of micronutrients to plants which is an essential feature of healthy and fertile soils.

However, secondary and high school level educational programs have paid little attention to this crucial factor closely tied to soil productivity (Bertha, & Leslie, 2002; Megonigal, Stauffer, Starrs, Pekarik, Drohan, & Havlin, 2010; Vila, Contreras, Fernández, Roscales, & Santamaría, 2001).

OBJECTIVE

On the basis of the above, this paper presents a practical proposal specially targeted for the laboratory of secondary education with the purpose of encouraging a vision of soil organic matter as a finite and vulnerable resource which is essential to sustain plant life, the environment and to the foodstuffs industry.

METHODS

The following is the teaching sequence proposed to achieve the previously highlighted objective. To this end, and as a form of an example, this paper presents a real study carried out with five soil samples.

First step: Sampling and sample preparation

The five soil samples analysed in this study were collected using a metal trowel to a depth of 10 cm.

First of al, the samples are left to air dry for three days on a white blank sheet of paper. Then, 150g of each soil sample is taken, without stones or plant debris and are sieved and ground with a mortar until a homogeneous powder is achieved. The final samples, duly sieved and ground, are stored in clearly labelled paper bags.

Second step: The impregnation of the stationary phase with light-sensitive substance

To continue with the experiment Whatman qualitative filter papers (grade 4) are required. In this case, 5 circular filters are to be used, one for each sample. With a pencil, two points will be marked on each filter, four and six centimetres respectively from the centre of the circle.

On another development, five small pieces of filter paper are cut (2cm x 2cm) and these filter pieces are rolled up to form small cylinders as a cannula or tiny tube. Finally, a hole is drilled into the centre of each filter and each of the previously created cannula is inserted perpendicularly through the holes in the centre of each filter.

The filter with the cannula lodged in the centre is placed on a Petri dish in which previously a 0.5% silver nitrate ($AgNO_3$) solution is poured (see photo 1).

Photo 1: The impregnation process of the filters with $AgNO_3$

The dissolution will rise by capillarity through the cannula, soaking into the filter paper. When the dissolution reaches the previously marked point (4 cm from the centre of the filter), the filter is removed from the Petri dish. Finally the cannulas are removed from the filters and these are left to dry. To this end, the filters are kept separately between sheets of paper and inside a dark box so that the silver cannot be reduced by light.

Third step: The extraction of organic matter

The procedure to extract the organic matter of the soil samples should be carried out as follows. Firstly, 5g of each of the soil sample previously sieved and ground are weighed inside a 100*mL* Erlenmeyer flask. Subsequently, 50*mL* of a 1% solution of sodium hydroxide (NaOH) should be added to the Erlenmeyer flask. Finally, the mixture is rocked gently for about 10 minutes and then left to stand for at least 12 hours so that the organic matter can be extracted.

Fourth step: Chromatography

After the extraction of the organic matter, 10mL of the dissolution contained in each of the Erlenmeyer flasks are collected with a syringe and poured into a plastic shallow container. After that, the container with the dissolution inside is placed in a Petri dish as illustration 2 shows.

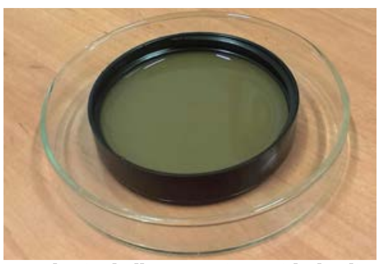

Photo 2: A plastic shallow container with the dissolution

In this regard, it is important to avoid disturbing the mixture and also to use different syringes for each sample (or to flush with distilled water in the case of reusing the same syringe).

The dry filters which were previously impregnated with silver nitrate, are now placed on each of the containers and a new canicula made with a paper filter should be inserted vertically into the centre of each filter (see photo 3). It is very important to be sure that the central part of the filters is not touched by hand to avoid damaging the photosensitive substance.

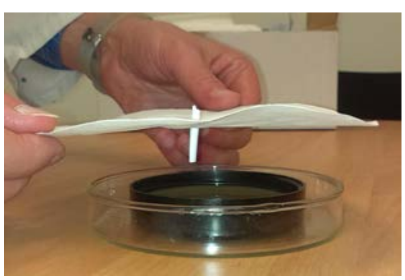

Photo 3: The infiltration process of dissolution into the filters

In this way, the fluid that carries the dissolved organic matter soaks the filters by capillarity. At this point in time, the different compounds of the dissolution start to separate and one can see how some coloured stains start to become evident on the surface of the filters (see photo 4). The filter paper is taken off from the cap once the soaking area reaches the point of 6 cm from the centre of the filter.

Photo 4: The initial results of the chromatography process

The final step is to leave the filters to air dry for about 8 hours in a well lit place but avoiding direct sun light. The silver that the photosensitive substance has is reduced by light, which yields a chromatogram with clear colours and crisp lines. Photographic illustration 4 presents the results of the chromatography process, just before the drying period**.**

Fifth step: The qualitative assessment of the chromatography

In line with previous studies related to the use of radial chromatography to qualitatively assess the condition of the soil organic matter (Quintanilla, Yane, & Monge, 2013; Restrepo, & Pinheiro, 2011), the following criteria are proposed to be used to analyse the chromatograms:

- The first criterion: the colours that appear on the chromatogram. The presence of colours like brown, yellow and ochre are related to a greater amount of organic matter. However, grey, violet and black colours mean lower content.
- The second criterion: The presence or absence of a well-defined radial structure, made up of radial streaks. If this structure appears, instead of a dense, lumpy and blurred area, this feature indicates good availability of organic matter in the sample.
- The third criterion: The presence or absence of up to four different ring-like concentric areas on the chromatogram:
  - In the case of healthy soils, the inner area of the chromatogram often has a white to off-white or light cream colour. However, this area could appear dark or even black in the case of soils that have suffered a severe mechanization process and intensive exposure to plant protection products. If a pale white colour is very apparent in this zone, this usually means a significant use of organic fertilisers.
  - Above the inner area a zone linked to the mineral substrate in the sample can appear, and just above this, a ring-shaped zone which is related to the presence of organic matter.
  - Finally, an outer zone can appear which is linked to soil enzyme activity. The chromatogram of healthy soils usually displays undulating and wavy lines in this external area.

RESULTS

The first sample was collected from a cereal crop field near the municipality of Apodaka (Basque Country, Spain). Photo 5 shows details of the chromatography obtained with the sample of this soil.

This soil sample comes from a single-crop cultivation from which a high production is needed resulting in intensive farming and the utilization of chemical fertilizers, pesticides and others.

Concerning the chromatogram, a well-marked radial structure and, also, ring-like concentric areas are displayed (the second and third criteria). Grey, however, is the main colour with some minor areas displaying muted brown tones.

Photo 5: The chromatogram of the sample from a cereal crop field

The next sample was collected from a well-preserved holm-oak wood in Gorliz (Basque Country, Spain). The illustration 6 presents the chromatography achieved with the sample of this soil.

With regard to the soil characteristics, the sample comes from a zone of high environmental and scenic interest with soils rich in organic matter (Aguirre, Prieto, & Rodrigo, 2010).

Photo 6: The chromatogram of the soil from a holm-oak wood

The result of the chromatography displays brown and yellow colours and also ring-like concentric zones. However, the chromatogram shows an unclear radial structure.

Photo 7 shows the chromatogram of the sample from a wetland zone located in the outskirts of the city of Vitoria-Gasteiz (Basque Country, Spain). This wetland area displays a favourable conservation status (Aguado, Legarreta, & Miguel, 2013). However, it is worth noting that the sampling site is located in an area that has been classed as an environmentally vulnerable area (Antigüedad, Martínez-Santos, Martínez, Muñoz, Zabaleta, Uriarte, et al., 2010).

Photo 7: The chromatogram of the sample from a wetland soil

Regarding the chromatogram, it shows both a radial structure and ring-like concentric areas. The colours, however, are a blend of some areas with brown and yellow tones and others with grey and blue colours.

The next soil sample was collected in an ecological vegetable garden located in the town of Ozaeta (Basque Country, Spain). The illustration 8 shows the chromatography obtained. Concerning the characteristics of this land, the most notable features are that no chemical pesticides or fertilisers are used and the farm plot undergoes regular crop rotation.

Photo 8: The chromatogram of the soil from an ecological vegetable garden

Moreover, brown, yellow and white to off-white are the major colours on the chromatogram and radial structures and the ring-like concentric areas are clearly evident.

The fifth sample was collected from an urban garden in the municipality of Gorliz (Basque Country, Spain) and photograph 9 presents the result of the chromatography. Concerning the features of the soil, it should be noted that artificial fertilizers and plant protection products are usually used for garden maintenance. Furthermore, the ornamental grass is the predominant ground-cover in this resource and the grass is frequently mowed. However, the cuttings are usually collected which leads to soil impoverishment and to the necessity of using more fertilisers.

The chromatogram shows that the greyish shades are very relevant; besides, only three of the four ring-like areas appear and the radial structure is blurred and diffused.

Photo 9: The chromatogram of the soil from an urban garden

Table 1 shows the summary of the qualitative assessment of each of the soil samples examined above. Concerning this table, a plus mark means that the characteristic considered matches a pattern of positive assessment and, on the contrary, a negative mark points out that a certain aspect of the soil sample matches a pattern of negative valuation.

Table 1: A summary of the qualitative assessment of each of the soil samples studied

Sample	Colours	Radial structure	Ring-like areas	Global assessment
Cereal crop field	greyish shades (-)	well-defined (+)	Yes (+)	(+)
Holm-oak wood	brown, yellow and white to off-white (+)	Vaguely defined (-)	Yes (+)	(+)
Wetland	greyish shades (-)	well-defined (+)	Yes (+)	(+)
Ecological vegetable garden	brown, yellow and white to off-white (+)	well-defined (+)	Yes (+)	(+ + +)
Urban garden	greyish shades (-)	Vaguely defined (-)	Only 3 zones(-)	(- - -)

DISCUSSION

The qualitative assessment of the chromatograms previously presented indicates that the sample from the urban garden has the poorest quality in terms of the availability of organic matter and of productive potential. This conclusion is coherent with the treatment that this resource has; that is to say, frequent mowing that removes plant debris and utilization of artificial fertilizers and plant protection products.

By contrast, the sample of the organic garden shows the highest quality and the greatest availability of organic matter. This finding is consistent with the non-use of chemical treatment in this resource and, also, with the planning of crop rotation and fallow periods. In this way, the transformation of organic matter in humus by living things in soil is favoured and this resource improves in terms of the availability of organic matter.

The chromatogram of the soil from a holm-oak wood points out that this sample is set at an intermediate level regarding the quality of organic matter. This is a significant fact, since the sample comes from a well-preserved natural environment. Even though this study cannot shed light on the reasons that may explain this finding, from an educational perspective it may be interesting to speculate about the role that the geological structure of soil plays in the formation of humus. In that regard, the subterranean drainage that characterises the calcareous bedrock of the sampling site (Aguirre et al., 2010) constrains the surface water availability which might affect the process of humus formation. This is consistent with the fact that the holm-oak wood, from where the sample was collected, shows a strikingly poor shrub and herbaceous layer.

CONCLUSIONS AND EDUCATIONAL IMPLICATIONS

The teaching sequence described in this paper proposes an educational tool to foster the secondary school students' knowledge concerning soil organic matter. The sequence places a particular emphasis on detailing a practical procedure to ensure that students can be actively involved in their learning process. In this regard it should be stressed that teachers' skills for designing practical activities and laboratory experiences are considered one of the most significant factors related to the improvement of science education (Wenglinsky, & Silverstein, 2007).

The teaching sequence allows students to emulate the actual laboratory activity carried out in the field of soil science. More specifically, a method for comparing the availability of organic matter that different soil samples have is detailed but by avoiding very technical, expensive or inaccessible methodologies.

This is a key point of the teaching sequence, since that, finding a feasible and practical procedure to address the topic of the role that organic matter has in the productive capacity of soils is not an easy issue in the confines of a secondary school classroom.

Moreover, comparing samples from soils subject to different uses (urban utilization, intensive farming, well-preserved natural environment, et cetera) allows students to consider how the availability of organic matter in soil is closely tied, not only to the environmental characteristics of the sampling site but, also to how this resource is used by human beings.

In this manner, it is believed that students might achieve the final objective that this teaching sequence pursues; that is to say, being aware of the importance that soil preservation has for ecosystems, biodiversity, and for ensuring sustainable development.

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Educational implementations of experiments in Green mustard (*Brassica juncea l*) production with cow urine for horticulture learning

Aplicación educativa de los experimentos de producción de mostaza verde (*Brassica juncea l*) con orina de vaca en el aprendizaje de horticultura

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Abstract

This study is to identify (1) whether the use cow urine affects the production of green mustard; (2) whether the model of this experiment can be implemented in horticulture learning process. This is an experimental study that uses the simple experimental design, posttest only control group. 90 sample plants were grouped into two groups. The experimental group was given cow urine which had been stored for 2 weeks while the control group was not given cow urine. The data obtained were in the form of production or wet weight of leaf mustard. The t-test analysis showed that there was significant difference between the production of leaf mustard that was fed with cow urine and the production of green mustard that was not fed with cow urine. The production of the plants that were given cow urine was higher than the production of those that were not given cow urine. This experiment is very relevant to be implemented in horticulture learning since this experiment can increase creativity of the learners, is relatively low cost, takes only 42 days.

Key words*: education, cow urine, production, green mustard, horticulture*

Resumen

Este estudio es para determinar: (1) si la orina de vaca influye en la producción de mostaza verde; (2) si el modelo de este experimento se puede implementar en proceso de aprendizaje de horticultura. Se trata de un estudio experimental que utiliza el diseño experimental simple y el control posterior a la prueba. Noventa (90) muestras de las plantas se dividieron en dos grupos. El grupo experimental fue tratado con orina de vaca que había sido almacenada durante 2 semanas, mientras que en el grupo de control no se aplicó la orina de vaca. Los datos obtenidos se colectaron a través del peso húmedo de hojas de mostaza. El análisis de t-test mostró que no había diferencia significativa entre la producción de hoja de mostaza que se alimenta con orina de vaca y la producción de la mostaza verde que no se alimenta con orina de vaca. La producción de las plantas que recibieron la orina era más alta que la producción de los que no se les dio este componente. Este experimento es muy relevante para ser implementado en el aprendizaje horticultura ya que puede aumentar la creatividad de los alumnos, su costo es relativamente bajo y dura solo 42 dias.

Palabras clave*: educación, horticultura, producción, mostaza verde, horticultura, orina de vaca*

INTRODUCTION

Horticulture or plantation is one of the popular science topics which focuses attention on the science of gardening plants that have artistic or aesthetic, health and economy value. It contains the artistic value because it can meet the spiritual needs of, among others, could cause mental tranquility and gratification to the viewer. Horticulture is said to have health value as its product contains a variety of vitamins and minerals that are needed by the body. As a part of the plants that produce horticulture food, it also has economic value because the result can be traded, both in the domestic market and abroad.

Horticulture is a branch of agronomy. In contrast to agronomy, horticulture focuses on the cultivation of fruit (pomology / fruticulture), flowers (floriculture), vegetables (olericulture), medicines (biofarmaca), and the park (landscape). One characteristic of horticultural products are perishable because they are fresh (Wikipedia, 2014).

A vegetable is a plant that can be consumed both fresh and processed. Vegetables are needed by society because of the importance of the fresh and healthy foods intake in order to maintain a healthy body. Demand for food will continue to increase in line with population growth. Among the vegetable crops that are easily cultivated, is mustard greens. Mustard greens are favored by everyone as an ingredient to make the kind of dishes such as sayur lodeh soups, and lalap (dish of raw vegetables). Mustard greens have a good flavor when fresh and lots of protein, fat, carbohydrates, Ca, P, Fe, vitamin A, and vitamin C. The mustard greens crop is very good for relieving itching in the throat as it also acts as a blood purifier, improves renal function and facilitates digestion.

The green revolution *(green revolution)* has changed the face of the horticultural plants cultivation, not only in Indonesia but throughout the world. The real change is the shift of the horticultural cultivation practice from traditional to modern which is characterized by the excessive usage of artificial fertilizers and pesticides or herbicides. The changing face of horticultural crops cultivation practice was followed by the changing face of agricultural land that is increasingly critical as the negative impact of the use of inorganic fertilizers, pesticides and herbicides (Zulkarnean, 2010).

The use of inorganic fertilizers and synthetic pesticides in high doses not only affects lower levels of soil fertility, but also results in the decline of biodiversity and increased pests, diseases, and weeds. The negative impact will also be seen in the emergence of resistant pests, development of parasitic organisms, the increasing threat to the predator organisms, fish, birds, and even to the health and safety of humans. Toxic effects are not only limited to local use, but can be distributed more widely through the components of the food chain, such as drinking water, vegetables, fruits and other contaminated products (Zulkarnean, 2010).

Studying the chemical composition of the plant will give the clues about the nutritional needs of plants. By using hydroponic cultivation method, it has successfully identified 17 elements that are essential nutrients for all plants and some other elements that are essential for certain plant groups. The elements required by plants in large numbers are called macronutrients. There are nine macronutrients. The six main constituent elements of organic compounds: carbon, oxygen, hydrogen, nitrogen, sulfur and phosphorus. The three other elements of macronutrients are potassium, calcium and magnesium. The required elements by plants in very small quantities are called micronutrients. The micronutrients are iron, chloride, copper, manganese, zinc, molybdenum, boron and nickel. Nitrogen, phosphorus and potassium are the three elements that are often lacking in the fields and garden soil. (Campbell, 2000)

Cow urine contains various compounds in dissolved form that are produced by the kidneys. (Dwijoseputro, 1992). Cow urine also contains Auxin (a growth regulator) as one of the substances contained in green food that is not digested in the cow's body and eventually wasted with cow urine. The auxin content of cow urine is higher than the bulls' (Supriadji, 1985). Supriadji (1985) states that, cow urine can be used as a source of auxin. The urine should be diluted with water to obtain a concentration of 5-10%. Cow urine is used as a stimulant on the rooting of Robusta coffee cuttings. One effort to stimulate root growth bud cuttings can be done by using Growth Regulator Substance (Auxin).

Liquid manure (cow urine) in addition works quickly since it also contains certain hormones that can significantly stimulate the development of plant. In liquid manure, the N and K content is large enough, while the solid manure contains enough P content, so the results of the mixture between the two in the cage is a good fertilizer for the growth and development of plants (Aisha, 2011).

In addition to urea, a high content of elements K, N and Cl also found in the urine of cattle, in the form of ions K^+, $NO_3^-$and Cl^- (Oliveira, 2009). Nutritional analysis of cow urine tested in the winter and spring showed that the urine of cattle in the winter contain 0.88% N ($NH4^+$ 0.18%, 0.70% Urea), K^+ 1.04%, 0.081% S, Ca1185 ppm, 147 ppm Mg, Na 31 ppm, 390 ppm P. While in the spring containing N 0.70% (NH_4^+ 0.34%, 0.36% Urea), K 0.85%, 0.065% S, Ca 280 ppm, 85 ppm Mg, Na 410 ppm, 280 ppm P. (Legard, 1982)

Among different organic sources cow urine is a source of nitrogen. The analysis of cow urine has shown that it contain nitrogen, sulfur, phosphate, sodium, manganese, iron, silicon, chlorine, salt, vitamins, A,B,C, D and E mineral lactose, enzyme hormone as well as other acids. [5]. Total N in the cow urine ranged from 6.8-21.1 g N litre of which in average 69% was urea, 7.3% allantoin, 5.8% hippuric acid, 3.7% creatinine, 2.5% creatine, 1.3% uric acidand 0.5% xanthin plus hypoxanthin, 1.3% free aminoacid nitrogen and 2.8% as ammonia(Singh, 2014).

Cow urine, which has been considered as waste, can actually be utilized as a good quality liquid fertilizer that can be relied upon to replace chemical fertilizers. It is an organic liquid fertilizer that contains more complete nutrient compared to chemical fertilizers. With a simple processing, cow urine can be converted into a liquid fertilizer that is higher in value. Liquid fertilizer can be done in a simple way. The making technology of liquid fertilizer from urine is easy, cheap, and provides many benefits for farmers and ranchers. Liquid fertilizer is made using urine, feces, molasses, and water (Hadi, 2013).

Cow urine can be used as liquid organic manure if we process it, because it contains all the nutrients needed by plants including Nitrogen of 1%, phosphorus of 0.5%, potassium of 1.5%, carbon of 1.1%, water of 92%, and Phytohormone Auxin that is stimulus substance that can be used as a growth regulator. After the urine liquid fertilizer is processed, the nutrients are increased. Nitrogen increases to 2.7%, phosphorus to 2.4%, potassium to 3.8% and carbon to 3.8%. The color, which is originally yellow, turns into a blackish, and the pungent smell, which was originally is much, reduced. Another strength of this urine liquid fertilizer is that it is able to repel pests, rats, leafhoppers, walang rice pest and borer, so that, the plants avoid the attack of these pests. Cow urine should not be used directly. If it were directly sprayed on the plant, it will harm the plants because it forms ammonia gas. Urine is allowed to stand for 2 weeks without being processed (Margono, 2014).

According to the law of the national education system number 20 of 2003, the national education goals is developing students' potentials to become a man of faith and piety to God Almighty, noble, healthy, knowledgeable, skilled, creative, independent and responsible.

If we look over the educational goals, it is clear that the creativity increase of the learners becomes one of our priorities. Our global creativity index is very low. Based on reports from Martin Prosperity Institute and Richard Florida, our global creativity index is the second lowest number in the World after Cambodia. Two-thirds of one's creativity abilities gains through education, the remaining third comes from genetics. The converse applies to intelligence, i.e.: the one-third is obtained from education, the remaining two-thirds is derived from genetics. This means that the intelligence-based learning will not give such significant results as those based on creativity (Mendikbud, 2013).

Good learning is learning that requires active learners and meaningful *(meaningful-discovery learning)*. In active learning *(discovery learning)*, students are no longer placed in a passive position as recipients of teaching materials provided by the teacher / lecturer, but as a subject of active thinking process, searching, processing, parse, merge, deduce, and solving problems. (Hanafi & Sukana, 2009).

Based on the discussion above, the objectives of this study are to investigate: (1) does the application of cow urine affect the production of mustard greens? (2) Can this experiment model be implemented in the horticulture learning process?

RESEARCH METHOD

This research is experimental, using simple experimental design *post-test only control group design.* The seed-population in this study is the green mustard in the nursery box, which is planted from seeds that originated from a single parent plant which has been prepared as a seed crop. Green mustard plant that will be used as samples, are taken at random from the box and planted in the experiment pot that has been provided. Each pot contains one plant. Samples are grouped into two: the first group as the control group and the second group as the experiment group. Each group consists of 15 plants because there are three replications (test) then the total number of plants of each group was 45 plants. The number of green mustard samples that are used for both groups, is as much as 2 x 45 plants = 90 plants. The experiment groups are given cow urine that has been stored for 2 weeks and sprinkled in a circle around the plant. The watering distance is three centimeters from stem, while the control groups are not given cow urine.

The data that are obtained in the form of production (wet weight) of mustard plants are tested for normality and homogeneity. Normality test is done by using the *Kolmogorov-Smirnov* statistic and the *Shapiro-Wilk, w*hereas homogeneity test was performed with *Levene test.* Level of significance (α) is set of 0.05. The used criteria of normality and homogeneity test is when the number of significance (sig.) is greater than the significance level (α), then the numbers obtained are not statistically significant, meaning that the sample data came from a normally-distributed population. If the requirements have met the normality and homogeneity criteria, then the parametric analysis is conducted by t-test.

RESULT AND DISCUSSION

The collection of research result is conducted for 42 days of seeding in the nursery box or 28 days after transplanting into pots. Harvesting is done by cutting the plants into three inches above ground level. Average production (wet weight) of green mustard after experiments with three times of testing is presented in Table 1.

Table 1 Average Production of Green Mustard Plant

Group	Testing		
	I	II	III
Experiments	61.25	60.96	79.87
Controls	30.75	29.58	31.04

Based on the above table, it can describe the average production of mustard greens after three times of testing for each group as shown in Figure 1.

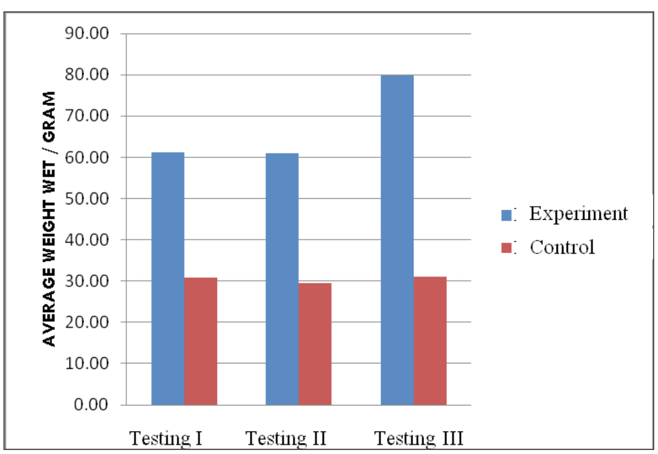

Figure 1 Average Production of Green Mustard Plant after Three Times Testing

Normality and Homogeneity Test

Green mustard production data normality is tested with *the Kolmogorov-Smirnov* and *Shapiro-Wilk Z,* while the homogeneity is tested by *Leven* test. The normality and homogeneity analysis results of data are presented in Table 2.

Table 2 Data Normality Test using the *Kolmogorov-Smirnov Z* test and the *Shapiro-Wilk* test and homogeneity test using *Levene* Test

Group	Value of p		
	Kolmogorov-Smirnov Z	***Shapiro-Wilk***	***Levene***
Experiments	0.200	0.979	0.066
Controls	0.123	0.244	0.066

Based on the normality test results using *the Kolmogorov-Smirnov Z* test and *the Shapiro-Wilk* test on production data of greens mustard in the experimental group and the control group, it shows that the data are normally distributed. Because the p-value of *the Kolmogorov-Smirnov Z* for the experimental group = 0.200 and control group = 0.123 or > 0.05. While the p-value from *Shapiro-Wilk* test for the experimental group = 0.979 and control group = 0.244 or > 0.05. Based on the results of *Levene's* test of homogeneity, it turns out that the data is homogeneous, because the p-value of *Levene's* test for the experimental group = 0.066 and control group = 0.066 or > 0.05.

t-test

To determine whether the application of cow urine gives significant influence or not on the production of mustard greens, mustard greens crop production data are analyzed by t-test. t-test analysis results are presented in Table 3.

Table 3. t-test analysis

Group	Value of t	SD	Value of p
Experiments	16.987	2.173	0.000
Controls	16.987	2.173	0.000

The results of t-test analysis show that t count is 16.987 with significance of 0.000 which is smaller than the set significance level (α) of 0.05. Thus, it means there are significant differences between the productions of green mustard plants which are fertilized with cow urine and the mustard greens which are not given cow urine. The green mustard plants which were fed with cow urine produced significantly more than the green mustard plant not given cow urine.

DISCUSSION

The results of t-test analysis found a significant difference between the production of green mustard plants which fed with cow urine and the mustard greens that are not given cow urine. The plants, which are given cow urine, produce more than the plants that are not given cow urine. This is because cow urine contains mineral elements needed by plants, including nitrogen, phosphorus, potassium, carbon, water, and auxine phytohormone (Margono 2014).

Nitrogen, phosphorus, potassium, carbon elements are the essential elements and the macronutrients that are needed in huge quantities by plants (Campbell, 2000). Nitrogen (N) is indispensable for growth, especially in the vegetative phase that is the branches, leaves, and stems growth. Nitrogen is also helpful in the formation process of green leaves or chlorophyll. Chlorophyll is essential to the process of photosynthesis. In addition, nitrogen is helpful in the formation of proteins and other various organic compounds. Nitrogen deficiency can cause the growth of abnormal or stunted plants. The leaves will turn yellow and dry up. A lot of (severe) nitrogen deficiency can cause the plant tissue to dry and die. The growth of fruit, which get nitrogen-deficient, is not perfect, fast ripening and its protein level is low. Phosphorus (P) is useful to establish roots, fruit ripening accelerator, strengthening plant stems, and increasing the yield of grains and tubers. Phosphorus deficiency causes plants to become stunted, the root growth is not good, and the growth of branches or twigs is hindered. In addition, phosphorus deficiency can cause delayed fruit ripening, more green leaf color, and yellow old leaf before it's time, and the less fruit or seed. Severe phosphorus deficiency causes plants not bear fruit. The function of Potassium (K) is to assist the formation of proteins and carbohydrates. Furthermore, potassium serves to strengthen plant tissue and has an important role in the formation of antibodies that can fight disease and drought. If potassium is deficient, the plants are not resistant to disease, drought, and cold air. Lack of potassium can inhibit plant growth and cause the leaf looks a bit curly and shiny. Eventually the leaves will turn yellow at the tops and edges. Finally, the leaves between the fingers turn yellow, while the fingers remain green. In addition, potassium deficiency causes the leaf to be weak so that it is easy to drop, and the seed shell wrinkled. Carbon (C) is beneficial to form carbohydrates, fats, and proteins that are beneficial to plant growth. In addition, it serves to establish cellulose which is cell membrane and strengthen parts of plants.

Nitrogen, phosphorus and potassium are the three elements of minerals that are commonly less abundant in fields and gardens (Campbell, 2000). Cow urine contains all the three elements. This means that by the application of cow urine, the essential minerals become abundant in the soil of green mustard plant pot as the experimental group. The same thing does not happen in the soil of the control group. Consequently the growth of green mustard plant in the experimental group became more optimal, so the production is better.

Liquid manure (cow urine) in addition to working quickly, also contains certain hormones that can significantly stimulate plant growth (Aisha, 2011). Urine cow contains auxin as one of the substances contained in green food that is not digested in the body of cow and finally wasted with cow urine (Supriadji, 1985). Auxin is a growth hormone that cannot be separated from the process of *plant growth and development.* Auxin is derived from the Greek *auxein* that means increase. The researchers found no growth would occur in the absence of auxin. In addition, studies show that auxin can increase the osmotic pressure, increase cell permeability to water, reduce pressure on the cell membrane, increase protein synthesis, and increase plasticity and cell membrane development. All of this is supporting the development of the plant. Auxin can accelerate the formation and extension of stem and leaves. Auxin also plays a role in extension and early root growth.

Based on the discussion above, it is clear that the content of cow urine either in the form of mineral elements and phytohormones is indispensable for the growth of the vegetative phase of plant mustard greens, especially the growth of branches, leaves, and stems and the formation of roots, strengthen the tissues and prevents the leaves from curling. Since the production of mustard greens is calculated from the wet weight of the plants which are cut into three centimeters above ground level, which only consists of stems and leaves, then the application of cow urine obviously give a significant effect on the production of green mustard plant.

By the nature of education in the context of national development has the following functions: (1) to unite the nation; (2) equalization of opportunity; (3) development potential. Education is expected to strengthen the unity of the nation within the Unitary Republic of Indonesia (NKRI), giving equal opportunity for every citizen to participate in the construction, and giving the chance for every citizen to develop their own potential optimally.

According to the law of the national education system number 20 of 2003, the national education goals is the development potential of students to become a man of faith and fear of God Almighty, noble, healthy, knowledgeable, skilled, creative, independent, and become democratic and accountable citizens. Such purposes include (1) aspects of attitude which consists of a spiritual attitude (believe and fear in God Almighty) and social attitudes (noble, healthy, independent, democratic and responsible); (2) aspects of knowledge (knowledgeable) and aspects of skills (proficient and creative). The low quality of education is due to the lack of students' creativity, whereas creativity is the base of innovation. There will be no innovation without creativity. Two-thirds of one's creativity ability is acquired through education, the remaining one-third comes from genetics. The converse applies to intelligence capabilities, that is: the one-third of intelligence is obtained through education, and the remaining two-thirds are derived from genetic (Mendikbud, 2013, 2013).

Provision of education expressed as a civilizing process and the empowerment of learners that lasts a lifetime, where in the process there should be educators who provide exemplary and able to build a will, and develop potential and creativity of the learners. The principal aim is to cause a paradigm shift in the educational process, from the teaching paradigm to the paradigm of learning. Teaching more focused on the role of educators on students' learning rather than on transmitting knowledge. Learning paradigms are shifted to provide more roles for learners to expand the potential and their creativity. This is in line with what was stated by the Hanafi and Sukana 2009 which states that good learning is learning that demands learners activity and meaningful (meaningful-discovery learning). In active learning (discovery learning), learners are no longer placed in a passive position as recipients of teaching materials provided by the teacher / lecturer, but as an active subject thought process, search for, cultivate, extract, merge, deduce, and solve problems. In the learning process, the creativity capabilities are acquired through: Observing, Questioning, Associating, Experimenting and Networking. Therefore, the teachers / lecturers need to design a learning process that emphasizes the personal experience through the process of observing, questioning, associating, and experimenting (observation-based learning) to increase the creativity of learners. In addition, the students must be accustomed to working in networking through collaborative learning.

The provision of education in Indonesia, prior to the enactment of Law No. 14 of 2005 on Teachers and Lecturers, explicitly organized by the Institute of Education Workers (LPTK). The form can be a High School Teacher Training Education (STKIP), Institute of Teaching (Teachers' Training) and the Teacher Training Faculty of Education (Guidance and Counseling, whose existence under the university). Such institutions are the source of agency personnel or teacher educators (Azhar, 2009). Teachers are professional educators with the primary task of educating, teaching, guiding, directing, training, assessing, and evaluating students on early childhood education, formal education, elementary education and secondary education. One of the subjects that are taught in LPTK is horticulture which generally appearing in the fifth semester. By implementing research "Cow Urine Increase Crop Production Green Mustard (*Brassica juncea L.)"* on the practical horticultural courses, students will be trained how to design an experiment, make observations, collect data, analyze the data. So that someday when they have become teachers, they can be creative educators who are able to develop the potential and creativity of learners. Thus the criticism leveled at LPTK stating that the system and the learning process less attention to the establishment of an independent personality, creative, innovative and democratic be annihilated.

CONCLUSIONS

There are significant differences between the production of green mustard plants which are given cow urine and the mustard greens which are not given cow urine, where the production of the given one is higher than the production of the other one. By implementing research "Cow Urine Increase Crop Production Green Mustard (*Brassica juncea L.*)" on the subject horticulture so in practice the candidates for teachering will be trained how to design an experiment, by making observations, collecting and analyzing data. So that someday when they have become teachers, they are able to develop the potential and creativity of learners

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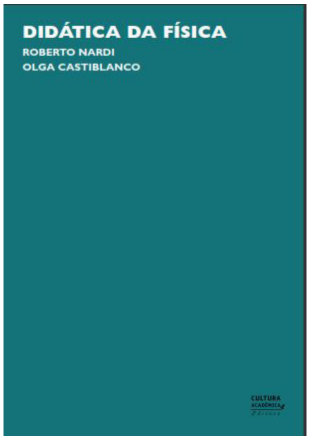
Book reviews

Roberto Nardi, Olga Castiblanco. Didática da Física. Sao Paolo, Cultura Academica, 2014. 160 pp.



This book contains a wealth of practical information for the teaching and learning of physics. It should be on every physics teacher's book shelf as a handy reference that is full of ideas on how to teach physics. The book is in Portuguese but Spanish speakers should be able to understand the basic ideas regarding teaching techniques that are presented throughout the book. English speakers can use the summary below to get many ideas to use in their own classes. The book is the result of the experiences of the authors while teachers of high school physics in Brazil and Colombia. The book is also based on past research, national and international, on the teaching and learning of physics. The goal of the book is to aid in the production of a university curriculum for training future physics teachers. The authors consider science teaching as an established research area with its own issues yet to be resolved. Training of future teachers needs fundamental reformulation based on research in recent decades. This book is available free on line at http://www.culturaacademica.com.br/_img/arquivos/11_didatica_da_fisica-WEB-otimizado-travado-v2.pdf This is a secured pdf file, which cannot be altered or printed but it can be downloaded to your device.

Following is a summary of the topics covered in the book and the authors' observations about those topics.

Literature research

The first part of the book is a summary of a literature search that the authors did. The literature search highlights the importance of preparing future teachers to be critical thinkers and to train their students in critical thinking. Future teachers should engage in metacognitive exercises to reflect on their own learning to better prepare them for such activities with their future students. Future teachers should be trained to do their own research on teaching and learning of physics. Interdisciplinary education should be part of teacher training, although a definition of interdisciplinary educations varies widely among various authors and educators. Teaching of physics is interdisciplinary just because it requires an understanding of the physical principles involved and it requires an understanding of the context in which it is taught – the classroom and the teaching strategies.

Each scientific discipline (biology, physics, chemistry, astronomy, geology...) has different research needs due to the unique knowledge base of each discipline. However, teaching of all disciplines involves common areas: social sciences, epistemology, the psychology of learning and the philosophy of science. Issues to be dealt with here are: 1. How can we use for physics teaching knowledge developed in teaching other disciplines?, 2. What types of student activities are most appropriate for learning physics? 3. How do we proceed from the simple to the complex – from basic introductory physics to advanced physics? 4. What should the sequence of topics be in the courses and curriculum?

In the literature there exists a consensus that teacher training needs to be improved. There is not consensus on how to do it. The authors attempt to identify areas of research in the teaching of physics by three brazilian authors. Various questionaires for these authors reveal a consensus only on general research areas, which are: 1. teach and learning of physics in diverse contexts, 2. curriculum development and 3. student-teacher classroom interaction. They have found that, in general in Brazil, future teachers are not well trained in physics teaching; they lack a base in interdisciplinary teaching.

They go on to say that students in the physics teaching program should learn to study their own activities as a teacher with the end of improving the processes of teaching and learning. A list of things to be studied in the teaching and learning of physics are: 1. The cognitive processes of teachers and students; 2. Communications in the classroom; 3. The planning and development of teaching processes; 4. The creation of teaching devices; 5. The use of resources such as laboratories and technologies; 6. The relationship between teacher, student and content; 7. Publicizing scientific work.

The principal objectives of a physics-teaching curriculum should be: 1. Use of interdisciplinary links for the solution of problems in the teaching of physics; 2. Overcoming "common sense" approaches to the teaching and learning of physics; 3. Teaching critical thinking not only for content but for teaching activities; 4. To teach research in physics education and to apply physics teaching research; 5. To develop a professional identity specifically for teachers of physics. According to the literature, physics teaching is not just the teaching of content, but deals with questions such as: what physics topics to teach, how to teach them, how to detect and deal with preconceptions and how to generate models and practices appropriate to each type of content and in each context.

One fact that appears repeatedly in the literature and in their own research is the contrast between methods of teaching the future teachers and the methods they are expected to use in their future classrooms. They go on to say that the practice of physics teaching should include as a minimum: exercises of self recognition, colaborative work, analytical work and directed work. Learning technologies should be included, not as an end but as a means of addressing problems in teaching and learning. Collaborative work should encourage students to listen, learn scientific terminology and debate ideas. Based on all of the above, they propose 9 possible dynamics (methods) of interaction: 1. Of the individual with the collective – starting with individual reflections which are then transmitted within one group and then introduced to the entire class 2. Of the collective to the individual – begin with free exchange of ideas within the entire class then break into smaller groups and ending with each student doing a written summary of the ideas dealt with, 3. Group work – A major problem is divided into sub-topics, each sub-topic being dealt with by a different group. Each groups' solution is then passed to another group to be analyzed until all groups have seen every other group's solution. The professor then leads the entire class through a comprehensive review of the solution. 4. Research questionaire – the professor prepares a survey over a topic to be done at the start of class. The results of the questionaire, done anonymously by the students, is then analyzed by the class as a whole. 5. The rotation – The students sit in one big circle. Each student writes a question or statement in a notebook. The notebooks are then passed to the person on their right, who then writes an answer or comment in the notebook. When each notebook has passed by all students and returned to its owner, the professor opens the class for a general discussion of any of the topics covered by the original notebook owners' questions or statements. 6. Feedback – The professor organizes student responses to a given topic with the aim of clairifying any misconceptions or deepening the coverage of the topic. 7. The Debate – The professor presents an existing problem in academia, the literature or in society, explaining why this problem exists and why it has not yet been resolved. The students are then put into groups and given one writer's opinions on the problem. The groups then debate this problem taking the position of their paper's writer. 8. The Watch – Equal numbers of students are arranged in two concentric circles. Two students at a time interact, one on the outer circle with one on the inner circle. The interactions can deal with many different topics in many different ways. For example, the inner student can act as a recorder and record the responses of each outer student to a question. At the end, the professor opens a group discussion for further exchange of ideas. 9. Co-evaluation – Students evaluate a talk or a paper produced by another student. The professor can distribute guidelines for each evaluation.

The three teaching dimensions

The authors identify three contexts for the teaching and learning of physics that they call the "dimensions". They are: 1. The Physical Dimension – learning the concepts of physics. Included in this dimension is metacognition, the history of physics and the philosophy of physics. 2. The Sociocultural Dimension – the content and methodologies for teaching physics in diverse educational settings (psychology, language, sociology and pedagogy), and 3. The Technical Dimension – the use of technology to support learning in the classroom and to promote student interactions. This includes the laboratory, learning technologies and textbooks.

In the next section they present examples of exercises for each "dimension" that were used by them during the seventh semester of a university program in the state of São Paolo in 2012.

The physical dimension

The first is an open-ended exercise. The question is: "An object is launched straight up. What is the maximum height it will reach?" The students are first grouped in pairs to organize an approach to the problem. They found that many variables are identified and that the importance of initial conditions is recognized. It also reveals existing (continuing) misconceptions. To encourage further reflection on the problem, the follow-up question was used: "What is the role of experimentation in the solution of this problem?" The final question in this exercise was to ask the students: "What would be the first steps you would do to teach this phenomenon?"

The second exercise is one involving the history of physics regarding the nature of light. The focal point was a time line with the names of scientists located along the line. A description of light was associated with each scientist. This exercise helped the students to see how the history of physics can be used to demystify the idea of science as absolute truth and to see how knowledge is constructed through critical thinking.

The third exercise involved the use of epistemology. The students were prompted to think about the nature of time with a series of questions about time. They were then presented with definitions of time using various philosophical approaches including naive realism, empiricism, traditional rationalism and surrealism with the end of identifying where their own descriptions of time fit. The students were surprised to see the range of philosophies into which their various responses fit.

The fourth exercise involved observation. Each student was given a small branch, which had leaves on it. They were asked to describe the object, listing whatever characteristics they observed. Their observations included properties such as colors, size, leaf distribution, texture, shape, state of the leaves (living versus dead), external agents – dust, insects. The second part of the exercise was to expand the significance of observable characteristics when the system cannot be observed with the naked eye. Further group discussion expanded on the characteristics of the observer, the observed and the instruments of observation.

This section ended with 27 suggested references for the reader to use as a base to generate new exercises.

The sociocultural dimension

In this section they propose the development of a transition from the identity of a university physics student to his or her identity as a teacher of physics. Teaching to four groups were studied: 1. visually impaired students, 2. grammar school students, 3. middle school students, and 4. teaching adolescents versus teaching adults. The students recognized the multiple difficulties with each group, especially the necessity of making the teaching age-specific.

Exercises were done to relate science technology to society. Students were given articles to read about topics like: 1. energy consumption, 2. global warming, 3. energy efficient light bulbs, 4. energy policy in Brazil. They were asked to decide which physics topics could be taught using each article and to propose a lesson plan to introduce the concepts and solve the problem discussed. The students came up with a wide variety of creative lesson plans, which are discussed in the book.

Exercises were done to promote the development of self-reflective teachers. Six situations were chosen based on actual experiences of the authors. Each situation described involved some last minute difficulty that required the professor to immediately adapt to the situation in order to make as good a use as possible of the time allotted for that particular class. The students read individually each situation and then reflected on how they would respond. The responses were then discussed by the group. This was followed by specific questions for the students to further develop their thoughts about any possible situation: 1. What sources could you consult, other than physics textbooks, to augment your understanding of the topic taught and to improve the lesson? 2. How would you plan, with your teaching colleagues in other disciplines, an integrated view of the sciences and mathematics? 3. How and when would you reveal to your students that you lack an understanding of a topic? 4. Given that you will inevitably confront situations requiring last minute improvisation, how could you prepare to minimize the risks associated with these improvisations? This section ended with 55 suggested references for readers to use to generate their own new exercises.

The technological dimension

First the uses of experimentation were studied. In each experiment the students were asked to describe the theory to be studied, identify the variables, parameters and constants. The authors attempted to help the students analyze experimental methods by getting them to think about the advantages and disadvantages of each experiment. The following experiments were selected both from the literature and from their own classes. 1. An Einstein thought experiment dealing with objects released in an elevator for inertial and non-inertial reference frames. 2. Newton's disk 3. Simple pendulum 4. Mechanical tractor – made with a spool, ice cream stick and rubber band.

Second, the uses of information technologies were studied. They chose to study what happens in the classroom when different types of technologies are used. They asked for students to suggest an appropriate class use for many different types of technologies: animations, educational games, simulations, search engines, sensors, distance education, out-of-class exercises and video conferencing, to name a few. They then developed exercises for five technologies: 1. audio stories – a science fiction story, 2. videos – showing how sound is produced, 3. stroboscopic photography – to study objects in free fall, 4. interactive mathematical software – studying the effect on simple pendulum period of amplitude, starting angle, length of the pendulum , and 5. on-line testing. Each student group worked on an exercise for one technology. Their results were then shared and discussed.

Third, use of bibliographical materials were studied. The authors selected five types of bibliographical resources, all dealing with the theme of motion. The resources were: 1. a book on the development of scientific ideas, 2. A physics text book – first case, 3. A physics text book – second case, 4. A textbook based on research in physics education, 5. A virtual encyclopedia (Wikipedia). 6. A book based on physics research. Each student was given a copy of the materials from each source and asked to identify the author, year produced, and give a summary of the content. They were asked to state their level of agreement with the ideas presented by each author and explain how they would use the material to teach about motion. Possible uses suggested were: introductory, to promote thinking, to use as a base for class discussion and to discuss errors in the text. This section ended with a list of 37 references for the reader to use for further ideas.

Final Considerations

The pupose of this book is to deepen the understanding that Physics Teaching is its own discipline. To that end the authors identify two related objectives: 1. To match present teaching methods for students in the Physics Teaching program with methods to be used in their future classrooms. 2. To use physics-teaching research to develp those methods. They propose doing this through the "Three Dimensions": develop understanding of the physical principles, recognize the sociocultural dimension and finally, enhance the teaching with the technology available. They encountered initial student resistance to new methods of teaching. But that resistance continually decreased as the students learned by using those methods. In Brazil there exists general agreement on what topics to teach a physics undergraduate, but there is no agreement on what should be taught in a Physics-Teaching curriculum.

Charles Hollenbeck, USA

INSTRUCTIONS FOR AUTHORS

The Journal of Science Education (REC) publishes articles, short communications and other original materials relating to the results of investigations and new experiences in the field of teaching natural sciences (Biology, Physics, Chemistry, Environment sciences , Biotechnology and other natural sciences), in secondary (high) school and university . Also investigations in the teaching of Mathematics, applied to education of the sciences. Opinions and discussions on the improvement of the national and international educational policy at all levels will also be welcomed.
Articles and short communications sent to the REC should not have been previously published or submitted for publication to other national or international Journals.
The principal sections of REC are:

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The authors should fulfil the following instructions:
The word processed manuscripts of the articles , double spaced and written in English or Spanish should be sent in triplicate , in white paper (21,6 x 27, 5 cm), keeping margins of 3 cm. An electronic copy must be included on diskette (PC format)
The preliminary text of the article can be sent as a .doc file in the attachment by e-mail:
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The text must be elaborated in Word for Windows or compatible word processors, using 12 points Times New Roman letters .
The work must have a maximum of 15 pages, included figures, tables and bibliography.
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The authors have to present the results, propositions and conclusions in a form that can suit better for teachers from different countries .
We recommend the following structure for article:
Title: no longer that 15 words; a translation of the title in Spanish or English must also be included.
Authors: names and surnames of the authors, the institution to which they belong, their electronics address (e-mail).
Abstract: not to exceed 200 words written in single paragraph. Key words: no more than five words; Resumen : a translation of the abstract into Spanish . Palabras claves: the translation of key words into Spanish.
The body of the text of the article must generally have the following parts:

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

Introduction:
general planning of the topic, objective or hypothesis of the investigation, references to relevant previous works.
Investigation methodology:
in case of investigations on new methodologies and innovations in sciences teaching the details of the organization of the pedagogic experiment or other methods of the educational investigation must be presented.
Results and discussion:
Supporting evidence should be presented together with the stated results of the pedagogic experiments, including tables , figures and photographs (black and white). and relevant statistical data. The discussion must be short and be limited to the key aspects of the work.
Conclusions:
should be based on results and if possible the solutions to the problem outlined in the introduction should be mentioned.
References in the text:
the name of the author and the year of issue , indicated between bracket (for example, (Moore, 1997).
Bibliography: the list will be cited in alphabetical order .
Reference to books : authors, name of the cited book (in italic), editorial, city, country, year of the publication, cited pages.
Example:
Hanson, R., Molecular Origami. Precision Scale Models from Paper, University Science Books, Sausalito, AC, 1995, p. 3-4.
Reference to articles: authors, name of the article, name of the magazine (in italic), volume (in bold), number between square brackets, initial and final pages, year of publication.
Example:
Rugarcía, A., El ingeniero químico para el siglo XX1, Educaión Química 9 , [1], 46-52, 1998.
Short communications (3-6 pages) should generally contain the introduction with the problem planning, results, discussion, conclusions and bibliography. We especially recommend this form to teachers of the secondary (high) school.

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- Logros educativos
- Libros de textos en ciencias y otros medios de enseñanza
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- Olimpiadas de ciencias y otros.

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Los manuscritos de los artículos o comunicaciones cortas , escritos en español o inglés, deben enviarse por triplicado , en papel blanco, tamaño carta (21,6 x 27, 5 cm), a espacio doble , con márgenes de 3 cm.
Debe incluirse la copia electrónica del trabajo en diskette.
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El trabajo debe tener una extensión máxima de 15 páginas, incluidas figuras, tablas y bibliografía.
El lenguaje debe ser claro y preciso. El trabajo debe ser escrito en un estilo impersonal.
Se aconseja a los autores, presentar las recomendaciónes y conclusiones no sólo de carácter local, para que los materiales sirvan mejor a los profesores e investigadores de diferentes países.
Recomendamos la siguiente estructura del artículo:
Título: no más de 15 palabras. Debe incluirse la traducción del título al inglés.
Autores: nombres y apellidos de los autores, la institución a la cual pertenecen, dirección electrónica.
Resumen: no más de 200 palabras escritas en un sólo párrafo.
Palabras claves: cinco palabras claves.
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La estructura del texto del artículo debe tener generalmente las siguientes partes:

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

Introducción:
planeamiento general del tema, objetivos de la hipótesis de la investigación, referencias a los trabajos previos relevantes.
Metodología aplicada para investigación:
en el caso de que la investigación sea sobre nuevas metodologías e innovaciones en la enseñanza de ciencias, deben ser presentados los detalles de la organización del experimento pedagógico u otros métodos de la investigación en la educación.
Resultados y discusión:
los resultados de los experimentos pedagógicos , incluido las tablas , figuras y fotografías (en blanco y negro).. Se recomienda presentar los resultados con los cálculos estadísticos pertinentes. La discusión debe ser breve y limitarse a los aspectos claves del trabajo.
Conclusiones:
deben basarse en los resultados obtenidos; si es posible, mencionando las soluciones al problema planteado en la introducción.
Referencias (citas biblliográficas en el texto):
el nombre del autor y el año de edición , indicados entre paréntesis (por ejemplo, (Moore, 1997).
Bibliografía: la lista se citará en orden alfabético .
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Ejemplo:
Hanson, R., Molecular Origami. Precision Scale Models from Paper, University Science Books, Sausalito, CA, 1995, p. 3-4.
La referencia a un artículo: autores, nombre del artículo, nombre de la revista (en itálicas), volumen (en negrillas), número entre paréntesis cuadrados, páginas inicial y final, año de publicación.
Ejemplo:
Rugarcía, A., El ingeniero químico para el siglo XX1, Educación Química 9, [1], 46-52, 1998.
Las comunicaciones cortas (3-6 páginas) generalmente deben contener la introducción con el planeamiento del problema, los resultados, la discusión, conclusiones, bibliografía. Recomendamos especialmente, esta forma para los profesores de los colegios.

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