10th EUROPEAN CONFERENCE ON RESEARCH IN CHEMISTRY EDUCATION

BOOK OF ABSTRACTS

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

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PEDAGOGICAL UNIVERSITY OF KRAKÓW

KRAKÓW, 2010 JULY 04-07

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FUNDUSZ SPOŁECZNY

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Abstracts were reviewed by the Members of The Scientific Committee

Publisher:

Pedagogical University of Kraków

Institute of Biology

Department of Chemistry and Chemistry Education

ISBN 978-83-7271-618-7

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Foreword

Dear Colleagues,

As a long tradition, ECRICE (European Conference on Research in Chemical Education) has been organized under the auspices of EuCheMS (formerly FECS), within the activity of the Division of Chemical Education. This 10th meeting follows successful conferences held in Istanbul (2008), Budapest (2006), Ljubljana (2004), Aveiro (2001), etc.

This Conference is an opportunity to exchange experiences on research and practice in chemical education at every education level - from primary school via graduate studies up to lifelong learning. Delegates from 33 countries all over the world are here together to familiarize the scientific environment with the most recent achievements of the various research and educational centers as well as to develop international cooperation. It will also be an opportunity for you to visit Krakow, famous for its culture heritage and friendly atmosphere.

The present book contains abstracts of 153 contributions: plenary lectures (7), oral presentations (83), workshops (2) and posters (61) prepared by Ph.D. students, academic staff and emeritus professors, researchers and teachers, for whom English is the native language and those for whom English is 2rd or 3th foreign language, who represent educational systems with 15 students in a class or 40, who work in fully equipped in multimedia classroom or in a simple one. I hope that the variety will be a great advantage of this meeting.

I would like to thank all those who have made this conference possible: the participants, the Scientific Committee - particularly for their contribution to the reviewing process, the members of DivCEd EuCheMS – who were very active in the promotion of this conference among members of national chemical societies and outside them, the Organising Committee – for their hard work, The Pedagogical University of Kraków for providing the facilities, OPCW and all other sponsors who have supported us.

I wish all the participants of the Conference a fruitful stay in Kraków with plenty of new scientific contacts and unforgettable impressions.

Iwona Maciejowska

Kraków, July 2010

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The conferences are held under the auspices of:

Division of Chemical Education of

European Association for Chemical and Molecular Sciences

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Plenary Lectures

Making a difference: factors that affect young people's interest and participation in science

Judith Bennett

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Many countries experience problems in creating a climate where young people feel enthusiastic about their experiences in school science lessons and beyond. One effect of this is that levels of participation inscience beyond the compulsory period give cause for concern.

The first part of this lecture begins by looking at some of the attitudes young people have to science, to school science, and to scientists, which are often negative. Next there is a consideration of various features that illuminate and impact on young people's attitudes and their effects: the nature of the problem and its origins, why it matters, the widespread nature of the problem, and the ways in which views of science link to performance in national and international studies. These features are illustrated with data from a recent survey of attitudes to science conducted in the UK, and with data from other national and international studies. The major challenges posed by the situation are identified.

The second part of the lecture presents the findings of a research study currently being undertaken called *Schools that make a difference*. In this study, a large dataset, the National Pupils Database, has been used to identify a number of schools that are similar according to a specified list of parameters (such as type of school, location, nature of pupil intake, external examination results), but have very different uptake of chemistry and physics beyond the compulsory period. The findings of a series of case studies will be used to identify a number of strategic, contextual, structural and practical features within schools that impact positively on uptake of science.

Problem Solving: The Difference Between What We Do And What We Tell People We Do

George M. Bodner

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Analysis of the solutions to problems given in textbooks shows that these solutions are logical sequences of steps, which string together in a linear, forward-chaining fashion from the initial information directly to the solution. The same can be said of the solutions many instructors present to their students during class, the research seminars we give to our colleagues, and the instructions we give to individuals who work for us. The approach taken by many texts and instructors to problems are good examples of how routine exercises are worked by individuals who have many years of experience with these tasks. They have little similarity, however, to the anarchistic approach experts and novices use when they encounter novel problems. This talk will examine classical models of problem solving and show how these models are best suited to working routine exercises. It will describe some of the experiments we have done to get a better understanding of how good problem solvers successfully solve novel problems they encounter. It will then introduce an anarchistic model of problem solving that might serve as the basis for improving our teaching of problem solving in both industry and academics. If time permits, some of our more recent work on problem solving in organic chemistry will incorporated into the discussion.

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From Homo Sapiens To Homo Mobilis
“Digital technologies is not only a basic necessity for chemistry education it is a challenge for personalization of learning“

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Keywords: homo mobilis, digital technologies (DT) in chemistry education, personalization of learning with DT.

Background. Internet, Informatization, Globalization etc. are the new phenomena witch very quckly change quality of our life. How changed the technologies the communication and education at the time ?

Fig. 1. Homo Sapiens - Homo Mobilis

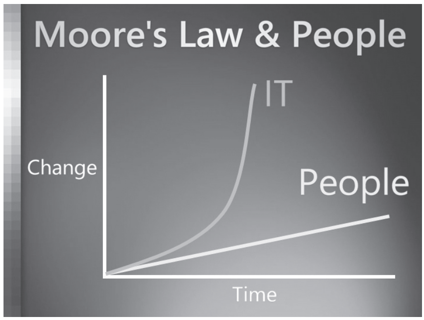

Fig. 2. Digital paradoxes (1)

Prof. Richard Noss´s from London Knowledge Lab asks very important question for present time: **„We would like support with new DT the old school conception, or we would like support with new DT the new school conception** [2],[3] ?“

We can see a new trends at the school reform in many countries. The main importance is put into the Scientific knowledge, IT and Math. For example: Russia – project Archimedes– increases the scientific knowledge at schools. Korea – 5-years plan to create the scientific laboratory and invest to the high-tech at schools. Great Britain – scientific work in practise compulsory subject at schools. USA – the Parlament approved the new Federal Act NCLB (No Child Left Behind) - PC/child 1/1 this year. Israel – the High-Tech Laboratories at school [4, 5, 6, 7].

The Methodology of education with DT

Current “digital world of science education” is based on three distinctive views:

- look in the past,
- considerations about the preset,
- vision of the future development.

Modernization of education is a demanding process of looking for balance between these three views on changing education with DT. This balance is very fragile and unstable as considerations about the presence are becoming very quickly considerations about the past. Research shows that the period of supportable balance between the present and the future is growing steadily shorter. Some experts argue that currently this period is less than 10 years and is becoming shorter until the presence becomes past and the future present.

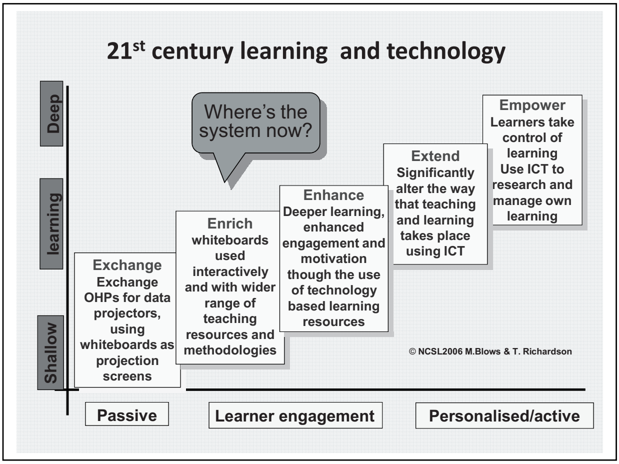

Fig.3 Digital technologies the challenge for Personalised learning (8)

Conclusions and Recommendation

New thinking about learning & teaching with DT for near future.

We are live it up an eduation, social and economic revolution. To survive it we need a new conception of human resources.

- Current approaches to education and training are hampered by ideas of intelligence and creativity that have wasted untold talent and ability.
- To develop these resources we need radically new strategies for education. We won't survive the future by simply doing better what we have done in the past.' (9)
- We are currently preparing students for jobs that don't yet exist, using technologies that haven't been invented in order to solve problems that we don't even know are problems yet' (10).

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School laboratory for one cent - demonstrations and experiments

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Nullis in verba … was the motto of the Invisible College established in early XVII century in England. There was a group of modern scientists who decided to acquire knowledge through experimental investigation.

Since September 2009 the new program on chemistry was introduced in gymnasiums. In the documents the stress is put on practical skills like a proper use of information and laboratory experiments. The teaching of chemistry without experiments is like eating hard-boiled egg without salt. Such egg is tasteless. The experiment is the essence of teaching chemistry. Unfortunately, in numerous cases this process is very difficult to carry out for lack of chemical laboratory, equipment, chemicals and so on. Sporadically the schools laboratories are controlled by officers and, for that sake, teachers quit with lab experiments to avoid troublesome inspections .

In spite of these difficulties, we try to encourage teachers to perform experiments. The chemistry experiments cannot be expensive and dangerous. A lot of systems of microscale experimentation developed in many countries are now available. Thus, teachers can adopt them to follow educational standards [1-4].

A lot of useful hints can be found in old books on popular and professional chemistry [5-9]. The experiments described there can be adapted to modern teaching chemistry after some modification. After some modifications teachers can find a lot of valuable hints how to prepare cheap and simple laboratory equipment with the application of disposable syringes, PET bottles, coca-cola cans, medicine vials, plastic pipettes and so on. Some equipment can be made by pupils as a part of teaching projects.

It should be kept in mind that great Edison started with the primitive small lab in a boxcar and after some time….So we should provide to young people a chance to experiment in the labs. It is a worth-while effort.

Internet resources and literature

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Making Chemistry Teaching Relevant and Promoting Scientific Literacy by Focussing Authentic and Controversial Socio-Scientific Issues

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The presentation will outline a theoretical base for justifying a stronger inclusion of authentic and controversial socio-scientific issues into chemistry teaching. Sources for the theoretical framework will stem from the debate about contemporary scientific literacy, from activity theory, and the German concept of Allgemeinbildung (e.g. Eilks, Marks & Feierabend, 2008; Marks & Eilks, 2009). As consequence from these theoretical resources, about ten years ago, the socio-critical and problem-oriented approach to chemistry teaching was developed (e.g. Eilks, 2002). Thus in a second part of the presentation, its central assumptions and criteria for structuring lesson plans are presented as they have been refined along a series of lesson plans developed by Participatory Action Research (Eilks & Ralle, 2002) in recent years. The summarized teaching approach intends to more thoroughly promote reflection on scientific questions in the framework of their socio-economical and ecological consequences. This is done by inserting authentic and controversial debates on socio-scientific issues into chemistry teaching, which provoke and allow for open discussions and individual decision making processes. After discussing the framework, different examples will be presented in brief, which deal with e.g. musk fragrances used in cosmetic products (e.g. Marks & Eilks, 2010) or different diets (e.g. Marks, Bertram & Eilks, 2009). From experience gained in applying the different examples, the potential of this teaching approach is then reflected upon as a source for raising the perception of relevance and promoting the process-oriented skills of evaluation and communication as essential parts of a well-developed scientific literacy. This last part of the presentation will be presented as a collection of students' comments and reflections.

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Teaching Inquiry-based Issues with a Historical Approach: Enhancing Scientific Literacy

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In recent years we have become increasingly aware of the need for people to understand the nature of science in order to make decisions posed by new developments in both science and in technology. The National Science Education Standards (National Research Council, 1996) as well as the 2061 project (American Association for the Advancement Of Science, 1990) reaffirmed the conviction that inquiry is central to the achievement of scientific literacy. Notions such as 'scientific literacy for all' are beginning to play an important role in considerations pertaining to educational goals. However, these ideas pose many problems, both regarding the actual meaning of the term 'scientific literacy for all', as well as the ability to provide all students with some background in science. In this paper we will describe an attempt to use a historical approach to science teaching in order to enhance students' scientific literacy by exposing them to a new teaching unit (module), *"Science – An Ever-Developing Entity",* which uses a historical approach to teaching science. *The module* interweaves aspects of science, technology, and society, related to the development of the concept "structure of matter", and surveys the development of our understanding of the structure of matter. It attempts to develop models that can explain the accumulated observations regarding matter and chemical reactions, which is a process that is as old as science itself (another parallel subject is, for example, astronomy). Based on the above, the research question of this study was to examine the effect of learning the module *"Science – An Ever-Developing Entity"* on 10^{th} graders regarding their attitudes towards science and their scientific literacy enhancement.

From The Challenges Of Disadvantage, A Wealth Of Insights Into Chemical Education Perspectives

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The challenges posed by underprivileged or disadvantaged educational contexts stimulate a huge variety of reflections on teaching approaches, in relation both to general-character aspects and to the specific learning objectives of a given discipline. In the case of chemistry, reflections span over a particularly broad range, because of its characteristics as a science implying extensive experimental components, two interconnecting levels of description (macroscopic and microscopic) and considerable presence of mathematical descriptions. Moreover, because of the essential roles of chemistry for development, chemical literacy and the training of an adequate number of sufficiently prepared chemists are key objectives in trying and address those same factors generating or characterising disadvantages in a given context/region. The effectiveness of chemical education responses to the challenges of disadvantage becomes functional to fostering development in general, and sustainable development in particular.

The context that has stimulated the reflections outlined here combines a particularly high number of disadvantage-generating factors (Mammino, 2008): the officially recognized "historical disadvantage" associated with the fact that the institution was "for blacks only" during the apartheid period, what, besides severe under-resourcedness, also implied poor recognition of fundamental goals of science education; the problems common to poor rural areas, where the current students are nearly always the first generation approaching higher education in their community; the difficulties inherent to studying through a second language that students do not master adequately (Rubanza, 2002); serious under-preparedness of incoming students, in terms not only of acquired knowledge, but also of acquired skills; and the all-permeating passive attitude that unavoidably stems from the cumulative impact of all these factors.

The challenges of chemistry learning are well known. Understanding is closely linked to a series of abilities: the ability of analysing experimental observations and making inferences from the analysis; visualisation abilities, essential to develop a perception of the structures and events of the microscopic world of molecules; the ability of following rather complex logical frameworks; and the ability of handling mathematics as a tool for description of physical phenomena. When incoming students have not acquired these abilities to a basic-literacy level, it becomes necessary that the teaching approaches integrate the attainment of such basic literacy into the work on the expected course contents. Designing the integration ideally requires a comprehensive perspective of the entire learning process, starting from the first year and continuing through the advanced courses of the undergraduate and postgraduate levels. Thus, trying and addressing the problems of disadvantage greatly emphasises the importance of extending educational research to advanced chemistry courses – a particularly challenging investigation, as the linkages between the teaching approaches and the content become increasingly tight and pervasive as the conceptual demands of the material increase.

The reflections proposed here are the outcomes of direct observations – ranging from the analysis of students' answers in their works to the information inherently stemming from classroom interactions and to personal interviews – throughout twelve years, while teaching the first year general chemistry course, all the undergraduate and postgraduate physical chemistry courses and the process technology course (introducing the foundations of chemical engineering). Different courses highlight students' difficulties in different ways, cumulatively offering a multisided picture of the situation and simultaneously posing individual challenges. The first year course poses the major challenge of familiarising students with the nature and methods of chemistry while simultaneously bridging the gap with secondary school, fostering basic-level development of needed skills and addressing already-existing (often taught) misconceptions. The physical chemistry courses pose the challenges associated with the extensive presence of mathematics and with the presence of rather complex logical frameworks (Mammino, 2009) – the former often turning into the fundamental question of the extent of mathematics presence that is necessary to retain throughout simplifications, in order to ensure adequate contact with the very nature of physical chemistry. The quantum chemistry course poses the challenge of abstraction and abstract thinking, of learning to think in terms that have no correspondence with everyday reality. The process technology course poses the challenge of requiring profound understanding of the first year material and the challenge of the extensive presence of chemical thermodynamics – a physical chemistry component perceived as particularly difficult. All the courses pose the major challenges of continuous attention to ensure that students understand the literal meaning of sentences, despite their poor mastering of the language that is the medium of instruction, and of a continuous struggle against passive attitudes and passive memorization, which requires ceaseless design of non-conventional approaches to stimulate active participation, engage students in interactions and foster intellectual curiosity, search and reflections.

The inferences emphasise aspects that can be viewed as acquired heritage of chemical education investigation: the importance of early (pre-university) familiarisation with basic skills of the scientific approach; the value of classroom interactions and students' active engagement in their learning process; the significance of highlighting the interconnections between the contents of individual chemistry courses, to foster a realistic perception of chemistry; and the importance of references to everyday experience and local reality, to promote concreteness perceptions about chemistry. The challenges posed by disadvantaged contexts provide impressive evidence of the fundamental roles of these educational aspects, by displaying the heavy consequences of their neglect through what can rightly be considered massive, thorough and detailed documentation. Moreover, by demanding continuous design of novel, often unconventional approaches to try and reduce the impacts of disadvantage, those same challenges stimulate reflections leading to deeper insights into crucial issues of chemical education, whose value is not limited to disadvantaged contexts, but extends to any endeavour aimed at familiarizing students with the nature, the significance and the beauty of chemistry.

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Oral presentations, workshops and posters

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Research-based chemistry teacher education in Finland

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The quality of chemistry teachers and teacher education is a key role to students' preparation as effective chemistry teachers. The objective of teacher education is to educate teachers who are proficient in their respective fields, pedagogically skilled, aware of their responsibility as educators, and who maintain their professional competence. Details of two examples are presented: (i) a model of the Chemistry Teacher Education Unit in the Department of Chemistry, University of Helsinki and (ii) a model of Department of Teacher Education, University of Turku.

Finland provides an example of research-based teacher education. Instruction at the University of Helsinki is expected to be based on scholarly research; up-to-date research findings on teaching and learning are used in planning it. Thus, the goal of chemistry teacher education in the Department of Chemistry at the University of Helsinki is to educate students to become *lifelong research-active chemistry teachers* - teachers that are able to follow developments in chemistry and in chemistry teaching, can incorporate up-to-date research information in their professional work, and engage in chemistry-teaching research.

The Chemistry Teacher Education Unit has been in operation at the Department of Chemistry in the University of Helsinki since 2001. Over a period of five years (M. Sc. degree), students in the chemistry teacher option complete approximately half of their courses at the Department of Chemistry. In addition to chemistry teaching courses specifically aimed at teachers (in all 77 ECTS), the studies include general chemistry courses (in all 86 ECTS). The Chemistry Teacher Education Unit at the Department of Chemistry organises education for student teachers studying chemistry as a major or minor subject, primary school student teachers, postgraduate students in chemistry education, as well as subject and primary school teachers. Annually, approximately five hundred students participate in the teaching. There are over one hundred major subject chemistry students and a dozen postgraduate students in basic education.

A continuum research-based (evidence-based) model regarding chemistry teacher education for lifelong learning has three Phases: (a) During Phase 1, future chemistry teachers' research-orientation starts in their studies in the Teacher-Education Unit in the Department of Chemistry (4 y) and continues in the Department of Applied Sciences of Education, including teacher training (1 y). Students study at least two subjects during their M.Sc. studies (e.g. chemistry & biology, chemistry & mathematics, or chemistry & physics). (b) Phase 2 features active collaboration with newly-graduated teachers, novice teachers (e.g. seminars, workshops, e-news, e-mails, or post-graduate studies). A new research-based mentoring program addressing the various challenges of ICT (Information and Communication Technology) has been developed as the first such program in Finland started in 2009 in close collaboration with the Department of Applied Sciences of Education and (c) During Phase 3, the national Centre for Chemistry Teacher Education (Kemma) in the Department of Chemistry (established in 2001 as part of the national LUMA Centre; see http://www.helsinki.fi/luma/english), closely collaborating with the Chemistry Teacher Education Unit, chemistry teachers, other societal partners (e.g. industry), and international partners.

Research in the Chemistry Teacher Education Unit focuses on chemistry teaching, studying and learning with regard to school education, chemistry teacher education and other university-level teaching of chemistry. Main research interests are (a) meaningful learning in chemistry with Technology, (b) meaningful learning and thinking skills in chemistry, (c) research-based pre-service and in-service chemistry teacher education, and (d) meaningful university-level chemistry education. Teacher students have been studied during our all courses. This year a study of teacher students' inquiry-based learning of renewable resources is continuing.

The Departments of Education in the Universities offer studies (60 ECTS) qualifying the subject students for subject teacher posts in secondary education. For example more than 200 students complete their pedagogical studies in the Faculty of Education in the University of Turku every year. The pedagogical studies can be made as either an internal or a separate module of a university degree. Before beginning the module, students are required to pass an aptitude test and they must have completed at least intermediate studies (50-60 ECTS) in their main subject. Students taking this as a separate module must have a M. Sc. degree. All students receive a broad pedagogical education and qualifications in those subjects in which they have a University degree. In the Department of Teacher Education in Turku there are about 30 - 50 teacher students in mathematics, chemistry and physics completing their pedagogical studies. Chemistry as a main subject has 10 - 15 of them.

The pedagogical studies consist of basic and intermediate studies. Both levels include studies in theories of education, didactics and teaching practices. The students in the University of Turku have altogether 14 ECTS in didactic studies. In these studies there are theoretical and practical parts concerning the National Curriculum, lesson planning, different kind of teaching and learning methods, demonstrations, laboratory work and assessment formats for teaching, learning and experimental work. In Turku also the students themselves do a small research in didactic studies. In addition the teacher students in mathematics, chemistry and physics are taking part in an assessment study. The success of an experimental task has been examined for over two years. The results of this study show how important in teacher education it is to improve the quality of assessment practices - a part of teacher's professional competence.

A nanoscience workshop for and from pre-service teachers

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Worldwide growing research in nanoscience and nanotechnology are becoming more prominent everyday. Understanding nanoscience/nanotechnology and its innovative implications has becoming an integral part of scientific advances. The public attitudes and the societal implications of nanoscience and nanotechnology have been recognized and investigated by several organizations in various countries, including Australia, Germany and the United States. One such effort was the organization of a workshop that brought together nanotechnology researchers, social scientists, policy makers, government employees, and the private sector. The workshop was sponsored by the United States National Science Foundation (NSF) (Roco & Bainbridge, 2001). As Roco and Bainbridge reported, the workshop participants suggested recommendations to improve research and education. The goal was to educate the new generation of scientists, science teachers, and the professionals in nanoscience and technology, as well as to develop specific curricula and programs to introduce nanoscale concepts into mathematics, science and engineering education, and to include societal implications. Consequently, nanoscience and nanotechnology education have become an important part of science education.

The aim of this study was to investigate the initial knowledge and the attitudes towards nanoscience/nanotechnology, of pre-service science and mathematics teachers; and how those teachers would be affected as they become involved in the organization of a nanoscience workshop for science teachers. The research was conducted in an undergraduate course called 'Science, technology, and society'. Students were solicited for voluntary participation. The twenty pre-service teachers who participated in the study were majoring in chemistry, physics, and mathematics education and varied in the year of their studies. Initially, the pre-service teachers took a nanoscale/nanoscience conceptual test and a survey of attitudes towards nanoscience. The nanoscale/nanoscience conceptual test, which was developed by the researcher, covered the key concepts. The survey of attitudes towards nanoscience was developed based on the findings and the categories identified by Bainbridge (2002). The participants were found to be varied in their level of knowledge and attitudes towards nanoscience. Next, the participants selected a certain aspect of nanoscience education such as introduction, applications, hands-on activities, research and social concerns, based on their abilities and interests. Each participant prepared 10 minutes talks or activities for their section using computer visualizations. After class and group discussions, the talks and the activities were edited by the peers, the researcher and an nanoscience expert. Then the participants combined their sections to compose a 'Nanoscience Workshop' and presented the workshop to a group of pre-service teachers who had not participated in this study. Finally, all the participants took the nanoscale/nanoscience conceptual test and the survey of attitudes towards nanoscience again. In addition, individual interviews were conducted. The results and the implications of the study will be discussed in the light of the importance of nanoscience education in the undergraduate science curriculum.

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Mental Models of Equilibrium Scale: A Tool for Measuring the Effect of Computer Visualizations of Physical Equilibrium

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Keywords: Mental models, physical equilibrium, computer visualizations.

Mental models or mental representations are the small-scale models of reality that people construct from perception, imagination, or the comprehension of discourse as visual images or abstract situations that cannot be visualized (Craik, 1943). According to Rapp (2005) mental models are combinations of stored knowledge with immediate experiences used to solve problems. Individuals' mental models are not exact replicates of external information; rather they are abstract representations that include spatial, physical, and conceptual aspects of the experiences. Rapp claims that mental models are difficult to define since they cannot be revealed by physical methods such as neuroimaging or directly observed. They are abstract descriptions of memory and can change over time. Rapp also argues that mental models show a person's individual understanding, but are not always valid or reliable. According to Rapp, cognitive engagement, interactivity, and multimedia are the three instructional features that affect the construction of mental models.

In this study the effect of a dynamic visualization accompanied by a supplementary worksheet on students' mental models of physical equilibrium was investigated with the help of a scale. The study was conducted on two physical equilibrium topics: solubility and liquid-vapor equilibria. Participants were two different groups of introductory college chemistry students. An open-ended questionnaire on physical equilibrium was given before and after working with the visualization. Participant responses were coded and grouped with respect to common features of their understanding. Selected students were also interviewed to develop a deeper understanding of their mental models. The mental models of equilibrium scale (MMES), a five-point scale in which one represents poor, and five represents expert-like understanding of physical equilibrium, was developed. Questionnaires that contained misconceptions or only macroscopic statements received the lowest scores on the MMES. Questionnaires that contained accurate statements, described the processes at the particulate level, and discussed both of the competing processes in the equilibrium received the highest scores.

Students' scores on the MMES before and after the implementation improved significantly ($p < 0.001$) as their mental models shifted towards expert-like understanding of both topics of physical equilibrium. A multiple-choice test of conceptual understanding of physical equilibrium was also administered to the students. The MMES was found to reveal significant changes in student understanding of physical equilibrium not revealed by the multiple-choice test. For example, some novice mental models of solubility equilibrium were found to include a chemical reaction between solute and solvent.

The visualizations used in the study helped novices to enhance their mental models and move towards a more expert-like mental model on the scale. In other words, they exhibited more accurate mental models of equilibrium after the implementation, because they were better able to describe the dynamic nature of equilibrium. Such computer visualizations could be used during lecture and laboratory instruction to help students visualize the dynamic nature of equilibrium. The use of a scale to evaluate responses to open-ended questions could help instructors better understand how instructional aids such as computer visualizations affect the mental models of their students.

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Study of the Effect of a Visual Representation on Students' Abilities to Chemical Calculations

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Keywords*:* visual representation, chemical calculations

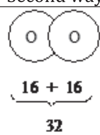
Chemical calculations are difficult for many students, but in researches the problem isn't examined enough? The purpose of our investigation is to study the influence of visual representation on students' ability to solve chemical problems.

We are of opinion that a teacher should discuss with students different ways of calculations problem solving. We have compared two ways of representation during chemical calculations in our research. According to the first way, students were to use only calculating formulas. According to the second way they could use visual models and reasoning.

In our research we tried to find answers to next questions: "Which way do students prefer for chemical calculations? Which way is better to improve students' skills in calculations?"

Pedagogical experiment was provided by two teachers from two schools. One of these schools is in Chelyabinsk. This is an ordinary secondary school. Another school is in Ulyanovsk. It is a gymnasium. The teacher from Chelyabinsk school was acquainted with visual representations in chemical calculations, but the teacher from Ulyanovsk gymnasium didn't know it. At the lessons students of the 8-th grade got directions, which contained descriptions of two ways for chemical calculations? We can see examples of these directions in the table 1.

Table 1. Instruction for calculations

Problem 1. Find the mass of $15{\cdot}10^{23}$ molecules of the oxygen (O_2)	
First way	Second way
Data: $N(O_2)$ = =$15{\cdot}10^{23}$ (molecules) ________ $m(O_2)$ – ? ***Solution:*** m=M·n, $n = \frac{N}{N_A}$ $M(O_2)=16{\cdot}2=32$ (g/mole) $n(O_2)=(15{\cdot}10^{23}$ mole): ($6{\cdot}10^{23}$ molecules/mole)=2,5 mole $m(O_2)$=32g/mole·2,5mole=80 g ***Result***: $m(O_2)$=80 g	 Consequently, $6{\cdot}10^{23}$ molecules of oxygen O_2 have mass 32 g $15{\cdot}10^{23}$ molecules have mass x g $x = \frac{15 \cdot 10^{23} molecules \cdot 32 g/mole}{6 \cdot 10^{23} molecules/mole} = 80\ g$ ***Result***: $m(O_2)$=80 g

At the first lesson "Mole. Molar mass" students got the instructions for following calculations: 1. Find the mass of $15{\cdot}10^{23}$ molecules of the oxygen (O_2); 2. How many molecules are there in 11 g of the carbon-dioxide gas (CO_2)? Students were to choose only one of the two ways: 1. Find the mass of $12{\cdot}10^{23}$ molecules of nitrogen (N_2); 2. How many molecules are there in 27 g of water (H_2O)?

At the second lesson "Molar volume of a gas" students also got two different instructions for solving the following problems: 1. Which volume $1.8{\cdot}10^{23}$ molecules of hydrogen sulfide (H_2S) are there under normal conditions? 2. Find the mass of 33.6 l of the ammonia (NH_3) under normal conditions. Then students did sums by themselves: 1. What volume has $1.5{\cdot}10^{23}$ molecules of chlorine-gas (Cl_2) under normal conditions? 2. Find the mass of 11.2 l of oxygen (O_2) under normal conditions.

As the experiment showed students' choice of ways of calculating to a considerable degree depended on the teacher's explanations. But we could find some relation, a visual ways of representation can improve student's ability in doing sums better than using formulas only. At the second lesson most of the students preferred visual way of representation for calculations. We can see these regularities in the table 2.

Table 2. Results of the students' chemical problems' solving

Teacher	Lesson 1 "Mole. Molar mass"				Lesson 2 "Molar volume of the gas"		
	Way	Choice	Problem	Right solving	Choice	Problem	Right solving
1	1	11 (46%)	1	8 (73%)	9 (38%)	1	7 (78%)
			2	7 (64%)		2	5 (56%)
	2	13 (54%)	1	12 (92%)	15 (62%)	1	13 (87%)
			2	10(77%)		2	10 (67%)
2	1	68 (96%)	1	54 (79%)	58 (69%)	1	47 (81%)
			2	52 (76%)		2	54 (93%)
	2	3 (4%)	1	3 (100%)	26 (31%)	1	26 (100%)
			2	3 (100%)		2	26 (100%)

A similar educational experiment at Chelyabinsk secondary school in the 11-th grade showed that only 20% of students had chosen the second visual way of calculations. On the question "Why?" students replied that they got accustomed to use formulas.

Conclusions and implications. Our research showed that students' choice of ways depended on both the teachers' explanations and students' own personal experience. The main conclusion is that the visual representations are necessary to develop students' calculating skills. We think that using of formulas is necessary to develop students, but they should use visual methods and reasoning (method of proportion) before. We've created new technology to teach students for chemical calculations which we are ready to implement.

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How it can be simplified to learn abstract subjects of chemistry? Using models and stories to increase student attitude and achievement towards chemistry

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Research design and methodology of data analysis: This study described the analogical models and stories used to introduce and teach Grade 9 chemical covalent compounds. We examined the teacher candidates' reasons for using models combined with stories. We explained each model's development during the lessons and analyzed understanding students derived from these learning materials. In this context, achievement and chemistry attitude scales were used to analyze the effectiveness of model and analogy based learning material. We planned to use the students' pre-knowledge wherever possible and we responded the questions with stories and extended and enriched analogies. A case study approach was used and the data were drawn from the observation of two Grade 9 class on covalent compounds, pre- and post- lesson interviews, covalent compounds achievement test (CAT) and chemistry attitude scale(ChAS). Experimental research was conducted in the first term of 2009–2010 educational years. Two classes were randomly selected. The experimental group (EG) was instructed through model and analogy based method with using sheets whereas the control group (CG) was utilized by traditional teacher-centered method. The study carried out on 60 high school students in Izmir, Turkey. The differences of CG and EG tests' were outlined. Statistical analyzes of data showed that there was a significant difference between pre- and post tests ($p<0.05$) of EG and CG, and EG was more successful than CG. Consequently, it was determined that students' interests and attentions may easily attract with using model and analogy assisted by a story. It can be said that models, analogies and stories are great ways to illustrate teaching, training and chemistry lessons having abstract and complex characters.

Theoretical framework and rationale: The studies suggest that, as science teachers, we spontaneously use analogies to help pupils understand. Use of models and stories to teach of chemistry at the level of universities and high schools increase its effectiveness and permanence from day to day (Montgomery, 2001). Models are scientific and mentally activities to make easy to understand and learn complicated phenomenon. An event difficult to comprehend maybe facilitates using another incident described by a model. In this case an unfamiliar fact is a target while a familiar phenomenon is a source. Modeling is a major element in scientific methodology and models play a vital role in chemistry because they can serve a wide range of functions. They can represent complex phenomena, make abstractions more readily visualizable, enable predictions to be made, provide the basis for the interpretation of experimental results, and most importantly, enable explanations to be devised (Gilbert, Boulter, Rutherford, 1998). Raghavan and Glaser (1995) showed that by making models a central feature of the learning process, students were able to show high levels of conceptual understanding. More recent studies have confirmed the learning gains which can be achieved by making models, modeling and evaluation of models central to the learning process (Erduran, 2000).

Research findings: In this work, the effect of using models, analogies and stories to make easy to learn abstract chemical subject as covalent compounds was studied. For this purpose we searched answers to following questions: Is there any difference between control group and experimental group on the students' achievements, the gender, and the attitude in chemistry lesson? The control group learned with the traditional teacher-centered education while experimental group learned using a new learning material supported with models, analogies and stories. Additionally, it was carried out as a qualitative study towards the students' ideas about

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new learning material. An instructional material using models and stories for 9th grade chemistry course about covalent compounds was prepared as an alternative to traditional written material. This new material included models and stories giving opportunity to students to make analogy. In order to assess the new chemistry learning material's benefits more precisely the following parameters were evaluated: Students' motivations and interests depending on the new learning material; teacher candidates' ideas and comments about this learning material.

Research data were collected at different situations as described in the following: Pre-lesson interview which focused on teaching intentions; achievement pre-test implementation; chemistry lessons in regular class (CG) and in analogy and story assisted learning class (EG) which focused on aspects of covalent compounds; achievement post-test implementation; post-lesson interview which focused on teaching reflections; test alternatives to put the case clearly about students' achievement and success on "*covalent compounds*" using regular or model, analogy and story based learning material to the 9th class. The stories were "*boy as bonding electrons, girl as protons"* and *"separated twince"* that the language of science is central in how people understand the word in which they live serves as a means to learn and to communicate personal understanding to others. It was used for different models to make easy to understand covalent compounds. The idea to create these models were coming from how the electrons to make desire a covalent bond. The study was carried out on 60 high school students in Izmir (a Province in Aegean Region, Turkey). Statistical evaluation of experimental data showed that the learning material based on analogy and story help to improve to understand and constructive covalent compound having and imaginary character. The crucial question then becomes is "narrative and appropriate tool to enhance apprentice students understanding of chemistry or of science", generally. Rather, we mention, the purpose of science education is to provide future generations with and appreciation of the cultural value of science and its strengths and weaknesses. In this sense we argue that using narrative becomes of value in supporting the understanding of scientific concepts and matters by none-experts. This statement has a good agreement with some other researchers. Further research in this area is necessary in order to develop appropriate learning materials based on narrative for the other subjects of the introductory chemistry which foster students' successful and meaningful learning of basic chemistry concepts.

Here there is a pedagogical reason for keeping them wondering that is we want students to see that our ideas in chemistry are sensible; also we want them to like chemistry. As well as we hope they will find chemistry sympathy and useful. The narrative used here indicates a high level of reflection and attention to students' interests. However some comment of interview show that we are not as well connected to student interest as we think. Like covalent compound we are mentally moving backwards and forwards between analogies and stories to find the best sense. Furthermore, if working analogies are to promote relational understandings, the shared and unshared attributes must be carefully mapped and conceptualized with the hearers. Students' comments from interview suggest that they lacked precise understanding of this kind of learning strategy. In the pre-lesson interview all analogies and models break down somewhere yet just once we did mention a limitation of our analogies to students. The teacher candidates attending this application express positive sense about new learning material. On the other hand, from a learning perspective and based on the presented findings, it can be seen how the analogy and story surface similarities provided access to deep relational ideas embedded in the mappings. Students are attracted to the analogy and story because they described and everyday situation that they felt were only imaginary useful. The findings prove that more structured analogies and stories improve learning environment because we believe that systematical, logical and familiar phenomena built relational ideas.

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The Italian ISS National Plan to enhancing science literacy through science teachers' education

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Keywords: Teachers' education, science literacy, peer education, chemistry in context.

Background, framework and purpose. Science literacy is strategic for life skills in our culture based on science and technology (EU 2006). European reports (Rocard, MASES) highlight the importance to have science through education and education through science for the cultural growth of citizens. ISS "Insegnare Scienze Sperimentali" (MIUR 2006) is a National Plan whose overall goals are improving Science Teaching so as to enhance the students' performance and providing Science Teachers with an effective and innovative in-service training set on peer education and active learning, in a constructivist student centred perspective. ISS aims at the enhancing of Scientific Literacy in all the compulsory school levels (age 5-16). Pisa (PISA 2003, 2006) outcomes showed that Italian students do not perform very well in Science. In Pisa 2003 they scored 486 (the average score being 500) they held the 27th position out of 40 countries and in Pisa 2006 they performed even worse sinking to the 43rd position out of 59 (they scored 475). The situation is not the same all over the Country, the Northern regions scored better; (Emilia Romagna score was 510). To contrast the poor achievements and its negative trend, and to benefit from mutual help between different regions, a National plan was designed and implemented.

Methods. ISS promotes a combined science approach that preserves the peculiarity of the different disciplines. Teaching and learning Chemistry in context, and in meaningful environments that combine science together in a systemic approach, should result in more effective learning, because active and "Inquiry-based methods proved their efficacy in science learning with increasing both children's interest and teachers' willingness to teach sciences". (Rocard report 2007). ISS was implemented by the synergic effort of different actors: Italian Ministry of Education, three Science Teachers Associations: Physics, Natural Sciences, and Chemistry (DDSCI), and two Science Museums in Milan and in Naples. The variety of promoters highlights that ISS is an important bottom-up process and it should be taken into account that "primary and high school teachers and their representative associations are important stakeholders of the science in society field" (MASES' 2009).The Plan is largely embedded into the social context to link traditional educational agencies and new teaching environments to promote the cooperation between schools, local industries, science centres, museums and other teaching sources. In the context of the new scholastic autonomy the "Indicazioni per il Curricolo"(MPI 2007) set the students' competencies but leave up to each School their responsibility to design the Curricula. The teachers' in-service training is relevant to promote their capability to design effective education projects. ISS is based on: *Laboratory* work and laboratory of ideas**,** *Competency* to enhance literacy standards, *Learning in Context* to make sense of the topics, *Verticality* to develop the same subject, recursively at different school levels*, Integration* to promote a systemic approach to science, and *Communication and Documentation* to share experience. Four themes were selected and developed with ISS approach: Transformations, Read the Environment, Light Colour and Vision, and World and Universe. They were selected because of their disciplinal importance and their ubiquitous presence that permeate most of science fields. Transformation was the theme selected by chemists' community. The Plan is administered and monitored at a national level by the National Steering Committee and the Scientific Committee that set the general criteria, and at peripheral level by Regional Steering Committee and Presĕdi. Presĕdi, are Selected schools in which three tutors, of different school levels, work together and meet other teachers to provide in-service training and to design innovative educational projects. Tutors are experienced teachers who attended national seminars to be trained on ISS theoretical bases and methodology. The active Tutors are 368, they work in teams of three from different school levels to train, in a peer perspective, other teachers. Usually twenty or more teachers follow in-service training at local Presĕdi so the plan has involved more than 2500 teachers. Support and monitoring were provided by teams of experts. The follow-up was guaranteed by national and local seminars and online environment.

Results. The monitoring took place in 2009 and it resulted in a report stating that all the Presĕdi were active and only 6,9% of the teachers quitted the plan. Tutors, after having designed an implement teaching material; will be qualified to carry out the initial-training of other science teachers on the theoretical basis of ISS. Teachers appreciated the bottom-up approach very much ("We don't work on teaching units pre-packed by experts" one of them stated), the interaction with colleagues of different school levels and stages of experience, and the opportunity to cooperate and share opinions and PCK (Pedagogical Content Knowledge).

Conclusions and implications. In Italy there is a shift from programs (lists of contents) to curricula (sets of competences) so it is important to train teachers not only updating their subject knowledge but also providing effective teaching methodologies and to improve their capability of designing educational projects. The Plan has obtained positive feed back; teachers addressed positively sharing PCK, and bottom up re-thinking of Science teaching, but they found problematic the use of the online environment, the lack of funding, and the documentation of the activities. The Plan will be diffused all over the Country (MIUR 2010 pg 3)

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Promotion of argumentative competitions in scholar science by means of the education of the kinetic one of the chemical change in students of secondary school[1]

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Keywords: Cinética, Cambio Químico, Explicación, Argumentación, Lenguaje Científico, Enculturación, Modelos

Abstract. Within the framework of a professional practice of a professor in formation in chemistry, this proposal was elaborated to develop it in a Municipal Grammar school of the city of Santiago, of Chile. The thematic unit selected to apply in the students is the one of Kinetic Chemistry, which agreed to the Chilean curriculum, must be taught in the third year of average education (students of 16 to 17 years). Design a Didactic Unit (Jorba and Sanmartí, 1997) from an approach of the *Didactology*, worked on the basis of the theoretical model of the chemical change, in order to generate an alternative that promotes the effective process of *inculturation* (Chamizo, 2007) along with the promotion of argumentative abilities, such as the explanation and argumentation (Márquez, 2008), that favor the process of modelling of the students (Adúriz-Bravo, 2006).

Theoretical Frameworks. From epistemology, the competitions argumentation are a basic tool in the process of genesis of the scientific knowledge, since it allows to construct significant relations enters theoretical evidences and models (Pipitone, 2009), These important abilities activate and they are pronounced by means of the argumentative text production and are valid for all the curricular areas, but they take shape of way different for each from them (Márquez, 2008).

Method and collection of data. The cycle of learning proposed by Jorba and Sanmartí (1997), for the stage of introduction of new contents of the Unit of Kinetic, worked with students two documents about two routes different from synthesis of 'aspirina:' a natural one carried out by the trees and another artificial one carried out by the laboratories of Bayer S.A. The questions were focused to identify the differences in the chemical speed of synthesis of aspirina and factors that influence in the rapidity differences. For it, it was requested to them to explain the differences and to argue about the identified chemical factors. For the development of the activity, initially the text was read aloud, soon the most important ideas by means of a discussion forum were discussed and later the students responded the questions of individual form. The documents been responsible for the students were analyzed after finished the experience.

Results. All the students expressed, by means of the explanation, differences based on the synthesis method, or would be natural or artificial, and the different uses for which aspirina in cases is synthesized both. In their totality, the students managed to explain the natural route of synthesis of aspirina, not therefore the artificial one, since this one to explain it, needs a made scientific language more, to which they do not dominate these students, due to problems of lack of educational in the previous year. The argumentation was obtained only in some cases due to the difficulties of structuring of scientific models bases, through which the argumentative positions can be developed. On their majority, the ideas expressed by the students, were based on a literal

[1] [1] Scientific Product derived from FONDECYT research 1095149 (Abbr.) sponsored by CONICYT – CHILE.

reproduction (Márquez, 2008) of the factors mentioned in the text, without managing to develop the argumentation. Still more, within the few answers where the argumentation was observed, the identified factors on which constructed the answers, were social and economic, reason why no student managed to relate the model to the influential chemical factors in him. We understand that this could be at the rate of the poor scientific language and the consequent unsuitability of its mental models, to interpret the phenomena of the world, which are characteristic of the public Chilean scientific education, reason why continues reproducing the classic models of education (Quintanilla, 1999).

The development of the competitions of scientific thought, like the explanation and argumentation, for the introduction of the new contents of kinetic of the chemical change, is a support to the process of learning of the students, since it allows to diagnose and to demonstrate the profit of the construction of models around the kinetic one. Although not all the students, managed to show an argumentative position, if they demonstrated advances in the explanation, which indicates that a reconstruction of initial theoretical models exists towards more complex models, which would justify the necessity to continue using the explanation and argumentation to favor learning of the model of kinetic of the chemical change.

Conclusions. The kinetic one of reactions normally is education in the Average Education, from the theoretical notion of chemical equilibrium. The use of the abilities explanation and argumentation made possible, in the class of chemistry of a state school, the reconstruction of the model of the chemical change towards kinetic of reactions, the different one from the proposal by the curriculum of the country, this became necessary, due to the deficiency of previous theoretical slight knowledge on the part of the students. This work allowed evaluating this new proposal for the education of the kinetic one of reactions, where we understand that also from the chemical change we have a good option to arrive towards the model from kinetic. Opening therefore the door to the Didactology, and the generation of multiple models of the education of scholar science (Adúriz-Bravo, 2006) with a theoretical body of established knowledge that allow the scientific *inculturation*, by means of the argumentative competitions and they tie the models of the erudite knowledge of the kinetic one, to the mental representations of the students around kinetic chemistry.

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Using learning communities to develop learning materials.

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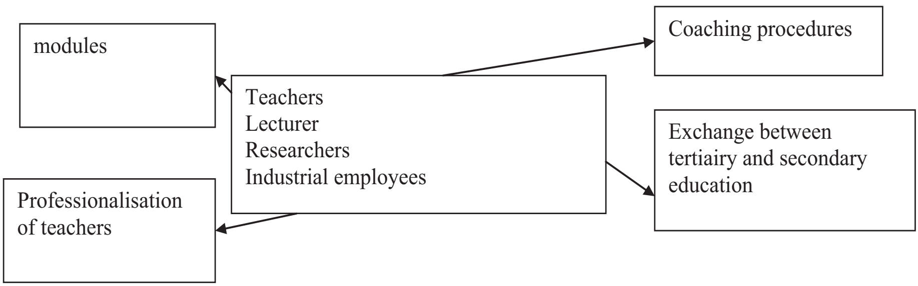
Introduction: At the university of Groningen schoolteachers have been active in working together with teaching staff of the university at renewal of science education since 1996. Since 2002 this collaboration has been directed specifically at the renewal of science education. Groups are active in different fields of science, ranging from the traditional subjects like mathematics, physics, chemistry and biology to broader fields like research and design, technology, and common subjects like biochemistry.

Focus: In this paper we report on the process of colloboration in the group as well as the products of the group. Other aspects of interest are the impact on the professionalization of the teachers, and the impact the process has had in their classroom.

Participatory Action Research: The group working on chemistry education has been set according to a principle of participatory action research as described by Ingo Eilks and Bernd Ralle ((Eilks & Ralle, 2002))

A group of teachers works together with a lecturer in chemistry education, researchers from relevant research groups, and people from (chemical) industry.

Focus is on the devlopment of educational material based on context oriented chemistry, in line with national developments as described by the van Koten committee ((Driessen & Meinema, 2003)). As a special focus this group worked together with the team from Chemie in Kontext(CHIK), based in Oldenburg(I Parchmann & Ralle, 1998)



Main questions: One of the conclusions of the van Koten (Driessen&Meinema, 2003) committee was that teachers should have more influence on the subjects taught in their classroom. When starting this group one of the main questions was whether communities of teachers could be used to renew chemistry education towards this goal.

Two of the main questions we try to answer in this paper are the following:

What is the process the communities go through while producing the learning materials, and which steps in the process need to be taken to get satisfactory educational material.

Information and data collection

As is usual in participatory action research data are collected from the process itself. During the group meetings minutes were made. The minutes of year one and two were analyzed. Focus was on the subject of discussion during the meetings. When analyzing these subjects a number of phases in the discussion in the group can be discerned. The group met about 9 times each year. They had a definite time planning when the group started.

The products made by the group

The group produced a first module about combustion in the first year.

In year 2 modules for grade 9 about the production of sugar, additives to food, cleaning materials and chemical weapons were made.

3 to 5 teachers tried out the products of the group in several classes. Both teachers and students reflected on the use of the products, by filling out a questionnaire. These questionnaires were analyzed. From these questionnaires the quality of the educational material was rated. When teachers found they could work with the material without problems and students were positive about the material, the product was considered satisfactory.

Results.

The process in the group

Groups developed an expertise in making educational units. The first year can be considered as a learning year. During the first year input was given about the pedagogical background of context- concept learning(Demuth *et al.*, 2006; I Parchmann *et al.*, 2006). After that quality and variety in the produced materials changed. The group started out as a group of about nine teachers. During the first year they worked and learned together as a group. In the second year they split up in three groups that worked more or less independently. These smaller groups were able to welcome new teachers without any problem. During the second year input was given from university teachers and from industry.

During the process in the groups phases can be distinguished.

Phase 1. Introduction to theory. At the start of the work emphasis was on the input of the didactics. The way CHIK(Chemistry in Kontext) worked was explained.

Phase 2. Application of theory. Teachers tried to relate the phases to their own experience in the classroom. One particular module (Verbrennungen, gewünschte und unerwünschte Folgen) was studied. The teachers tried to adapt this module to their own situation. There they ran into all sorts of problems, that couldn’t be solved during the meetings.

Phase 3. Consultation. The group went to the IPN in Kiel to discuss their problems with a group of experienced teachers at the IPN in Kiel. A number of their questions were answered.

Phase 4. Design of a module.

Phase 5. Try out of the module.

Phase 6. Reflection on the outcome and start of developing new modules.

Products

In general both teachers and students were enthusiastic about the modules when they were tried out in the classroom. The results of the first module about combustion led to the development of modules about food, about cleaning materials and about chemical weapons.

Conclusions

The process in the groups led to groups of teachers that worked together cooperatively and were very successful in producing educational material. After a year of learning the groups were able to produce a variety of materials.

The success of this group of teachers led to the formation of other groups of teachers at other universities working on the development of educational material to be used in the chemistry classroom.

This indicates that this type of learning community can be successful means of renewing chemistry education. Lastly the success of these learning communities has led to a wide range of other activities at the University of Groningen

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Orientation Bases As Mediating Instruments In Model-based Science Learning

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Keywords: *modelling, metacognition, learning, chemistry*

Background, frame and purpose. Justi (2006) advocates for a science education strongly based on modelling, in accordance to the nature of scientists' science. She proposes a reflective process along which representation, anticipation, planning, execution, and adjustment of the events under study and of the theoretical meanings and symbols constructed on them would allow students to *think*, *do* and *communicate* a science that is both *rational* and *reasonable* (Izquierdo-Aymerich, 2004). In order to enhance these model-based processes, we deem important that students have access to *collective tools with which to think*; rather than fostering understandings 'in solitude', we seek the use of mediating tools and collaborative work. This approach modifies our view of school scientific experimentation (even at the University): we want to shift from 'mastery' to execution under *distributed cognition*, from 'effectiveness' to *mediated self-regulation*.

For the purpose of this presentation, we will understand a model as a representation of an idea, object, event, process or system, created for a specific purpose (cf. Justi & Gilbert, 2003). Such representation *abstracts* and *translates* the nature of the entity represented. In the educational context, *school scientific activity* (Izquierdo-Aymerich & Adúriz-Bravo, 2003) is conducted by means of *school theoretical models*, which result from transposition of scientific models. School models include the possibility of being represented by means of drawings, scale models, simulations, metaphors and analogies.

Methods. An emerging line of research and innovation on modelling in science education suggests the need of designing processes that foster in students the development of theoretical ways of *thinking*, *doing* and *talking* that lead to competences such as being citizens and living in society. Implementation of modelling activities in the classroom would need, in our view, taking into account the following key elements: 1) introduction of 'good questions' that permit actively intervening on reality, thinking theoretically and using abstract languages; 2) a robust understanding of the nature of models and modelling in historical and current science; 3) mastery of the ability to *plan actions*.

Action-planning reveals knowledge of procedures to attain goals and a pre-existing recognition of the consequences of each step taken. In this sense, it combines four elements: the goal, with its values; the operations that are strategic to reach it; the internal conditions of performance; and the epistemological vigilance of the process. Close adjustment between these four elements constitutes *hypothetical* or *moderate rationality*, which means that scientists and science learners choose the means most adequate to the goals (Izquierdo-Aymerich, 2004). A student who anticipates and plans the task is able to *represent* the decisions to make in order to succeed in model-based interventions. For most students, higher-order self-regulation needs to be learnt. Therefore, our science teaching should favour instructional situations in which material, cognitive and discursive procedures are meta-cognitively analysed. This is why we propose the use of mediating instruments that enhance reflection on action and on learning. Our approach to fostering self-regulation in chemistry students at the University has extensively used orientation bases, 'scaffolding' in them the internalisation of a construction and use of models in which thought, action and discourse converge to intervene on the natural world in a critical way.

Our proposal on the use of orientation bases is mainly located in Justi's (2006) *third phase* of school scientific modelling, in which teachers favour small-group and whole-class discussion on the representation codes that permit model expression. Orientation bases constitute an external aid for the organisation of instances in which students negotiate ideas and test their individual and co-constructed models.

Results. We analyzed 18 productions corresponding to three practical sessions. The first result was to identify two different 'Formats' in the *Orientation Bases*, that we denominate 'horizontal' (Type A) and 'vertical' (Type B). We presented a type A example on the determination of the density of a solid.

- G2: The group poses a problem to solve; their instructions are very synthesized and outlined, data are used mechanically and their origin is not justified. (They think that if they have a result, it is not necessary to justify it.)
- G3: The group aims at finding the data required and are not concerned with the procedure needed to obtain them. They are interested in finding the value derived from a formula "d=m/v", together with statistical conventions needed for precision, but they only concentrate in mathematics and not on chemistry. They agree that magnitudes are obtained from an instrument.

Advances and concluding remarks. In order to implement model-based science teaching, it would be necessary to continue discussing, researching and innovating around: nature of models in science and at school; science teachers' professional development; students' conceptions, procedures and attitudes; design of instructional units that foster self-regulated modelling. The implementation of strategies and instruments that promote reflection and regulation skills is not new, but it provides another way out of the dogmatic and positivistic chemistry teaching that still prevails in some contexts. We consider that this approach to the design of a science education of quality for all can have major impact in current practices in the different educational levels.

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Experiences with the use of a Classroom Response System (CRS) in a Chemistry Foundation Course

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Keywords: Classroom response system, Clickers, Interactivity

The University of Auckland invited applications to participate in a project trialing the use of 'personal response systems'. A chemistry course, which is a component of the Tertiary Foundation Certificate (TFC) program, participated in the trial in the second semester of 2009.

The TFC program at the University of Auckland is a well established, two semester bridging program for students who do not meet university entry requirements. On satisfactory completion of the TFC program students can enroll in degree programs. TFC students electing to include chemistry in their TFC program take a chemistry course in each semester.

The chemistry TFC cohort includes mature students returning to study from the workforce or social benefits and also significant numbers of disaffected school leavers who lack motivation and direction. The diversity in backgrounds in chemistry, attitudes and expectations makes for a challenging teaching situation.

Teaching of the TFC chemistry courses, other than for a limited number of laboratory sessions, is scheduled in formal lecture theatres. As such lectures are the primary method of delivery of core course material. Lecturers have attempted to encourage interactivity between students and themselves and also between groups of students, but this met with little success. Mature students were generally found to lack confidence and be reluctant to engage overtly, and school leavers were passive and unresponsive to direct questioning. A plateau in terms of dialogue in the classroom had been reached.

The trial using 'personal response systems' was seen as an opportunity to improve teaching and learning by promoting a more engaging and active learning environment for students (Addison, 2009).

The University provided the Qwizdom student response system ((Qwizdom, 2010), which uses clickers in conjunction with a USB host receiver and instructor remote. The Qwizdom system interfaces with Microsoft Powerpoint. The students, who had already completed the first semester TFC chemistry course, were issued with clickers for use in the second semester course.

It was decided, despite the capability to do so, not to use the Qwizdom system to monitor attendance or for grading. This decision was taken to avoid students feeling inhibited in using the clickers for fear of getting the wrong answer. Responses relating to specific clicker registration numbers were recorded, but lecturers could not correlate these with individual students.

The lecturers planned questions of a true/false or multichoice format to use at one or more points in each lecture session. Students were given time to respond to each question. Where a significant distribution of responses was observed by the lecturer on the instructor remote, students were encouraged to discuss with adjacent students their responses. Students had the opportunity to adjust their response after these discussions, before the lecturer displayed the histogram of responses and the correct answer to the class.

The lecturer discussed each question after displaying the histogram of responses to address misconceptions and reinforce concepts. The questions and the associated feedback were included on Cecil™ (The University of Auckland Learning Management System) after the lecture as part of the lecture resources.

Students responded to the introduction of 'clicker' technology seamlessly. High participation rates were recorded in all sessions. The interactivity of students was evidenced by observing changes to responses on the instructor remote after discussions between students. As the semester progressed lecturers observed spontaneous discussions between students.

A student survey was carried out in the final week of the semester. Data in Table 1, selected from the survey, gives an insight into the student perception of the effectiveness of the Classroom Response System.

Table 1: Student survey feedback on Classroom Response System (Clickers) *

	Mean	Std. Dev.
I find clickers useful in enhancing my interaction in the class.	4.22	0.85
Using clickers makes me more attentive during lectures.	3.90	1.02
With clickers it is easier for me to tell if I am mastering the course material.	4.24	0.81
I feel more engaged during class when we use clickers.	3.73	1.03
Because of clickers I am more certain how my learning is progressing.	3.93	0.79
Using clickers increased my likelihood of attending class.	3.15	1.41

*Students rated their level of agreement with each statement on a 5-point scale: 1=Strongly Disagree, 2=Disagree, 3=Undecided; 4=Agree; 5=Strongly Agree. Questions were adapted from a University of Auckland Project Office Questionnaire and Siau (2006)

On the student survey, in the open ended comments section, students frequently commented positively on the anonymity of their clicker responses and the value of the ability to judge their performance relative to other students.

The Classroom Response System enhanced both the teaching and learning environment of the chemistry course. Teaching staff had the opportunity to give timely and specific feedback. The student survey results show the majority of students perceived significant benefits in using clickers, particularly in regard to assessment of mastery of course material and enhancing interaction in the class. Survey results parallel those observed by Demetry (2005).

One concern for teaching staff was the amount of time which, without careful monitoring, could be taken up with 'clicker questions'. Another concern, based on the decision to make the clicker responses anonymous, was the inability to approach students who routinely could be seen from response reports to be consistently answering questions incorrectly.

The increased general confidence of the cohort over the trial was tangible and was viewed as an important contribution to the TFC graduate profile.

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Audiovisual Context Based: Socio-scientific Issues in Chemical Education

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Keywords: motion pictures, socio issues, contextualization, younger's education

It is therefore important to think of education systemic term, not limiting the student's experiences to what can possibly take place in the classroom. The role of alternative learning environments therefore becomes critical as a prelude, a complement a follow-up to the school-based learning process (Härnqvist & Burgen, 1997).

We are assuming that a film, like a play, is a mainly a performative genre, that is, a genre designed to be performed, a genre that "comes to life" in a performance. Watching a movie, like watching a play, are a collective public experience and a social occasion. We have to remember that, experience comes from interaction with a learning environment. Films viewers' come with a large number of (mostly unconscious) expectations about how the filmic medium presents a real or fictional story (Barthes, 1982).

This work discusses the possibility to create contexts based on audiovisual, movie in this case. Based on the socio-interacionist approach by Vygotsky, it is acceptable that an audience can interact with the characters and share their emotions and actions showed in an audiovisual language.

On this way we analyze a movie considering the potential of audiovisual, socio-scientific and common languages to be used as a tool to create a context, a situation that helps students to give meaning the concepts (De Jong, 2006). We report a movie analysis based on the film analysis (Jahn, 2003) of Erin Brockovich focused on the environmental problems that seem an interesting socio-scientific issue, because this issue can connect chemistry with student's personal lives. We can use these selected scenes to organize classroom's activities to contextualize the scientific content and motivate students to our science classes.

It is presented one problem with chromium (VI) when it is ingested by the residents in the area due to its presence in their water. It is an opportunity to discuss the implication about environmental contamination, and prepare students for their roles as responsible citizens discussing chemistry and its role in social issues, i. e. connecting scientific knowledge to social issue. As suggested by the professor in the movie, that hexavalent chromium also referred to as chromium 6, chromium (VI), or Cr^{+6} is very dangerous form of chromium, the Cr (VI) is added to the water that is used to cool the engines, this is what caused the contamination of the ground water of the areas surrounding the plant. It is possible to contextualize the corrosion process showing it as a result of reactions between a material, typically a metal, and its environment.

It is considered a mature understanding of science when the learners can demonstrate in terms of the ability to adapt to ways of talking and thinking about phenomena according to the context, recognising the appropriateness, power and limitations of each (Leach and Scott, 2003).

Among problems caused by ingesting chromium (VI) are various forms of cancer, respiratory diseases, gastrointestinal and reproductive problems, headaches, and hair loss. Workers in plants where chromium (VI) is present also experience problems with inhaling it and as it comes in contact with their skin. We have an opportunity to discuss some specific content with students but in a contextualized way contributing to the development of scientific and technological literacy of students.

When students have an opportunity to discuss about socio-scientific issues, for example, the problem of chromium contamination they can change from one sociocultural context to another one. What is more important based on the movie context, to keep the jobs or to take care of their health? This context, that caught student's attention also by emotions, seems to be able to promote the community aspects of the classroom and the role of peer discussion in supporting students to learn science. This can lead to the transformation of existing meaning of a concept or to the addition of a new meaning to the concept. As we can see the context precedes concepts and context follows them.

It seems to be more relevant instead just to memorize the content for do exams.

The identification process with the scenario, character, scene, dialogues is important to place the scientific content in a larger context and establish easy connections with the community outside school and to arrange the teaching situations. So the students notice the whole content as what is meaningful.

The emotions, is another way to engage students to class activities. It is possible to purpose discussion about health problem from environmental pollution. The movie show different medical cases of residents are brought up and many of these side effects are present.

The audiovisual context based can provide students to come to personal understandings of ideas and information that already exist in the culture, from their interaction during the discussion with teacher and peers about the scenes from movie related to socio-scientific issues.

We noticed on this movie analysis the potential of audiovisual, scientific and common languages to be used as a tool to mediating science teaching and learning. Furthermore, the audience can learn values, information and knowledge present into the movie discourse and thus, the cinema shows the science in a society. Moreover, audiovisual language may be important mediating variables that determine the effectiveness of cinema for enhancing chemical teaching and learning.

We believe that, with appropriate supporting activities science teachers trained in using this audiovisual context-based methodology can help reverse the negative attitudes that many students have toward real science by moving them from familiar experiences they enjoy to unfamiliar experiences they expect to be dull and difficult.

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KAPITAŁ LUDZKI
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CITIES – Inservice Training For European Chemistry Teachers

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Keywords: Comenius project, Inservice training, "hands on" experiments

Background. In service training for chemistry teachers is a need in all European countries: New teaching methods on one hand and new developments in chemistry on the other hand have to be dealt with in chemistry lessons. But there are some more important reasons to focus on inservice training: Some teachers in European schools are involved in teaching chemistry but have studied other subjects as biology or phsyics for instance. Last but not least many teachers never had contact with industrial processes nor have any idea of the importance of the chemical industry in Europe.

These considerations led to the Idea of CITIES (Chemistry and Industry for teachers in European schools). The COMENIUS project (2006 – 2009) produced four teacher training modules which will help teachers to make their chemistry lessons more appealing to students by placing the subject in the context of daily life. Besides basic information on European aspects of the chemical industry and chemistry teaching, CITIES offers course material with "hands on" experiments. The four modules will be free accessable via the CITIES homepage and will serve as the basis for either in service training courses ore direct information for teachers (CITIES, 2010). Practical and usefull hints for organizers of inservice training courses are enclosed. Most materials have been tested with different groups of teachers.

Methods and Results. In this contribution we will focus on the module "Chemistry - bringing it alive". This module includes "hands on" experiments covering three topics: "Forensic chemistry", "The Chemistry of canned Ravioli" and "Discovering Chemistry around us".

Forensic Chemistry

Crimes seems to fascinate people of all ages. This is not a phenomenon of our period. Many legends and fairy tales, such as the Nibelungen saga or "The Spessart Robbers" deal with fraud, murder and homicide as well as robbery – in many cases ethically sublimated. Detective stories are part of the great successes in literature and movies.

From the point of view of a chemistry teacher it is not to be discussed how a crime was committed, but the detection of traces is the main point of interest in the lesson. In such a case only analytical chemistry is the subject area. In this way pupils will not be tempted to try out certain crimes or to endanger others or themselves by producing e. g. explosives. There could even be the opposite effect: a suitable way of teaching could show how far advanced modern techniques of identifying traces are and this could deter students from transgressing the law. (Bader & Rottweil, 2003)

In the frame of the CITIES project, the various aspects for the intelligence of crime by means of simple chemical reactions, which are of great importance in forensic science, have been made accessible for schools.

The „Ravioli in a Can"– Project or: The Chemistry of canned Ravioli

A seemingly unspectacular object is closely observed and regarded under different aspects in context from a chemical point of view. It was to be shown with an everyday life product, in this case canned ravioli, which insights can be gained with simple well-known chemical tests for detection (Albrecht et al., 2002).

Since the activity of the students themselves were to come to the fore in the planned project, the emphasis was put on student experiments. The order of the experiments was to correspond to the researching method, which requires the student to approach the object of the research and to gradually gain more insight into it. The first thing that one observes on a can of ravioli in the supermarket is its colourful packaging, the printed paper. When it is removed the metal can is revealed, whose composition is to be determined. The question arises why such an elaborate and costly packaging is needed. The answer is given when one considers the different ways of preserving food. When the can is finally opened, the noodles are reached, which in themselves are the "packaging" for the meat. Finally thickening agents and pigments can be detected in the sauce.

Thus many different ranges are addressed, which, as is well known, can not be considered all at the same time in a regular chemistry class. The "Ravioli in a can"-project is especially suited for a class segment at the end of secondary school or at the end of eleventh grade in high-school or grammar school, when topics, which are already known, are to be considered in a more in-depth manner with the help of a practical example.

The topic offers a number of interdisciplinary points of contact for expansion. They span from the discussion on profitability of recycling of tinplate cans to modern dietary patterns and to the question whether additions to food are to be considered questionable to the health. In any case it gives an opportunity to see beyond the end of one's own nose.

Discovering Chemistry around us - Appealing Chemical Experiments Using Everyday-Life-Materials[1]

This set of experiments includes experiments with subjects which are part of our daily life such as packaging or furniture materials, synthetic resins and plastics, food, etc.. The experiments described are a usefull supplement for school chemistry. Examples are the detection of the thickness of an aluminium layer in packaging materials by titration, the synthesis of a polyurethane from castor oil, the preparation of bio-oil or the recycling of chipboard.

In this contribution we shall give an overview about the three topics of the module "Chemistry - bringing it alive" and present some examples of the experiments.

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Real and Virtual Environment in Early Chemistry Education: Tradition and Challenges

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The role of real experiment in chemistry education is irreplaceable. At the same time the real life brings more virtual environment items, new virtual worlds etc. Both children and adults are strongly motivated by experimenting, discovering and understanding things in their own way. The class experiment is to be purposeful, it means clear, appropriate to pupils age, simple, well organized and visible and safety realized. **Is the virtual (simulated) experiment able to meet these requirements?** The objective of this contribution is to discuss possibilities and their limits in the use of virtual environment supporting chemistry education, paying special attention to the early chemistry instruction. It means to discuss effectiveness of the computer simulations and "chemical" animations applied in early chemistry education, either independently, or in various combinations with real experiment. The main attention is to conclude relations, regularities and recommendations for meaningful and effective use of computer simulations and animations, remote and virtual laboratories, remote sensing, all in relations to pedagogical-psychological phenomena as pre-concepts, individual learning styles, visual literacy etc.

Methodological aspects cannot be omitted even in applications of information technologies in the chemistry instruction. Starting from this point of view, the basic and general methodological tools (methods) are as follows:

- empirical methods: simple and controlled observation, real experiment, work with empirical hypothesis,
- theoretical methods: thought experiment, modelling on different theoretical level (material, mental, mathematical, etc.), work with theoretical hypothesis.

Simultaneously it is possible to advocate that two sciences function each other as methodologies, mainly in situations when the science reflecting simpler fields of phenomena carries out the function of a methodological tool towards the other science which solves more complicated problems. Thus Physics is the methodological tool towards Chemistry, and Chemistry towards Biology. Sometimes another situation may appear - a more abstract science, e.g. Mathematics, is the methodological tool towards the other sciences.

The function of the interactive medium (ICT) is not directly, but vicariously methodological. It enables to apply basic empirical and theoretical methods in a faster, more complex way, and to save their results to memory in long-term periods, and to provide information on the history of the studied phenomenon at any time. This is a substantial auxiliary tool allowing improving methodology of gaining new and applying still existing pieces of information.

The particularity of natural sciences, and especially chemistry, lies in the sphere of observation of the course of chemical experiments (sensoric area) and in forming conditions for their repeating and changing (motoric area). It is obvious that intellectual activities are a necessary part of every sensomotoric (or either sensoric, or motoric) activity. This topic has been dealt with numerous authors. The dominant (or initial) activities in the theoretical procedure are the intellectual ones, in the empiric procedure – sensomotoric activities.

As it has been indicated above, a computer and other information technologies can be used as useful supporting means of emphasizing methodological aspects of natural science instruction.

They are mainly as follows:

- support to running experiment and modelling,
- support to directing empiric and theoretic hypotheses defining,
- support to forming empiric and theoretic items of knowledge.

Information and communication technologies play the role of traditional didactic means which aim at optimizing educational conditions, i.e. support planning, projecting, running and evaluating instruction so that the educational objectives were reached, and reached in an effective way. Opponents emphasize the factor of the learner, which is missing or considered a passive object of learning only. What we are trying to outline in our research and development projects is that the meaningful combination of the real and virtual environment in the natural science instruction is one of the crucial conditions in the process of innovation of school experimental activities (Bílek et al., 2009).

Main reference (will add):

BÍLEK, M. et al.: *Interaction of Real and Virtual Environment in Early Science Education: Tradition and Challenges*. Hradec Králové: Gaudeamus, 2009, 145 p. ISBN 978-80-7435-019-1

Safety Characteristics - the basis for compliance with ATEX directives

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Keywords : safety, ATEX, ignition source, risk assessment, explosive atmospheres

The EU Directive 1999/92/EC (ATEX 137) defines minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres. According this directive, employers are obliged to assess the specific risks arising from explosive atmospheres. This assessment includes in particular the characterization of the explosive atmosphere, its likelihood and persistence, as well as an analysis of potential ignition sources. Thus for a comprehensive analysis, it necessary to characterize the combustion and explosion characteristic of the substances involved in the respective processes, i.e. “the fuel”.The combustibility, the explosive concentration range, the dustiness (for powders), the oxygen concentration are typical data required to characterize explosive atmospheres.

For the analysis of ignition sources a multitude of data is necessary, such as: minimum ignition energy, minimum ignition temperature, thermal stability und various atmospheric conditions, as well as electrical conductivity to assess the risks from static electricity.

The presentation will show how safety characteristics fit into a systematic explosion risk assessment under ATEX 137.

Explosive Atmospheres

Fuels and oxidizers

An explosive atmosphere consists of fuel and an oxidizing medium. In most cases, the fuel is some organic combustible material and the oxidizing medium is oxygen (air). However, one should notice that explosive mixtures are also formed with other combinations.

Flammable Gases and vapors

Gases and Vapours mixed with air can be ignited if the concentration is in the explosion range. The explosion range lies between the lower explosion limit (LEL) and the upper explosion limit (UEL). The values can be taken from literature. The temperature at which the vapour pressure of a combustible liquid is sufficient to produce a flammable mixture with air is called the lower explosion point. This temperature is only slight higher than the flashpoint of the material, measured in a closed cup. Therefore, when combustible liquids are handled below the flashpoint[1], no explosive mixture with air can be formed.

Combustible Powder

Almost all organic powders can be ignited if they are dispersed in air (dust clouds) in a concentration between approx. 15 and 6000 g/m3. Exceptions are e.g. organic materials with high halogen content. The minimum ignition energy of raised powder (dust) is normally in the order of 10 to 10‘000mJ. However, some powders form dust clouds that can be ignited with energies of less than 1mJ.

Hybrid Mixtures

Mixtures of air, combustible powder (dust) and flammable vapor or gas are called hybrid mixtures. It is important to notice that such mixtures can be ignited even when the individual

1) A safety margin of 5-10°C is recommended for pure solvents, a margin of 15-30° is recommended for mixtures of combustible liquids.

concentrations of the dust one hand and the vapor (or gas) on the other hand are below the lower explosive limit!

The ignition energy of hybrid mixtures is mainly determined by the ignition energy of the vapor (gas), which is by 1-4 orders of magnitude lower that that of the powder (dust). This dangerous effect can occur if the vapor (gas) concentration is as low as 25% of the LEL. Therefore hybrid mixtures may be formed in presence of flammable liquids at temperatures as low as 30°C below the flashpoint of the liquid.

Aerosols, Mist

Explosive atmospheres involving combustible liquids may also be formed at temperatures far below the flashpoint of the liquid, if the liquid is dispersed in small droplets (aerosols, mist). Such mixtures can be ignited and can lead to explosions similar to dust explosions.

Safety Data

In order to characterize the properties of fuels and explosive atmospheres the following safety characteristics are required.

Flashpoint	Temperature, at which the vapor pressure of a combustible liquid is sufficient to produce a flammable mixture with air under defined experimental conditions.
Auto-Ignition temperature of liquids	Temperature of a surface, which is sufficient to ignite a droplet if a combustible liquid which are put onto it.
Combustibility Index	Qualitative Assessment of the Ignitability and Combustibility of a powder.
Self-Ignition Temperature	Temperature, at which a solid ignites in contact with air.
Decomposition Temperature	Temperature, at which a substance undergoes a decomposition reaction (only exothermic decompositions reactions are on the focus for safety considerations).
Spontaneous Decomposition	Propagation of a locally initiated decomposition reaction through the entire substance without contact to air.
Dust Explosivity	Flammability of a dust cloud in air. (Powder dispersed in air)
LEL, UEL: Lower and upper explosion limit.	Concentrations range, in which a mixture Of fuel with air is explosive.
MIE	Minimum Energy, which (within a defined standard test) leads to an ignition of an explosive mixture.
MIT	Temperature of a surface, which is sufficient to ignite a dust cloud in contact with it.
K_{max}, P_{max}	Characteristics of an explosion (K_{max}: Normalized maximum pressure increase rate, P_{max}: Maximum explosion pressure)
Restistivity, Conductivity	Electrical property of a material, indicating the risk of charge accumulation.

Ex-Zones

For each plant Ex-Zones must be assigned according to the following definitions:

Gases and Vapors

Explosive atmosphere …

Zone 0 … is present continuously or for long periods or frequently
Zone 1 … is likely to occur in normal operation occasionally
Zone 2 … is not likely to occur in normal operation, and if it does occur, it will exist for a short period only

Powders

Explosive atmosphere …

Zone 20 … is present continuously or for long periods or frequently
Zone 21 … is likely to occur in normal operation occasionally
Zone 22 … is not likely to occur in normal operation, and if it does occur, it will exist for a short period only

Ignition Sources

Open Flames

Dryers, which are operated with the combustion gas of gas burners are not in the scope of this documents. They require special measures against the transfer of glowing embers into the drying chamber. (Ember traps, spark detectors). Open flames may also occur after self-ignition of dust deposits. If work involving open flames has to be carried out in plants, this requires special work permits ("hot work permit"). The respective procedure must ensure, that such work is only be carried out, when direct contact of flames and the resulting hot surfaces with combustible material and dust clouds is not possible.

Electrical Equipment

Electrical sparks, e.g. due to switching mechanisms or due to damages of electrical equipment may ignite explosive dust/air mixtures and hybrid mixtures, which could result in dust explosions.

Hot Surfaces

Hot surfaces could directly ignite explosive mixtures of dust and air and also lead to self-ignition of dust layers deposited on them.

Hot surfaces may occur e.g.

- on pipes for transport of heating media (steam, air(!))
- on electrical or mechanical equipment (lamps, motors)
- in case of friction or overheating of drives and gearboxes)

Mechanical Friction

Mechanical damage or a foreign body trapped between moving parts or improper operation could also cause local over-heating of the product being processed. If the relative velocity of the moving parts v_{rel} is >1m/s frictional sparks may be generated, which could ignite explosive dust/air mixtures or powder deposits. This is of particular importance for mechanical grinding processes and high speed mixing.

Electrostatic discharges

Corona discharges and brush discharges are not effective ignition sources for dry powders and for most gases and vapors. Exceptions are Hydrogen, Acetylene and Carbondisulphide. Brush Discharges usually occur between non-conductive surfaces and conductive objects.

They are not effective ignition sources for dry powders but for most gases and vapors.

Spark discharges may occur between non-earthed/non-grounded conductive objects. They may ignite dust clouds. Therefore, all conductive plant items must be safely earthed/grounded and earthing must be regularly checked. Propagating brush discharges occur on non-conductive surfaces with 2-9mm thickness, where intense charge separation processes occur, i.e.

- in pipes with non-conductive liners for pneumatic conveying of powders
- in cyclones or dryers with non-conductive liners

Cone discharge occur in big containers and silo, when highly charged (non-conductive) powder is accumulated in side, such that the electric field beomes so strong that ultimately a breakthrough occurs to the wall of the container. The discharge energy of cone discharges increases with increasing diameter of the container and increasing diameter of the particles.

Exothermic Decomposition and Self-Ignition

If dust deposits, e.g. on the walls of a dryer start smoldering due to exothermic decomposition or oxidation, the glowing nest or the flames may ignite a dust cloud by direct contact. Therefore the temperature in dryers must be limited safely below the self-ignition temperature.

A three-stage model for developing chemistry teachers CK and PCK

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Background. Research findings on the effectiveness and professional development of teachers underscore the importance of teachers' knowledge and professional interest, as well as their pedagogical knowledge (Munby, Russell, & Martin, 2001). What teachers know and how this knowledge differs from other subject areas was discussed by Shulman (1986, p. 9), who defined it as Pedagogical Content Knowledge (PCK), "which goes beyond knowledge of the subject matter… to the dimension of subject matter knowledge for teaching". In order to develop the PCK, teachers usually attend professional short or long development programs, initiated at their schools or at educational departments or institutes (Krajcik, Mamlok, & Hug, 2001). These professional development programs guide and support the teachers in coping with learning difficulties or in implementing a new curriculum. However, these programs focus more on the pedagogical knowledge of teachers, and less on their content knowledge (Kind, 2009)

Based on the above arguments, a special program for enhancing chemistry teachers' content knowledge as well as their pedagogical content knowledge was launched at the Weizmann Institute of Science in the academic year of 2009. The program involves teamwork and collaboration among three groups: scientists, science educators, and teachers, and consists of three stages, in which the teachers attended (1) the course lectures together with the regular MSc students, (2) a "follow-up" tutoring lesson, which was prepared especially for them by one of the staff scientists, and was aimed at elaborating the course lecture, and (3) a workshop coordinated by a researcher from the chemistry group of the science teaching department, in order to apply the scientific knowledge to the educational field. The study focuses on evaluating a three-stage model for meaningful learning of advanced chemistry by high-school teachers during their first-year program and its influence on teachers' CK and PCK.

Methods

Participants:

The program's participants consisted of 7 chemistry teachers from 7 different high schools in Israel. All had at least 10 years of high-school science teaching experience, mainly in grades 10–12. All of them had completed their chemistry undergraduate studies more than 10 years ago.

Course description:

Two courses were selected for trying out the three-stage model. In this paper we will describe in detail how the three-stage model was used in the course "Organic reactions used in the total synthesis of natural products". Nevertheless, data analysis and research findings will include the two courses.

Research Tools and Data Analysis:

The data that we were interested in referred to the main goal of the study, namely, determining whether the objectives of the three-stage model were attained. The data consisted of a pre-post knowledge test (examining the change in knowledge that the teacher underwent as a result of the course), interviews with teachers, and an analysis of the posters (which were part of the course assignment), minutes of the course meetings, a lecturers' survey. These instruments could be regarded as valid and reliable when administered and if the data were collected at times when a person's almost immediate response can be obtained. The analyses of the interviews, the survey, and the minutes were done according to basic methods of qualitative data analysis (Glaser & Strauss, 1967).

Results. Pre and post knowledge tests were administered before and after the course. The Wilcoxon Signed Rank test was applied to the overall difference between the average pre and post scores $p<0.05$. The results show that in the post-test the students achieved average scores that are very close to the full answer (maximum), when they were asked about (1) the concepts that were discussed during the course, and (2) the basic concepts in organic chemistry. Learning advanced concepts in organic chemistry (as shown in Figure 2) influenced the teachers' understanding of basic concepts related to the high-school curriculum in organic chemistry, even though they were outside the course's scope.

As previously mentioned, the posters were part of the course assignments: the teachers had to choose one of the lecture topics and to produce posters, which should help them in teaching the topic to their high-school students. Each poster included (1) a topic that was learned during the course, (2) a component that was connected to the student's everyday life, and (3) basic chemistry principles and concepts. The teachers presented their posters to their colleagues who participated in the program, and got their feedback before using them in class. The analyses of the posters showed that by mastering the subject matter knowledge and applying it to their requested assignment (the posters), the teachers developed also their pedagogy content knowledge.

In the lecture I will present the results of the teachers' interviews, the lecturers' survey, and the minutes of the course meetings

Conclusions. The three-stage model was designed to support the teachers in learning advanced scientific content and in making it part of their teaching repertoire, thus enhancing their pedagogical content knowledge (PCK). We can conclude that by and large these goals were achieved. However, according to the teachers, there are many challenges that should be taken into account. In our presentation, we will refer to the challenges as well as to the contribution of the three-stage model.

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How Greek students aged 17 years perceive the energy concept in various chemical phenomena

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Keywords: chemical education, energy, misconceptions, questionnaire

Energy is one of the most discussed and most researched concepts in science education, (Schmid, G.B., 1982, Solomon, J., 1983a, Watts, M.D., 1983, Duit, R., 1984, Driver, R. et al, 1985, Duit, R., 1987, Goldring, H. et al, 1994, Trumper, R., 1997, Ebenezer J.V. et al, 2001, Liu, X. et al, 2005, Papadouris, N. et al, 2008). This is mainly for two reasons. First, energy is one of most fundamental science concepts, which unify physics, chemistry and biology. Second, energy holds an important role in global and topical social and environmental issues. The purpose of the study is to explore the ways in which Greek students aged 17 years, account energy in various chemical phenomena.

A close-ended questionnaire was constructed, in order to illustrate students' conceptions about energy in various chemical phenomena. For the construction of the questionnaire, we followed the steps: (1) Curriculum analysis in order to find out what Greek students had taught about energy during the teaching of Chemistry and (2) Literature review in order to find out students misconceptions about energy and also the researchers' methods to explore this (Duit, R., 2009). Then we constructed a close-ended questionnaire, which, we administrated to 150 students aged 17 years. In this presentation we present the findings of the pilot study.

The questionnaire had a Cronbach's alpha of 0.81. The results of the chemistry items can summarize as below:

(1) Only 40% of the students' recognise that during wood combustion and fireworks explosion energy is released. The rest of them have various alternatives frameworks and think that during the combustion of the wood, energy is absorbed or/and created.

(2) Only 13.5% of the students recognise that the energy, which is released during the combustion of a match and the exploding combustion of natural gas, derives from the energy of the reactants. 13.7% think that the energy released from the exploding combustion of natural gas is a result of the explosion and 11.6% think that the energy released in the combustion of a match comes from the fire.

(3) More than half of the students think that during the combustion of a candle, of gasoline and of bio-fuel the mass of the fuel is converted to heat or/and energy.

(4) Although 50% of the students recognise that during the expansion of helium gas, the helium atoms move faster, only 25% recognise that the energy of the gas increases during this phenomenon.

(5) Almost none of the students recognise that breaking bonds needs energy.

The above findings show that Greek students which are in the final year of the secondary school face several difficulties and obstacles to recognise the energy aspects of a chemical phenomenon. A rearrangement and reorientation of the curriculum is of great need in order to improve the understanding of the energy concept in Greek schools.

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Acquiring And Assessing Structural Representations Of Students' Knowledge

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Keywords: Concept maps; World Association Test; Meaningful learning; Problem solving.

Background, framework and purpose. Human cognition organizes knowledge in different complexity levels: higher-level knowledge is formed by first acquiring simpler concepts, which are then used to learn complex ones. As a consequence, every tool that helps to represent and organize the knowledge can be potentially useful in the classroom with the purpose to assist our students and facilitate them in the task of acquiring new knowledge. One of the most popular and versatile of such tools are the concept maps, a method for representing knowledge graphically. (Novak & Gowin, 1984) Concept maps are directed graphs in which the nodes represent concepts and the labelled links represent the relations between the concepts. Concepts are arranged hierarchically and are linked with arrows pointing in explicit directions to convey meaning between concepts; the concepts are listed only once but there can be multiple links between the concepts. As results from many studies, concept maps have also been used as a way of assessing the structure and the organization of an individual's knowledge (Pendley et al., 1994; Ruiz-Primo & Shavelson, 1996; Stoddart et al. 2000; Taricani & Clariana, 2006; Cline et al., 2010). A number of authors have been critical about the quantitative approach. (White & Gunstone, 1992; Kinchin, 2001; Johnstone & Otis, 2006; Ritchhart et al., 2009). In addition, problems of consistency in scoring schemes, have been reported (Liu & Hinchey, 1996; Jonassen et al., 1997). Some students have difficulty with mapping, and interviews of students in later years show no evidence of the long term benefit (Santhanam et al., 1998). There are advantages and disadvantages in the use of concept maps, including the time-consuming process of drawing a good map (Jonassen et al., 1993): this explains why some students do not like them. Furthermore verbal abilities (O'Donnell et al., 2002) and spatial abilities (Hilbert & Renkl, 2008) play a role.

Methods. We began a study on the scoring of concept maps in university courses by analysing their validity and reliability. In a professional course at our University, we instructed students on how to draw a concept map. Out of the 109 students who passed the normal exam, 17 students drew one or more maps (one student drew 12 maps) giving a total of 42 maps, of different quality and number of concepts ranging from 8 to 240 (Cardellini & Monosi, 2006). The average score in the final exam was 26.2 for the students with concept maps and 25.4 for the others: but there is no direct evidence that this meagre improvement is due to the use of the maps. In another study we analized for assessment 80 maps (each drew from 4 to 12 maps) of the 10 best students and 81 maps (each drew from 2 to 28 maps) of the 10 weakest students. This classification is made according to the marks they got to the oral final exam. We counted the number of concepts, cross links, nouns and verbs, the formulas, the examples, the data, definitions, drawing and schemata, and the errors. Students' different attitudes, their learning styles, logical reasoning ability, and motivation were also considered. The claim that students using concept maps for their study and revision would perform better on their assessment tasks, than those who did not, is weakly supported (Cardellini & Monosi, 2008). In the present study under way we will report the correlation between the concepts, the propositions, the score on serious problem solving, a sure indicator of meaningful learning, and the score on conventional exam. Besides, the students' structural knowledge will be studied using the Word Association Test (Cardellini, 2008).

Results and conclusions. The correlations are in general quite low: for concepts the correlation is around .4 and some caution might be advised because some explanation of the propositions revealed a misconception. Furthermore, words on the concept maps and in the Word Association Test can be influenced by verbal association of words and not by real knowledge:

this is not so for all students, but certainly for some. It may result that maps should be treated as very personal learning tool analogous to a personal diary which could be difficult to understand by another reader.

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Chemistry Motivation and Gender: High School Students' Motivation to Learn Chemistry

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Keywords: Chemistry, motivation, high school students

1. Background, framework and purpose

Motivation is generally defined as the internal state that arouses, directs, and sustains human behavior (Brophy, 2004). There are some studies which reported there is gender difference on motivation to learn science at college level (Glynn, Taasoobshirazi, & Brickman, 2009; Britner, 2008) while not many which report whether there are gender differences at high school levels in chemistry. Chemistry Motivation Questionnaire (CMQ) was applied to high school students and investigates high school students' motivation to learn chemistry, why they want to learn chemistry, or how they feel about learning chemistry. Therefore, the purpose of this study was to investigate whether CMQ is a reliable and valid questionnaire in Turkish culture and high school students and whether there are any gender or class level differences in motivation to learn chemistry among high school students.

2. Methods

The sample of the study consisted of 1702 (826 girls and 869 boys, 7 missing) high school students enrolled in the ninth (927 students), tenth (430 students), and eleventh (345 students) grades of a chemistry course in two cities in Turkey. The CMQ which require about 15 minutes was administered to assess students' motivation to learn chemistry. The CMQ is adapted from the Science Motivation Questionnaire developed by Glynn and Koballa (2006) consisting of 30 items on a 5-point Likert-type scale, ranging from "never" to "always". The anxiety about chemistry assessment items are reverse coded, therefore, a higher score on this factor means less anxiety. Exploratory factor analysis with maximum likelihood estimation was used in order to analyze the items. The interpretation of factors were based on eigenvalues greater than 1 and the five factors were interpreted labeled as confidence learning chemistry, relevance of learning chemistry, self-determination for learning chemistry, anxiety about chemistry assessment, and intrinsically motivated chemistry learning. The total variance explained was 54.72%. The reliability coefficient estimated by Cronbach's alpha for each factor ranged from .75 to .84, which were acceptable. The total CMQ Cronbach' alpha coefficient was .90.

3. Results

The total mean was 95.76, which shows moderate level of motivation to learn chemistry in the range of from sometimes to often (scoring 90-119 out of 150, Table 1).

Table 1. CMQ total scores across gender and class levels

	9th class	10th class	11th class	Total
Female	95.53	100.11	96.07	96.82
Male	95.80	94.72	92.19	94.87
Total	95.67	97.23	94.02	95.76

The two-way ANOVA was run to test whether girls are more or less motivated than boys across class levels and found no significant interaction between gender and class levels, $F(2,1205) = 2.766, p > .05$.

Additionally, no significant main effects for gender, $F(1,1205) = 6.421, p > .05$, and class levels, $F(2,1205) = 1.968, p > .05$, were found. Although there were no significant differences in total CMQ scores due to gender and level, there were small and meaningful score differences on some factors. The two-way MANOVA was conducted to detect the effect of gender and class levels on five motivational factor scores.

No significant interaction was found among gender and class levels on the dependent measures, $Wilks'\lambda = .204, F(10, 2402) = 1.35, p > .05, partial\eta^2 = .006$.

However, significant main effects for gender, $F(5,1201) = 15.60, p < .01, partial\eta^2 = .061$, and class levels, $F(10, 2402) = 4.80, p < .01, partial\eta^2 = .020$, were found.

Follow-up tests to the MANOVA were conducted via ANOVA on each dependent variable. The self-determination mean score for the girls (M=26.31) was significantly different from the mean score of boys (M=24.12) and results illustrated that girls take more responsibility for learning chemistry, $F(1,1205) = 41.322, p < .01, partial\eta^2 = .034$. Additionally, the mean score for the eleventh grade students (M=24.05) was significantly different from the tenth graders (M=26.14) and ninth grades (M=25.48) on self-determination, $F(2,1205) = 13.026, p < .01, partial\eta^2 = .021$. The score on intrinsic motivation were higher among girls (M=17.78) than boys (M=16.86), although this difference is rather small but statistically significant, $F = (1,1205) = 7.745, p < .01, partial\eta^2 = .006$. Lastly, the scores on the anxiety were higher among girls (M=13.61) than boys (M=15.39) which illustrates that during chemistry exams boys are significantly less anxious than girls, $F = (1,1205) = 34.726, p < .01, partial\eta^2 = .028$

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4. Conclusions and implications

In the light of these results, the exploratory factor analysis results and reliability scores express that this questionnaire is a quite valid and reliable questionnaire to be used in Turkish culture. This study also illustrates high school girls are more interested and have more eager and more self-determination for learning chemistry while they are more anxious about chemistry assessments compared to boys. These results are consistent with the findings like Glynn, etal.(2009) reported female nonscience college majors scored higher science assessment anxiety and self-determination than male majors; and Britner (2008) found high school girls scored higher science anxiety in science classes such as life and physical sciences. This study contributes to the chemistry motivation literature about how high school students' motivation to learn chemistry is differentiated by gender and class level and indicates that there is a need for investigation more on how different learning situations in school affect the motivation to learn chemistry.

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The integration of environmental care, health and safety in Flemish higher education laboratories

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Keywords: environment, health and safety, laboratories, higher education

Since the start of the United Nations Decade of Education for Sustainable Development (UN DESD) in 2005, UNESCO (2005) is aiming at *'changing the approach to education so that it integrates the principles, values and practices of sustainable development'*. The general principles of Health, Safety and Environment (HSE) are among the aspects of sustainable development (SD) that deserve attention through formal education. Although these principles should be imparted to students of all educational levels (Calder and Clugston, 2005) – from kindergarten to higher education – this is often not the case. Nevertheless, different authors highlight the necessity of the incorporation in curricula of **pollution prevention and waste management** (e.g. Boon, 1997; EPA, 2006, Izzo, 2000; Mason et al., 2003; Parkhurst, 2000; Sales et al., 2006), or **health and safety issues** (e.g. Hill, 2007; Karapantsios et al., 2008; Nelson, 1999; Peńas et al., 2006; Perrin and Laurent, 2008; Senkbeil, 2004). For example, Sales et al. (2006) stress – specifically for the treatment of hazardous wastes in chemistry laboratories – that education and training programmes are primordial for achieving a thorough management of environmental issues.

In Flanders, the northern part of Belgium, laboratory lessons are part of various courses and degrees in higher education, such as in exact sciences (e.g. chemistry, biology), engineering (electronic engineering, car mechanics…) and medical sciences (e.g. physician or nursing) (Cappuyns & Ceulemans, 2008). The current situation of HSE-integration in Flemish higher education laboratories was assessed in 2008 through a study executed by the authors of this paper. Literature review, screening and analysis of all relevant Flemish higher education study programmes and course overviews (provided by the European Credit Transfer and Accumulation System (ECTS) files) and qualitative semi-structured interviewing of a sample of university stakeholders provided an overview of the current state of HSE integration in Flemish higher education laboratories, as well as some recommendations and examples of approaches to introduce or enhance HSE issues in higher education laboratory classes. The importance of student's attitudes towards HSE was also highlighted.

Since chemistry laboratory classes form a distinct part of the Flemish educational laboratories studied, the results can be valuable for enhancing HSE integration specifically in chemistry laboratories. Moreover, the results and recommendations can be applicable for higher education institutions in other countries urging to strengthen their efforts towards HSE integration in educational (chemistry) laboratories.

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A Hands-on Experiment based Professional Training Program on Fundamental Nanoscience and Nanotechnology for Thai High School Science Teachers

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keywords: high school science teachers, nanoscience and nanotechnology, conceptual understandings, hands-on experiment based professional training program

As an emergence of cutting edge nanotechnology, there is a call for nanotechnology education at all level across the world, including Thailand. Preparing high school science teachers for teaching such concepts is one of key movement in the early step of nanotechnology education at high school level. As thus, the Hands-on Experiment based Professional Training Program (HoEPTP) was designed and developed by the group of experts at the National Nanotechnology Center of Thailand (NANOTEC). The training program was set into a two-day training program. In the didactic session, set for the day 1, the 110 participating high school science teachers from the Northeastern area of Thailand were given lecture on the key fundamental concepts of size and scale of nanometer, meanings of nanoscience and nanotechnology, fundamental scientific principles at nano-scale, nanofabrication, nano tools and instrumentations, etc.. While the day 2 of the training, set as practical parts, the participating teachers performed the four designed hands-on experiments consisting of 1) the testing of lotus effect, 2) the making of water repelling clothes, 3) a simple synthesis of nano gold and 4) a simple synthesis of nano silver. To examine the impact of the training program, the conceptual understandings test, developed by the experts from the NANOTEC, was used before and after the training session. The uses of questionnaire with all the participants were also used to determine the participating teachers' opinion toward the training program. To get in-depth findings, an unstructured interview with three selected participating teachers was also used. Results indicated that the participating high school science teachers' conceptual understandings post-test score was significantly higher than the pre-test score at 0.05 level. Moreover, the teachers' opinion score toward the training program after training session was also significantly high. As a result, the findings suggested that the Hands-on Experiments based Professional Training Program has positive impacts on Thai high school science teachers in terms of enhancing their conceptual understandings and also their opinion toward the training program.

Molecular Visualization Educational Software for Learning and Teaching Molecular Symmetry: From Learning Objects to Online Course Material

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Keywords: molecular visualization, educational software, molecular symmetry

Over the past decades, development of molecular visualization software has changed the nature of chemistry research and created promising prospects for incorporation in chemistry education. Educational chemistry software should conform to research findings and guidelines from multiple disciplines such as chemistry and chemistry learning, cognitive science and pedagogy, technology and software development. In this paper we present the design, development and application of molecular visualization educational software for learning and teaching molecular symmetry.

Molecular symmetry is a demanding chemistry subject from a learning perspective. It challenges learners to construct and manipulate 3D mental representations of molecular structures by the observation of 2D symbolic representations. Traditional instructional media do not provide adequate surface features to help students visualize the dynamic nature of molecular symmetry concepts. Textbooks can provide only a limited number of examples. Moreover, many cases can not be depicted with 2D symbols and conventional media do not give the opportunity to practice and actively explore these dynamic concepts.

Our educational tools comply with four design principles for chemistry learning software [Wu and Shah, 2004, Antonoglou *et al*., 2008]: a) provide multiple representations of molecules; b) promote transformation between 2D and 3D representations; c) provide unique representations with dynamic surface features that support visuospatial thinking; d) provide extensive practice with chemical concepts which are not available with traditional media.

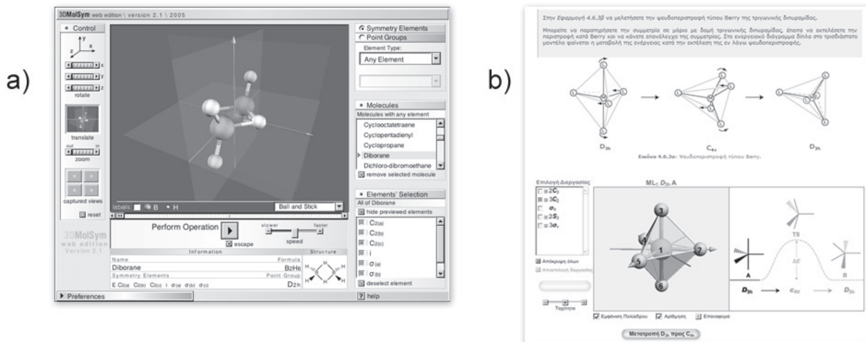

Figure 1. a) Screenshot of 3DMolSym, b) Detail from Online Course Material webpage.

From a cognitive approach to learning, our software can be used as presentational tool during oral instruction. It can provide a synergistic learning effect by supporting the active processing of both visual and audio inputs in working memory, enhancing learner's ability to connect multiple concepts that are represented in molecular visualizations [Ealy, 2004]. From a constructivist perspective our tools are designed as open-ended learning environments. They support active and discovery learning, enabling the learners to have individualized and extensive practice with the represented chemical concepts.

Our software was developed with Adobe Director authoring environment which allows web delivered real-time native 3D graphics, utilizing Shockwave player. It was designed with an object oriented programming approach, allowing straightforward development of multiple modules that correspond to different scenarios. Our technology was implemented as an open access single learning object, named 3DMolSym, and as a series of learning objects adjusted to specific educational scenarios and embedded in online course material.

3DMolSym operates as a searchable database of structural and symmetry data, regarding 50 molecules spread to all symmetry point groups of chemical interest. The user can select molecules having a particular symmetry element, or belonging to a particular point group. The essential tasks that the user can perform are: a) display and freely manipulate the molecular model to any viewpoint; b) display any combination or class of symmetry elements; c) select a symmetry element and actively perform the corresponding operation. 3DMolSym if freely available over the internet [Charistos and Sigalas, 2005] and has been proposed and utilized as a learning resource from more than 30 universities all over the world during the last semester of 2009.

The online course material encompasses eighty molecular visualization applets. It covers the topics of symmetry elements and operations, point groups, geometry and symmetry of platonic solids, symmetry and transformations of complex compounds. Each webpage simultaneously presents verbal descriptions, 2D symbolic representations and 3D interactive molecular visualizations. The online course material was incorporated in a hybrid course of molecular symmetry at our department, combining traditional face-to-face teaching with effective pedagogical use of learning technologies.

An evaluation of students' attitudes towards 3D molecular visualization applets were retrieved from questionnaires and course management system statistics. It showed that learning activities with molecular visualization applets were the most visited resources of the course. Students could readily manipulate 3D molecular models and could easily find how to interact with the tools and how to conduct symmetry operations. The majority of the students stated that integrated graphics and 3D molecular visualization applets enhanced their understanding of molecular symmetry concepts. They also stated that exercise and practice with molecular visualization applets were very helpful and improved their abilities to mentally transform 2D to 3D representations. On the other hand half of them encountered extensive downloading times in cases of webpages that contained multiple visualization applets.

Future research concerns the development and distribution of new learning objects, improvement of website performance and assessment of the effectiveness of molecular visualizations in chemistry learning.

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Does the Irish education system produce pupils who can think? A look at the cognitive development of Irish pupils/students and its implications for the teaching and learning of Chemistry

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Keywords: chemical education, second level education, third level education, cognitive level, gender, education, mathematical ability

Background, framework and purpose. Chemistry represents one of the most abstract and symbolic of disciplines and its study therefore places high cognitive demands on learners (Johnstone, 1991). This paper presents the findings of a study carried out on Irish second and third level pupils/students, which assessed their cognitive development. This investigation follows a previous investigation into the main topics of difficulty for Irish Chemistry pupils and students. (Childs and Sheehan, 2009). Chemistry by its nature is abstract and requires formal operational thought. It is a subject that contains many higher order chemical and mathematical concepts. However, one must wonder how many of our pupils have reached this stage of cognitive development. It has been noted, over the last number of years, that Irish pupils' participation and performance in Mathematics and Science is deteriorating. Low participation levels in higher level Mathematics have serious consequences for the development of Irelands' 'knowledge based economy' as it means that only a small number of pupils are eligible for Science, Technology and related courses at third level, which require a C3 grade minimum in higher level Mathematics. These statistics pose the question 'Is second level Science/Chemistry and Mathematics education in Ireland producing pupils/students who can contribute to the knowledge based economy?'

The research questions to be answered in this paper are as follows:

1. What are the cognitive levels of Irish pupils/students at Junior Certificate, Leaving Certificate and first year University levels?
2. Is there a link between cognitive level and Mathematical and Chemistry ability?
3. Is there a link between cognitive level and gender?
4. Is there a link between cognitive level and age?
5. Is there a link between cognitive level and the courses chosen by pupils at third level?
6. Is there a link between cognitive level and the number and types of chemical misconceptions held by pupils/students?

Methodology. A modified version of the Science Reasoning Task (SRT), Equilibrium in the Balance, developed by Shayer and Wylam (1978) in the UK was used to determine the cognitive ability on a sample of second and third level pupils and students. This test can be used at all three levels as it is content independent. It was modified for ease of distribution to Irish second level schools. The original involved a demonstration by the teacher before the pupils completed the test. The test we used substituted this demonstration with a number of practice questions, to which the answers were given. Twenty Irish second level schools took part in this investigation and a total of 297 Junior Certificate Science pupils and 221 Leaving Certificate Chemistry pupils completed the modified SRT. 336 first year University students and 67 first year Institute of Technology students also completed the same task. Responses were analysed using the software package SPSS 16.0. Chi- squared and Phi and Cramer's V significance tests were also carried out.

Results and Conclusion. From this investigation it has been shown that the majority of Irish pupils/students are operating at the concrete operational stage of cognitive development at all levels of the education system. Figure 1 shows the cognitive development of Irish pupils from Junior Certificate level to third level.

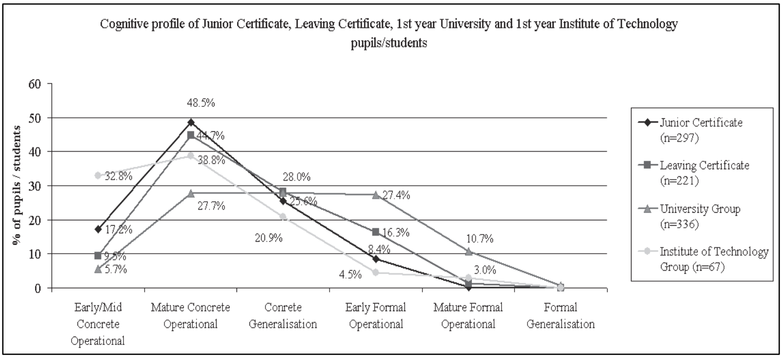

Figure One: Cognitive profile of Junior and Leaving Certificate pupils and First year University and Institute of Technology students

Analysis of results from the Junior and Leaving Certificate cohorts shows that only 8.4% of

the Junior Certificate and 17.7% of Leaving Certificate pupils are operating at the formal operational level, thus a large majority are still operating at the concrete level. The same is true at third level with 38.7% first year University students operating at the formal operational stage of cognitive development. There is a clear increase in the number of pupils/students operating at the formal operational stage of cognitive level as they progress through the educational levels.

Significant links between cognitive level and the pupils/students Mathematical ability were also seen. More pupils/students who studied higher level Mathematics courses for the state examinations were operating at the formal operational stage of cognitive development.

At Junior Certificate level, more female pupils operate at a higher level of cognitive development than male pupils. This has evened out by Leaving Certificate level, where there is no significant relationship between gender and cognitive development. This could be explained by the different physical and mental development of males and females, which has evened out by age 17/18 years. From this investigation it has been shown that there is also a link between age and cognitive development. There are a higher number of pupils/students operating at the formal operational stage of cognitive development at the higher age groups in this investigation, except for the mature students in the oldest age groups. At University level it was shown that more students in engineering courses, compared to Science and Education courses, have reached the formal operational stage of cognitive development. This could be linked with the high mathematical content in engineering courses and verifies the previous link between mathematical ability and cognitive development.

These results highlight that the majority of pupils/students at all levels studied in the Irish education system are operating at the concrete level, even at third level. Currently teaching strategies and the content of courses is not taking this into account. Our findings have major implications for the teaching and learning of Science in Ireland.

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Problem-Based Learning in Science Education in the Light of the Czech Curricular Reform

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The basic concept of Chemistry education at basic and secondary schools in the Czech Republic is currently changed by the realization of the frame (Framework Educational Programme for Basic and Secondary Education) and school educational programs. Chemistry is one of the subjects in the integrated area "Man and Nature". The "Man and Nature" includes problems connected with nature researching. General objectives in the „Man and Nature" aim at gaining key competences and learning pupils how to use empirical methods of cognition (observation, measurement, experiment, rational thinking) in researching facts and connections in nature; ask questions on causes and development of processes in nature and find correct answers to them, think to verify hypotheses in several independent ways; evaluate importance, reliability and correctness of data to verify hypotheses or not; join activities aiming at being friendly to nature systems, their own and other people's health, understand relations between man and nature; act and prefer effective use of energy and its renewable sources, especially sunshine, water and biomass; behave in life, property and nature threatening situations [1]. The Framework Educational Programme calls for a shift from the traditional transmissive strategies for teaching to the cognitive constructivism. According to constructivism pupils build symbolic representations of knowledge and mental concepts. Learning is not seen as simply adding new representations to prior knowledge and beliefs but as reorganising old knowledge in order to integrate new elements and, subsequently, by constructing new cognitive structures and storing them in memory. Teaching for transfer demands a shift from teacher-centred to learner-centred teaching methods. *The role of the teacher is to facilitate learning by guiding pupils in their efforts to apply knowledge and skills to novel situations so that they become competent individuals* [2]. The curricular reform is an important change which calls for specific readiness on the part of teachers and for specific conditions for the change to be accepted and realized. The teachers may become the risk factor unless they are fully identified, as personalities and as specialists with the profession autonomy.

The pupil shall therefore have the highest number of opportunities possible to master progressively the empirical as well as theoretical methods of natural-science research selected, utilize them in the instruction along with the information on natural sciences, realize the importance of both for scientific knowledge, and particularly for its objectivity and veracity as well as for solving the problems which Man encounters when examining nature [3].

In everyday life and professional workplaces, people expend their greatest intellectual effort solving problems. A problem is sometimes defined as a situation where at present the answer or goal is not known. For the problems normally encountered in educational situations, the way to that goal is not known initially [4]. Problem solving refers to the capacity to analyze problems, plan solutions, take decisions and evaluate the outcome. The Problem-based learning (PBL) is an instructional method in which students learn through solving problems and reflecting on their experiences [5]. The Problem-based learning model turns the student from passive information recipient to active, free self learner and problem solver, and it slides the emphasis of educational programs from teaching to learning.

The characteristics of the learning scenario that constitutes the basic education tool in PBL are as follows [6]: problems must be chosen from among the problems which are the most fitting to the real world; problem must be open-ended; it must arouse sense of curiosity; it must focus on only one issue; it must teach good and ethical behaviors rather than negative events and behaviors; it must help students to reflect on freely and express themselves; by making suitable personifications, students must be given the opportunity to treat the problem as if it were their problem and to be willing in solving it.

PBL is not only cooperative, but also teaches students skills like creativity, open-ended problem solving, motivation, seeing the problem in context, learning how to learn and disciplinary knowledge bases, higher-order thinking, authenticity and transferable skills such as communication and group work [7]. The method is hence one of the acceptable means for realization of the new curricular reform in Chemistry education in the Czech Republic.

The research findings point not only to better adoption of pupils´ knowledges and skills during the Problem-based learning realization in Chemistry education compared to the traditional teaching [8], but also point to more positive pupils´ relation to the subject [9]. What about teachers? In 2008 a research project was realized among the science teachers. Its aim was to find the state of the Problem-based learning use in Science subjects (Physics, Chemistry, Biology). From the conclusions follows [10]:

- the teachers use the Problem-based learning in Science education above all in application phase to understand the connections between the subjects matter and pupils´ everyday life;
- the teachers describe the problems with realization of the method because of the insufficient pregradual preparation at the universities;
- the absence of teaching materials for the realization;
- most of the teachers do not think that the curricular reform will contribute.

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Hands-on approach to visible spectrometry – a motivation study among students of German upper secondary schools

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Keywords: didactics of chemistry, motivation study, transfer of innovation

Background. A series of research outcomes have proven that autonomous academic motivation is positively associated with academic achievements [1-4], and could be stimulated by the autonomy-supportive style of teaching, related to a relaxing classroom atmosphere, which, according to neuropsychological research studies, is crucial for effective learning to occur [5-9]. The hands-on approach to learning science is one of the autonomy-supportive styles of teaching, which offers students direct contact with materials and instruments, thus increasing motivation for learning and contributing to better understanding of the concepts [10]. Several years ago, a simple, low-cost, small-scale spectrometer Spektra™ had been developed for the purpose of hands-on learning of analytical chemistry in vocational schools [11]. The spectrometer uses three color light-emitting diodes as a source of light and photo resistors as detectors. A number of analytical procedures had been developed for this instrument as a part of the Leonardo da Vinci project "Hands-on approach to analytical chemistry for vocational schools" [12]. They proved to be very helpful in teaching basic concepts of visible spectrometry [13] and chromatography [14].

Purpose, methods and results. The present study is a part of the Leonardo da Vinci project "Hands-on approach to analytical chemistry for vocational schools II" [15]. The purpose of this part of the study was to investigate: (a) how different types of motivation proposed by Self-Determination Theory (SDT) could be clustered into distinct motivational profiles of students[16], (b) how clusters' membership correlates with the students' attitudes toward the studied modules from the "Hands-on approach to visible spectrometry", and (c) how clusters' membership correlates with students' attitudes towards specific chemistry teaching methods and topics.

As the instrument, a 50-item questionnaire for assessment of students' motivation was designed on the basis of two questionnaires used in previous research [17,18] with the theoretical background from educational psychology research on motivation and self-concept. [19,20]. Specifically, the instrument was designed to evaluate (1) different components of students' motivation for learning chemistry (i.e., controlled motivation based on extrinsic motivational stimuli, regulated motivation based on internalized and integrated motivational stimuli, intrinsic motivation, and academic self-concept), (2) to identify students' attitudes toward different components of studied modules, and (3) to identify students' preferences for different learning methods usually applied in chemistry classrooms. The questionnaire was complemented with two additional open-ended questions on students' preferences toward different chemistry contents.

Fifteen students (4 female, 11 male, ages 16 – 18 years) took part in the study from German upper secondary schools, visiting the University of Gdańsk during their summer training. They took part in a workshop on basic concepts of light, color, light absorption and spectrometric determination of analyte concentration. First, students attended a lecture on the basic concepts of color perception, light absorption and the Lambert-Beer law (1 hour, the lecture was illustrated with the PowerPoint presentation). Next, they ran 7 experimental modules developed in the previous phase of the project [12]. Students were divided into four groups, provided with the instructions for modules in the form of a workbook, and worked in groups of 4 – 5 students. The number of groups was determined by the number of Spektra™ spectrometers available. After four hours, when all modules were completed, a questionnaire on "Motivation for learning chemistry" was administered; students were asked to respond to simple declarative sentences on a 5-point Likert scale ranging from 1 - not at all true to 5 - very true for me.

Analyses of the results revealed that students who took part in the study could be classified into a good quality motivation group [16] due to the high autonomous motivation (regulated motivation 3.8-points average, and intrinsic motivation 3.4-points average), and a controlled motivation group below average 2.9-points. Their good quality motivation profile is reflected in their preferences towards a more autonomous style of teaching (e.g. group work, hands-on experimental work and combination of group work with experimental approach). Regarding their attitudes towards the modules of the "Hands-on approach to visible spectrometry", they estimated the highest that learning was based on doing, and with a relaxing yet working atmosphere prevailing during the experimental work (4.27-points and 4.15-points respectively). They found the modules challenging because they finally understood the correlation between the color of matter and absorption of light (3.73 –points), and the usage of spectrometry in determining the concentration of substances (3.69-points). They found experiments with Spectra™ interesting because handling the instrument and reagent bottles with a dropper was simple (3.84-points) and all experiments were safe from the view point of personal health and environmental impacts (3.90-points). Among chemistry topics, general chemistry, ecology and organic chemistry were indicated as the most interesting and useful. Students liked them, because they seemed to them attractive, important for everyday life and because they had had the opportunity in the past to run some experiments and to come to interesting conclusions. Stoichiometry and physical chemistry were pointed out as the least likeable, boring and useless in everyday life.

Conclusions. The results of the study indicate that students with high autonomous motivation value the autonomy-supportive teaching style as offered by the hands-on approach to visual spectrometry modules. Their personal interest in the subject taught, their above average autonomous motivation and self-concept, as well as the alleged practical usefulness of a particular science are important factors that determine their preferences in learning science - chemistry. The hands-on approach inspires students' interest in science, promotes intellectual development, encourages experimenting, and enhances self-confidence. These results are similar to those obtained in evaluation studies run in Slovenian schools [13] and indicate that even very simple, low-cost instruments, such as the Spektra™ spectrometer, could be successfully used in gaining knowledge through the hands-on approach.

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Acknowledgement

This contribution was supported by LLP-LDV-TOI-2008-SI-15.

Origami in Chemistry – Turning over a new leaf in lecture participation?

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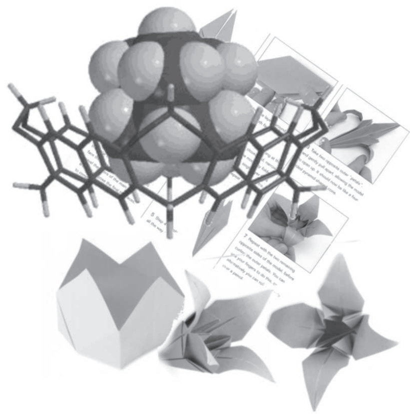
While Origami has been extensively employed for the teaching of mathematics, its exploitation within chemistry has been largely overlooked. This is certainly a wasted opportunity as it can be perceived as both enjoyable and sufficiently challenging to a range of pupils of varying abilities. Its relevance to chemistry relates precision with which macromolecular systems are constructed in nature where folding and molecular shape can be vital for maintaining activity. Many of the concepts in Origami have clear parallels with molecular engineering but allow an easy, inexpensive, and creative route through which pupils can directly visualise structure-function relationships. Moreover, the "puzzle" nature inherent to the assembly of some designs provides the pupils with a challenge format that is particularly amenable as a lecture based activity that can be used to engage and reinforce key concepts across the various teaching divisions. These can be organised with minimal effort within the conventional talk and chalk lecture/tutorials and provides the students with tangible models that can be kept for future recollection / revision purposes and contrasts the more traditional ball and stick modelling systems.



The workshop highlights the accessible nature of Origami and the ease with which it can be integrated as a multilevel resource within secondary and tertiary curricula. The session will comprise hands-on activities aimed at providing the participants with the background and skills necessary to adapt core models and puzzles to suit their own subject area. The activities are supported by key examples and contextual material to emphasize how cross disciplinary interactions between biology, chemistry and physics gives rise to advances in technology that provide new molecular systems that have a direct impact on daily life. No previous experience of origami is required as the demonstrators will guide the audience from the basics to the completion of more elaborate designs.

Slovenian Chemistry Textbooks explanations of triple nature of chemical concepts

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Keywords: content analysis, chemistry textbooks, macroscopic, submicroscopic, symbolic level of concepts presentation

Background, framework and purpose. Students' misconceptions can have different sources (e.g. inadequate teaching, students' low attention during educational process, students' superficial learning of the learning material, poorly prepared textbooks …). Because textbooks are one of the primary sources from which students obtain knowledge, the inadequate and inconsistent scientific knowledge presented in science textbooks will negatively affect students' ideas (Irez, 2009). Many teachers also rely on the textbook in deciding what and how to teach, especially when they are teaching outside their area of expertise (Stern & Roseman, 2004). Teachers, as facilitators of learning, should be aware of the problems and limitations of the text book their students are using (Haggarty & Pepin, 2002). According to the cognitive theory of multimedia learning (Mayer, 1997) the learner engages in three important cognitive processes: (a) incoming verbal and visual information to yield a text and image base for learning; (b) creating a verbally-based and visually-based model of the to-be-explained system; (c) integrating the verbally-based model and the visually-based model in the learners' mind. This theory suggests that it is better to present an explanation in words and pictures together than solely in words and should be take into account by the textbooks authors. Considerable attention has been devoted to the effect of visual learning on the acquisition of knowledge and the understanding of relationships and processes in science education (Mandl & Levin, 1989). Mayer (1993) found that 55% of the printed space was accounted for by illustrations. Cook (2008) suggested that because illustrations are a large part of science textbooks, more attention must be focused on understanding the impact visual images have on students and their learning. Research also shows (Dimopoulos et al., 2003), that images contribute to the higher level of meaning of the text.

The purpose of this paper is analyze selected chemistry textbooks in the light of possible misconceptions that can be induced during students' learning process using text and pictorial elements presenting triple (i.e. macroscopic, submicroscopic and symbolic) level of chemical concepts in Slovenian chemistry textbook. The main research question is: "What are the characteristics of the textual and pictorial material in the chemistry textbooks that represents triple nature of chemical concepts?"

Method. Slovenia has a rather centralized educational system, because there is a national curriculum that all teachers should implement in their classrooms. In this study we focused only on the textbooks used by teachers to teach chemistry in primary school (grade 8 and 9; students' age 13 and 14, respectively). Textbooks were published by five different publishers. Mixed (qualitative and quantitative) methodology was used to analyze the textbooks. Triple nature of presenting complex chemical concepts was selected to be analyzed. Content analysis (by three independent researchers) of the pictorial and textual material was performed by identifying key concepts and connections between them according to the national curriculum recommendations and some general textbooks' information were also identified.

Results. In all analyzed textbooks, the authors stress the narrative role of the text, stimulate discourse between the students and the teacher, and between the students themselves, and also stimulate observations of the phenomena. They also anticipate students' experimentation, and emphasize problem solving. Submicroscopic level was used in all textbook but their frequency was different. Usually the authors represent the triple nature of concepts separately and rarely combine all three levels in on picture. Pictorial material supported by the textual information shows some characteristics that can influence on students' misconception about submicroscopic nature of mater. The content analysis of the selected textbooks on the other hand shows that the textbooks retain the content directed by the national curriculum.

Conclusions and implications. It can be concluded that, in general, the analyzed textbooks meet the guidelines suggested by the national curriculum. By answering the main research question it can be summarized that text and pictorial material in the analyzed educational materials tries to stimulate phenomena observation, it explanations on particulate level, and using symbolic chemical language. Analyses also revealed that the chemical phenomena are most frequently illustrated by realistic images at macroscopic level. The submicroscopic level is used less frequently but the most authors try to present the chemical phenomena directly by symbolic level. According to these conclusions teachers should emphasize the concoctions between the three levels of chemical concepts using their own educational material. It can be suggested that authors should put more effort into developing such supporting pictorial material to the text, that students would develop adequate mental models about triple nature of chemical concepts. Further research ought to clarify the situation in Slovenian textbooks from the several points of view, such as: students' prior knowledge, opportunities for students' self-evaluation of their in-depth understanding of science concepts, teachers' guides and CD media support …

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Multicomponent Reactions As Green Organic Chemistry Teaching Tools

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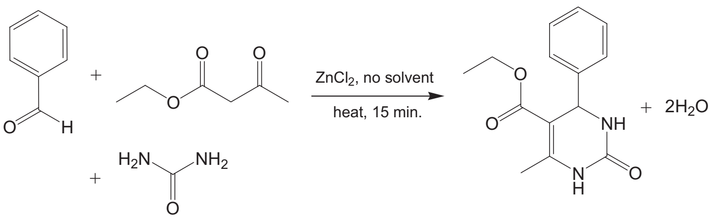
Keywords: Laboratory Instruction; Organic Chemistry; Catalysis; Green Chemistry; Microscale Lab.

Background, Framework and Purpose. The concept of "Green Chemistry" has existed for nearly two decades yet laboratory experiments highlighting green chemical principles are still just developing – particularly ones facilitating comparison between older and modern technologies. Biginelli and Hantzsch syntheses which both involve heterocycle preparation are discussed here as vehicles to examine how improvements can be made in the environmental profile of organic reactions. There is currently much interest in performing organic reactions under solventless conditions (1). Eradicating a reaction solvent directly addresses one of the Twelve Principles of Green Chemistry ("avoid using solvents, separation agents, or other auxiliary chemicals") (2). This presentation summarizes how mid-level undergraduates can simultaneously undertake "traditional" and "modern" (solvent-free) versions of a Biginelli reaction, within the same three-hour laboratory session. This promotes a didactic comparison between old and new synthetic methods with respect to catalysis, atom economies and energy consumption. The approach can be extended to Hantzsch preparation of 1,4-dihydropyridines.

Methods. A Biginelli synthesis is an established route to 3,4-dihydropyrimidin-2(1*H*)-ones (*3*). The reaction traditionally requires long, vigorous heating of urea, a 3-ketoester, an aldehyde and catalytic HCl in ethanol. A solvent-free Biginelli synthesis would potentially lessen the reaction time, significantly reduce energy requirements and improve its "greenness". Students adopt a recent literature report *(4)* using $ZnCl_2$ as a cheap and abundant Lewis acid catalyst for 3,4-dihydropyrimidin-2(1*H*)-one synthesis (Scheme 1). Zinc (II) chloride facilitates microscale solventless product preparation from benzaldehyde, ethyl acetoacetate and urea in 15 minutes (undertaken by a student individually during the heating component of the traditional method). The Biginelli product is generated by both approaches without need for further purification by recrystallization or chromatography and is identified by melting point, IR and NMR spectroscopy.



Scheme 1. A Greener, Modern Biginelli Synthesis

Results. Students synthesize the Biginelli product under traditional reflux conditions in reasonable yield (35 – 90%, average 62%). This is matched by results under solventless conditions (40 – 93%, average 65%). Products are of comparable purity, as evidenced by melting points, spectroscopic measurements and literature comparisons. These results afford several "take-home" green lessons. Performing the Biginelli reaction without solvent not only eradicates an unnecessary substance, but also confers a rate enhancement with concomitant reduced energy requirements. Calculations show this multicomponent reaction to be theoretically almost 88%

atom-efficient with water the only (benign!) by-product. But, considering compound masses rather than molecular weights exposes the traditional synthesis as only 71.5% atom-efficient whereas the solventless approach is 80% atom-efficient. The traditional synthesis has a green chemistry feature equally apparent in the modern approach (environmentally friendly solvents (water and ethanol) are employed in product purification). The Green Principle "use catalysts, not stoichiometric reagents" *(2)* is underscored, however neither catalyst (HCl or $ZnCl_2$) is recyclable, which provides occasion to reinforce that improvements are always possible in the field of green chemistry.

Conclusions and Implications. Comparison between old and new variations of the Biginelli reaction allows student discussion of and reflection about several green chemistry principles (*5*). Solventless synthesis of a 3,4-dihydropyrimidin-2(1*H*)-one occurs on heating benzaldehyde, ethyl acetoacetate and urea in the presence of zinc(II) chloride for a short time period. Organic chemistry undergraduates appreciate green chemistry in the context of recent research findings and are able to relate this reactivity to synthesis of medicinally important compounds.

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Analysis of verbal interactions in an Inquiry-Oriented Chemistry Laboratory in Arab and Jewish High-Schools in Israel

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Keywords inquiry learning · chemistry laboratory · ethnical aspects in science education

A major effort in science education reform has been the implementation of inquiry strategies into K-12 classrooms and laboratories. Inquiry has been the focus of curriculum projects in the USA and the UK since the 1960s and was incorporated into the BSCS (Biological Sciences Curriculum Study), Science Curriculum Improvement Study (SCIS), Elementary Science Study (ESS), Intermediate Curriculum Science Study (ISCS), and Physical Science Study Committee (PSSC) instructional materials (NRC, 2000). Since then, the National Science Education Standards (NSES) has included inquiry as both a learning and a teaching expectation for K-12 instruction (NRC, 1996), as well as a second publication, the Inquiry and the National Science Education Standards supplement (NRC, 2000). By the time students complete high school they should, in accord with NSES expectations, design and conduct several inquiry investigations in their science courses.

Development of Inquiry-oriented Chemistry Experiments in Israel More than 120 inquiry-type experiments in chemistry were developed and implemented in 11th and 12th grade chemistry classes in Israel in both Arab and Jewish sectors. All the experiments are part of the conceptual development of the chemistry key concepts (e.g., acids-bases, oxidation-reduction, bonding, and energy). The inquiry laboratory conducted in two phases: a) the *pre-inquiry phase* in which the students perform a pre-defined introductory experiment then they ask a relevant questions that they want to investigate, put appropriate hypothesis and design an experiment. And b) the *inquiry phase*, usually a week later, in which they perform the planned experiment, get the results, interpret them, and arriving to conclusions (Hofstein et al. 2004).

Ethnical Aspects in Science Education Research Several researchers have stressed the need to integrate social group variables such as race, class, and gender into educational research. The integration of these variables has been carried out in several national and international studies (Hall et al. 2000). Here in Israel, The Jewish and the Arab populations represent two ethnic groups with little inter-group contact (Kraus 1988). The Arab culture is more traditional and conservative, and uses great social control to safeguard its values, while the majority Jewish culture is achievement-oriented, individualistic, and 'Western' (Yaar et al. 2001). We can conclude from this that the educational system in Arab society is tend to be more teacher-centered, while in the Jewish society is tend to be more student-centered.

Rationale for the Study. The rationale underlying this study is based on the premise that the two student populations, namely, those in the Arab and Jewish educational system, will differ regarding the way that the inquiry laboratory is running according to it. The developers of this program envisioned that the inquiry laboratories in chemistry would foster student-centered learning according to the activities that each student had to perform, however, the education in Arab schools is generally teacher-centered as mentioned previously, this issue could affect the program developers' objectives. Therefore, in this research we want to determine whether our research hypothesis is correct and to insert any appropriate modifications accordingly.

Research Methods. This research is part of a comprehensive study. The research population consisted of 12th grade high-school students (ages 17-18) from both Arab and Jewish sectors in Israel. According to the research presented here, the research methods consisted of observations during the two inquiry phases of the teacher and one representative student team of two classes from each sector and interviews with the teachers and students after completing the laboratory phases.

Table 1 Statistical Comparison between observations in Arab and Jewish classes

	Teacher observation		Student team observation	
	$\chi2$	p	$\chi2$	p
Pre-inquiry phase	9.07	0.0108	9.84	0.0073
Inquiry phase	3.59		3.37	

Results. We analyzed the observations in accordance with the analysis of the previous data of the whole research. Namely, we analyzed the observations according to four scales: a) *teacher supportiveness* to the student during the laboratory work, b) *student involvement* in the laboratory work, c) *student cohesiveness* within the student team and d) *Rule clarity* which measure the government of student's behavior by formal rules.

We found that the verbal interactions between the teacher and the student teams were longer in the Arab sector that the Jewish sector and we found also that the Arab teacher and Arab student teams are significantly different from their Jewish counterparts in the pre-inquiry phase while they were significantly similar during the inquiry phase (see table 1). The Arab students were less individual and more dependent on their teacher than the Jewish students and the Arab teachers were more support to their students than the Jewish teachers during the pre-inquiry phase.

From the interviews we learned that the Arab teachers thought that the students need a continuous support during the laboratory work, whereas the Jewish teachers thought that the student must work individually. Moreover, the Arab students thought that they must get support from the teachers and they cannot do that work without that support, whereas the Jewish student thought that they can work in the laboratory even if their teacher is not there.

Conclusions and Implications. According to the results that we get in the current research, we can conclude that there were a significant differences between the two populations that we studied during work in an inquiry-oriented laboratory in chemistry. These differences were due to cultural issues as presented before. Tamir et al. (1993) had also found differences between Arab and Jewish classroom learning environment. They found, for example, higher level of formality that exists in the Arab schools in comparison to their Jewish counterparts. According to the results that we get, we think that there is a need for special *professional development* courses for Arab teachers who taught the inquiry laboratory in chemistry to peruse them to modify their teaching methods.

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Domain specific expertise development of experienced chemistry teachers teaching context-based chemistry education about macro-micro thinking in structure-property relations

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Keywords: Teachers' professional development, Curriculum innovation, Domain specific expertise, Context-based chemistry education.

Redesigning science curricula in terms of context-based programmes (Driessen & Meinema 2003), implies new domain specific content, new sequencing of content and an new teacher's role towards the students, that is not part of the teachers' regular expertise. To implement such a curriculum innovation successfully, an adequate professional development is necessary (Van den Akker 1999). A professional development programme was designed to help experienced chemistry teachers to develop this new domain specific expertise. To determine that the programme facilitated the acquisition of new expertise, the development needed to be captured and described.

Expertise is defined as the ability to perform successfully in a specific domain of practice (Ericsson, et al. 2006). Expertise involves a knowledge component (repertoire), practical component, meta-component (problem solving processes), learning component and an affective component (Sternberg 1999). This research aimed to describe the development of the components of expertise and how the development of these components is related when teachers participate in the professionalization programme.

Within a new context-based chemistry curriculum, innovative units were designed (Meijer, et al. 2009). In these units students and the teacher, as a senior project member, work in a project team to solve a chemical problem within an adapted authentic practice as a context. Students need macro-micro thinking in structure-property relations to solve the problem. Therefore, the nature and sequence of content and the teachers' role in this curriculum are different from the traditional curriculum.

Based on the framework of Stolk (Stolk, et al. 2009) a professional development programme was designed. This framework involved an orientation phase for teachers to develop expertise in teaching context-based chemistry curriculum about macro-micro thinking in structure-property relations by preparing a representative unit, an execution phase to teach the unit in class using the new expertise, and an evaluation phase to reflect on the execution of the unit to expand their existing expertise. Six experienced teachers guided by a coach participated in a professionalization programme.

Data were collected to capture the expertise of the teachers on several moments in the programme, as well as to capture the process of expertise development. Analysis of the data focused on describing the expertise development of the teachers during the whole programme.

First analysis gave preliminary results. In the orientation phase the teachers mainly focused on practical organization of teaching the unit, especially about working in project teams in class. As a result, teachers hardly developed expertise in teaching macro-micro thinking in structure-property relations. In the beginning of the execution phase teachers experienced a loss of control during performing in class. Teaching the innovative unit demanded too much new expertise at once. This caused a feeling of stress, incompetence and insecurity. This was a crucial point in the development of expertise during the whole programme. Because of the stress, teachers fell back in performing their traditional behaviour or even wanted to quit. The development of expertise stagnated. More results, conclusions and discussions will be presented at the conference.

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Are Models used from a 'Nature of Science' Perspective? An analysis of Swedish Chemistry Textbooks

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Introduction. The expression 'nature of science' (NOS) often refers to the epistemology of science, science as a way of knowing, or the values and beliefs included to the progression of scientific knowledge (Lederman, 1992). One important aspect of the development of scientific knowledge is models. A model is a representation of a target – a system, an object, a phenomenon or a process – based on a theory (Gilbert et al., 2000). During history scientists have come up with different answers and explanations of scientific questions. This has led to the development of different scientific models over time. These models are often the products which we want to teach to students in upper secondary school. Knowledge of models and their use, and recognizing their limitations, would allow students to gain a better understanding of scientific facts, the nature of science, i.e., how scientific knowledge is achieved. However, teachers and textbooks are not always explicit about the use of models. Further, they do not always use specific historical models but transfer attributes from one model to another which results in hybrid models that might be difficult to teach and to learn (Justi & Gilbert, 1999). Research has shown that textbooks play an important role for chemistry teachers planning and implementation (Drechsler & van Driel 2009).

In Sweden, the curriculum for upper secondary school was recently revised. Therefore all the Swedish science textbooks were rewritten in the year 2000. The new curriculum emphasizes that students should learn to use and discuss the scope and limitations of scientific models. In this study, Swedish textbooks for upper secondary chemistry are analyzed regarding their use of models. The research questions in this study are: (i) Are models used as an aspect of nature of science (NOS) in chemistry textbooks in upper secondary school? (ii) If not, is there an implicit use of models?

Methodology. The most frequent used textbooks in chemistry (n = 8) in upper secondary school in Sweden were analyzed. In the first part of the study, a table was made in which all the parts in the books in which models were mentioned with different subject matter and contextual frameworks were compiled. In the second part of the study historical models of *acids and bases,* were used to compare and identify the implicit use of historical models in the textbooks in the domain of acids and bases. Each paragraph was analyzed and a model of the content was constructed. These models were exposed in tables in order to compare them with the historical models. In the analysis we looked for whether different models were confused, and whether hybrid models were used.

Results. Only two textbooks provide a general explanation of scientific models in a NOS perspective. In the application sections there is not any reference to specific models at any stage and models are used as if they are facts. The only exception found was the atomic model in two of the textbooks.In the context of acids and bases, the textbooks use various historical models without being explicit about this use. In all textbooks hybrid models were found. There were no explanations of the following:

1. That models are used
2. What model is in use at the moment
3. Why different models are used parallel
4. The scope and limitations of each model.

Conclusions/Implications. In the national Swedish curricula for the science program (age 16-19) in upper secondary school, the use of models in a NOS perspective is emphasized as a crucial ingredient in education (The Swedish National Agency for Education, 2005). This study claims that the textbooks clearly do not live up to these goals. The implications of these findings may be even more serious if teachers strictly follow the textbooks design and content when planning their teaching, as previous research has shown. Therefore we suggest that textbooks should provide students with clear explanations of models. Students need to understand why at a certain point of the course a new model is introduced and how this model differs from the one that had been used before. Further, different models are used indiscriminately and hybrid models are often constructed in the textbooks. This suggests that scientific knowledge grows linearly and is context independent with no progression between the models. Different models of a phenomenon seem to constitute a coherent whole, an idea that according to Justi and Gillbert (1999) could lead to learning problems among students. A clear distinction between different historical models ought to be made. More research is needed for a better understanding of the role of textbooks in the classroom. It should also be investigated how students and teachers understand models and how they relate to the implicit use of models in the textbooks.

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Introduction of particle models in early science education?

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Keywords: Particle model, primary school students, young learners

Background. In Germany, it is rather controversially discussed when or even if an introduction of atom or particle models in secondary school (age 12-16) makes sense in view of the seemingly complex nature of this topic. In spring 2009, a project started that even took a step further: in a primary school approximately 70 students of the first grade had the possibility to work creatively with simple particle concepts in a unit conceptually developed by the authors and realized by school teachers. The main intention for the project is to develop units for primary school education where the intrinsic interest of students of this age for scientific phenomena is employed as a positive amplification. As we know from other studies, the foundation of a long-term interest in scientific problems can already be laid in early school learning in case of suitable promotion (Eskilsson/Helldén, 2003). Experience in other countries shows impressively that work with "reflective modelling" or "visualisation of concept with models" is not only possible but can be very fruitful for further learning processes in science education (Harrison/Treagust, 2000; Treagust/Chittleborough/Thapelo, 2002). For promoting effective learning strategies, it is important to evoke cognitive conflicts on the level of particles not only on the level of phenomena (Nussbaum, 2000). Although the acquired concepts are not stringent in the sense that continuous and discrete concepts are used in parallel depending on the context, the students are able to use them for their own argumentation in transfer experiments. Therefore, the research question being in the focus of our attention is if specific tasks can be developed that function as diagnostic instrument. In this presentation, we will report on the internal structure of the consecutive units that on the one hand already took place in July and October 2009 and in February 2010.

Methods. The project consists of courses conducted in three first/second grades (age 6 and 7) of a primary school in Bremen, Germany for at least 8 lessons a week. The structure of the lessons follows the ensuing sequences:

Motivation and way of posing a problem: With the aid of an introductory story, the children are confronted with a certain problem which needs to be solved.

Afterwards, a long period of *experimentation and role-plays* follows. In teams of 3 – 4 children the students carry out experiments some of which allow a rather free and independent way of working and exploring the materials. Other experiments are more guided and result soriented. In a first step, the students realize that matter looking homogeneous from a distance can consists of many different smaller pieces (soil) or that material looking similar (salt, sugar) has a different morphology if investigated under a microscope. This idea is transferred to the submicroscopic world: here also particles exist that cannot be observed. The problems are presented first on the phenomenological level (salt is solved in water). Here a volume reduction is seen (an experiment was developed where even small children can observe this effect easily). This volume reduction is macroscopically reconstructed on the model level by peas and pearl barley. In the following, solution and filtration experiments are carried out transporting the idea that the particles are small (cannot be filtrated) but present (detectable by taste).

As *documentation,* the students - according to their abilities - create a poster with the material and/or text plus own drawings within their group. They also present the poster in front of the class. In this phase, the *reflection* begins as the teachers can ask provocative questions. The teacher's role is to help the students focussing their ideas and work out sustainable concepts grounded on the students' presentations and drawings.

As far as the methodology is concerned, the second part of the project starting in February 2010 will be investigated by observation of each student in his/her class. The question in the focus is if there are different types of students that tent to work with more abstract concepts than others. These students are to be identified and later on been interviewed. The interviews will be analyzed qualitatively. They will be used to investigate the student's underlying ideas of particle concepts and shall provoke transfer use of them, as the students will be able to choose from a pool of different tasks which vary in the degree of abstraction. Another question which will be dealt with in a second step focussing on the whole class, is if these students also tent to choose the same task according to their grade of abstraction again. We aim at elucidating whether these tasks can be used as a diagnostic instrument. Therefore, we compare these results also with the results from a KFT-Test (German Cognitive Ability Test).

Results. The project aims at developing concepts regarding the particulate nature of matter step by step for young learners. In the first course they learn that matter is not continuous but must consist of small invisible units (*existence of particles*). The second course confronts them with the idea that these particles can move and that the different aggregate states represent different degrees of movement (*particles are in motion*). The third course shall establish the idea that the particles have different properties and are connected by bonds of different strength. This helps to understand different properties of the materials (e.g. hardness) (*particles are differently connected*). Forthcoming courses will the deal with reactions etc.

A first pilot-investigation in July and October show impressively that the concepts of the students vary in terms of abstraction (continuous – discontinuous – mixed forms) and are also strongly influenced by the teachers approach. These results will give defined hints for the study that follows in February and needs to be reassessed.

To our own surprise it was not a problem to initiate first ideas of the particle model within young learners and also the teachers were very interested in the cooperation. Their timidity of the scientific content could rapidly been reduced and turned into real enthusiasm.

In this presentation, we will summarize the results of the pilot phase as well as the results of the unit in February obtained with the described in-depth evaluation. We would like to discuss the possibilities and the need of introduction of simple particle models to young learners with the auditorium.

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An investigation of the difficulties of Organic Chemistry at third level

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Keywords: Organic Chemistry, third level students, areas of difficulty, attitudes, integration of theory and practicals.

Background. Chemistry has been identified as a difficult subject by many (Johnstone, 2000, Ellis, 1994 and Bodner, 1992) and a decrease in the numbers studying Chemistry has been recognised in a number of countries (Reid, 2008). Childs & Sheehan (2009) have identified the Organic component of Chemistry as a problem area at second and third level in Ireland. Organic formulae (Johnstone, 2006), curved arrow diagrams (Bhattacharya & Bodner, 2005 and Ferguson & Bodner, 2008), mechanisms (Rushton et al., 2008) and laboratory classes (Greenbowe & Schroeder, 2008) have all been identified as areas of difficulty for students. This investigation was conducted as part of a research study investigating the difficulties of Organic Chemistry for second and third level students in Ireland.

Purpose:

- To identify the precise areas of Organic Chemistry that third level students find difficult.
- To recognise any contributory factors affecting the teaching and learning of Organic Chemistry.

Method. A questionnaire was distributed to two classes of second year Organic Chemistry students from five different courses at the end of their second Organic Chemistry module in the University of Limerick. 91 questionnaires were distributed in total and 82 completed questionnaires were returned. The questionnaire had two distinct sections. The first section sought information about the students' previous Science and Mathematics background and their experience of Organic Chemistry at third level. The second section was a diagnostic test composed of 9 questions, chosen to cover known areas of difficulty.

Results. For 26% of the students, these two Organic Chemistry courses had been their first experience of Organic Chemistry. Of the 74% who studied Chemistry at second level, 38% of them listed Organic Chemistry as their favourite topic in Leaving Certificate Chemistry and 41% listed Organic Chemistry as their least favourite topic. In total 92% of the students who studied Chemistry at second level said that they carried out all or most of the mandatory Organic experiments on the course. 40% of the students found the Organic laboratories at third level interesting and 50% of the students disagreed that they were easy to understand. Only 27% of the students agreed that the laboratory classes facilitated their understanding of Organic Chemistry. 29% of the students did not enjoy studying Organic Chemistry at third level and 66% found it difficult. 54% of the students felt that they were improving with their understanding of Organic Chemistry. The Organic topic that most (61%) of students enjoyed was Naming Organic Compounds. Organic Mechanisms was identified as the topic that most students (77%) had difficulty with. Organic Reactions, Organic Synthesis and Classification of Organic Compounds were also identified as difficult topics.

In the diagnostic section of the questionnaire, 68% of the students scored below 40%, with a mean score of 29%. The highest score achieved was 66% by two students. 13% of the students did not score anything in the overall test. Many of the diagnostic questions that the students did not score well in, were the same areas identified as difficult in the first section. However, the areas that the students identified as enjoyable in the first section; Naming Organic Compounds, Molecular structures and Characteristics of Organic Compounds were also poorly attempted in the diagnostic test.

Conclusions and Implications. The results from the diagnostic test identified the main areas of difficulty. The overall performance in this test was very poor. Almost 70% of the students failed the test (<40%), even though the questions given were thought by the course lecturer (N.H.) to be within the capabilities of the students. Some correlation can be identified between the students' answers from the first section of the questionnaire and the diagnostic test. However, poor performance in the topics that the students categorised as easy and enjoyable highlights the disparity between the students' perceptions of their own ability and their actual ability.

Contributory factors raised by the students included note-taking during the lectures while trying to listen to the explanation. Many of the students saw Organic Chemistry as an abstract subject and had difficulty seeing the connection between the theory of the subject and their laboratory experiences. Few of the students recognised the importance of understanding rather than memorising theories and mechanisms.

Further investigation is necessary to establish *why* the specific topics acknowledged as difficult by the students are problematic. The findings will be useful in the possible development of innovative teaching strategies and training for teachers of Organic Chemistry at second and third level. Teaching materials based on research evidence will be designed for pupils to facilitate their ability to understand Organic Chemistry.

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How to Measure Experimental Abilities: Hands-on- or Paper-Pencil-Based?

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Background. Internationally, science education has increasingly stressed the outputs of schooling over the past decades. Current curricula and education policy favour basic abilities necessary for students to apply their knowledge proficiently over a canon of knowledge-items (cf. e.g. AAAS, 2001; Klieme et al., 2003; QCA, 2007). Amongst the core abilities rendered essential in the sciences, experimentation is probably the most characteristic one. Therefore, teachers are challenged to implement approaches to experimentation in their science courses that stress its processes rather than its mere outputs; especially, as science education research has repeatedly pointed out the inadequacy of imitatory experimentation for advancing science understanding (cf. Schauble, Klopfer, & Raghavan, 1991; Hofstein & Lunetta, 2004),

Re-orientating experimentation from ‘learning of science’ towards ‘learning to do science’ (cf. Hodson, 1996) implies for science educators to scaffold the processes for their students (Lunetta, Hofstein, & Clough, 2007). They can refer to a multitude of scaffolding structures from science education research (e.g. Mayer, 2007; Kipnis & Hofstein, 2008), most of which can ultimately be brought to match with the SDDS-approach (**S**cientific **D**iscovery as **D**ual **S**earch: Klahr, 2000). Here, experimentation is constituted by three fundamental elements: (1) searching a mental space of hypotheses, (2) searching a mental space of experiments, and (3) concluding from experimental evidence. This has been translated into a paradigm suitable for schooling purposes: finding ideas/hypotheses – planning and conducting experiments – concluding (cf. Klos et al., 2008). The paradigm has been shown to be effective scaffolding in science instruction and to advance students’ experimentation abilities (Walpuski & Sumfleth, 2007) but an instrument based on it that can be used in actual science classes is still lacking.

When thinking of assessing experimentation one has to take into account that at least two distinct sets of skills and abilities come into play in the domain: (1) manual skills enabling proficient handling of apparatus, (2) cognitive abilities guiding structured experimentation. Presumably with regard to the first set, assessments of experimentation other than hands-on have traditionally been put into question (cf. Garden, 1999). The proposed study suggests that the cognitive abilities guiding aimed experimentation can be assessed employing different modes and, therefore, aims at investigating this idea in more detail.

Method. 10- to 12-year-old students from the entrance stage of secondary schools (N ~ 200), who have been taught in integrated science classes for about twelve months, will each work on (1) three open hands-on experiments which they (2) document in structured report sheets; (3) they will fill in three paper-pencil-tests assessing the aforementioned experimentation-paradigm. While doing the experiments in pairs, students will be videotaped. Videos will be analysed according to adherence to the paradigm (Walpuski & Sumfleth, 2009). Experiments will address three different topics to account for possible advantages that single students might have due to special interests. Paper-pencil-tests will address the same topics (e.g. separation by evaporation) but in different examples (hands-on: desalination of salt water, paper-pencil: determining the sugar content in sweetened tea). In order to control for sequence effects, administration of the three experiments is rotated partially through a Latin square, as well as the order of administration of paper-pencil- and hands-on-assessments is inverted for half the population. As the three measures build on the same theoretical basis (SDDS, its ‘school-translation’ respectively), it is expected that results from the measures will correlate highly with each other.

First Results and Implications. Results from a pilot study show that the employed paper-pencil-tests are satisfactorily reliable (Cronbach’s $\alpha = .65 – .81$) and can be administered after moderate reworking in the main study. The implemented experiments are suitable for the age-group as determined through face-validity (cf. Pine et al., 2006). The main study has commenced in October 2009 and data collection will be completed by January 2010. Analysis of videos and report-sheets will be taken up immediately after completing the data collection. Results from the analysis will be available by the time of ECRICE-conference and can be reported there.

The study's findings will form a twofold contribution. Concerning science education research, it is expected to suggest a viable means to assess cognitive experimentation abilities on a paper-pencil-basis. Looking at science education in the classroom, it is hoped that the developed report sheet will prove an effective instrument for assessing students' experimentation processes without the need for close observation.

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Using and evaluating a framework of Schema to support the induction of trainee teachers into the cognitive processes of Chemistry

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Keywords: schema; metacognition; subject knowledge; pre-service teacher education.

Background. In response to a shortfall in recruitment of Chemistry specialists to meet the needs of the teaching workforce, a number of government-funded schemes exist to redress the shortfall. Most of these schemes involve intensively teaching additional Chemistry to graduates in other science disciplines prior to starting their initial teacher education. As well as the need to acquire significant amounts of subject content, participants in the scheme expressed a desire to be inducted into the subject to the point where they were able to 'see it like a Chemist'. 'How do you know….?' Is a common question

Metacognition, that is the development of thinking by discussing it explicitly, is an area previously researched in schools, where students were taught 'thinking skills', based on Piagetian schema, in Science,. (Adey and Shayer, 1993; Zikovelis and Tsaparlis,2006) The following presentation describes a comparable approach, focussing specifically on schema relevant to Chemistry, and used with a group of adult learners. The framework set out the cognitive processes identified by an audit of their curriculum. The list of schema was observed to have significant overlap with other accounts of the thinking skills associated with learning Chemistry (Shwartz, Ben-Zvi and Hofstein, 2006). In addition the framework indicated some of the historical precedents for the application of the schema, in an attempt to clarify further their understanding of how the schema relate to the body of chemistry knowledge (Chamizo, 2007).

Methods. The framework was given to each of the total of 30 students enrolled on the course during two presentations. It was distributed at the beginning of the course and discussed regularly (at approximately six weekly intervals) during tutorials over the six month course. It was presented as providing a means of identifying possible thinking strategies in unfamiliar contexts.

Evaluation was conducted by focus group discussions, conducted three times during each course for which students volunteered. Groups of 7 or 8 were convened and their conversations recorded, by prior consent. Subsequent transcription of their comments were subsequently transcribed and thematically coded (Alexiadou, 2001).

Results. Students expressed some initial difficulty in understanding the framework as a tool rather than an assessed component of the course. As its use was repeated and students were encouraged to use it to categorise their understanding, they grew more enthusiastic about its use. Some stated that they intended to use the framework when they began teaching, believing it would make the Chemistry content clearer. There was some limited evidence that its use improved their ability to solve problems in unfamiliar contexts. Other benefits associated with its use included making different areas of study feel more unified and giving them a way of auditing their growing body of knowledge and understanding. Varying levels of enthusiasm for the use of the framework were voiced but it received almost universal positive feedback. Crucially, the majority of students reported that they felt more confident about using their Chemistry in novel contexts, which had been the original purpose.

Conclusion and implications for future practice. The study corroborates previous work on the benefit of explicit categorisation of material. The work suggests that adult learners can benefit from more explicit discussion of the cognitive processes associated with Chemistry, including their historical precedents. The key gain for a group of putative Chemistry teachers was a gain in confidence arising from the development of a more cohesive and holistic understanding of the subject.

(Please note that evaluation is ongoing and the number of participants will have doubled by the end of the academic year 2009-2010 and further finding will be added to the existing study)

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Communicating content knowledge in context-oriented learning – contextual embeddedness of concepts in student statements

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Keywords: context-oriented learning, video study, communication

Theoretical Background. Teaching science in everyday contexts is not novel to the science education community. It has been introduced to face the problems of traditional science instruction, being an overload of the curriculum, an excess of isolated facts without apparent interrelations, lack of transfer, and obvious relevance of what is taught to make the subject more relevant to the learner (Gilbert, 2006). Although context-based approaches have been implemented in many countries, the approach still faces challenges which are mostly concerned with practical implementation matters and its efficacy with regard to student learning. Teachers often react reserved towards the approach not only because of its innovative structure and the need to rethink instruction but also because they doubt that their students will acquire science content knowledge as adequately and in the same amount of time as they do in traditional instruction (Bennett et al., 2005).

Although many studies have shown effects on student interest (Osborne & Collins, 2001; Ramsden, 1997), it is still unclear whether real life contexts have a positive or even distracting effect on the acquisition of knowledge. On the one hand, a dearth of research that evaluates the effect in more controlled studies is criticised (Taasoobshirazi & Carr, 2008), on the other hand, in-process studies comparing student group negotiation processes in different problem situations are not available. It remains unclear whether real life problems support or hinder the acquisition of content knowledge and whether this acquisition process is accompanied by specific quality patterns in how students exchange their knowledge.

Methods. The presented video study is part of a larger project which focussed on the effects of different contexts on student interest and achievement in science instruction. By means of a controlled design, students were assigned treatment groups which either worked on a problem embedded in a real life context or a laboratory environment. The learning environment was inquiry-based in that students conducted simple experiments in order to solve the problem. They were issued with boxes containing the problem task – referring to the respective context –, information on relevant content knowledge and necessary material to conduct the experiment. Afterwards, students were supposed to revise the learnt concepts. The overall implementation lasted over one week with students attending the project for one hour after school each day resulting in an overall number of five sessions. Tasks relied to problems taken from the content area of *acids and bases* embedded in the respective contexts.

An overall number of N = 286 students participated in the study at seven different secondary schools. A third of these students (n = 94) could be videotaped during the small group activities so that their communication could be made available for analysis. Student statements were coded if they related to content- or context-relevant information. With the help of a coding manual and after sufficient interrater agreement between coders, statements were assigned along two major coding variables: contextual embeddedness and conceptual linkage. While contextual embeddedness describes whether a content-related statement refers to a specific situational context, conceptual linkage refers to the way different concepts are interrelated (degree of connectedness). By this, student statements were coded along two lines and could be analysed with respect to their difference in the two treatment groups and their relation to student learning in the respective sessions.

Results. The level of connectedness between concepts was very low in both groups. In the laboratory context group, 75% of statements remained on the fact level, while only 70% of statements in the real life context group referred to facts. A chi-square-test resulted in a significant association between the treatment and the three levels of connectedness that fulfilled test requirements ($\chi^2(2) = 8.375$, $p < .05$) so that significantly more statements can be associated with higher levels of connectedness if students learn in the real life context group. As a positive relationship between the level of connectedness and student learning could be found ($r_s = .21$, $p < .05$), this might be one indicator for improved student learning in such settings.

With relation to the second coding variable, it could be shown that students in the real life group uttered more statements relating to abstract content knowledge (see Figure 1).

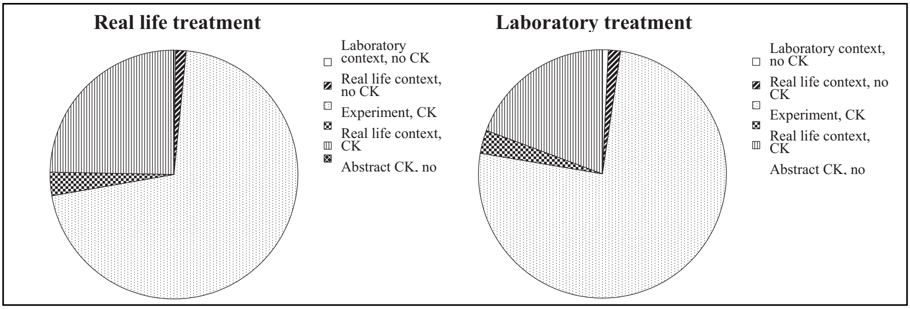

Figure 1. Results of video analysis coding statements according to their contextual embeddedness

While only 19% of statements related to abstract content knowledge in the laboratory group, 25% could be coded in the real life group. Students might be forced to abstract their knowledge from the context situation because it is not as closely linked to the subject matter and might, hence, improve their ability to decontextualise concepts.

Conclusion and implications. Taking a closer look at student communication in different educational settings might shed light on the processes that lead to improved learning. While the overall study confirmed improved learning of students learning with real life contexts, an accompanying video analysis helps to elucidate the processes that lead to this effect.

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Visualization and Chemical Education: pre-service teacher´s Conceptions

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Keywords: chemistry teachers, training, visualization

In the last years, four very different groups of people (computer software specialists, scientists, educationalists and cognitive scientists) have promoted the development, the discussion and the use of visual tools in sciences instruction (Gilbert, 2007). Therefore the traditional resistance to change, science instruction and more specifically chemistry teaching has suffered some progressive modifications, that go from small shifts in the traditional methods of teaching, strongly supported in the teacher, where in some punctual moments the students are allowed to built their own knowledge, to a complete change in the class dynamic, in teacher's role and therefore in the way of the students built their own knowledge.

Progressively educators began to recognize the value of the visual component on the chemical knowledge, which was until then, only attributed to the verbal and mathematical language; nevertheless the pictorial chemistry language is by itself a higher structured language (Ege, 1994). These studies refer that if models play important roles in science, it's also expected they are equally important in science education, both for students who may become scientists and for the majority who will need some level of 'scientific literacy' for later in life. We also found literature with some research (Rapp, 2007) that points out the importance of the construction of mental models by the students, without these models learning becomes very difficult, especially in chemistry.

The aim of this work is to know what conceptions about visualization, use of representations, images they have, and at the same time what was the contribution of their graduated course on this issue. We also want to know if they feel that they are prepared to teach in this new teaching environment.

We adopted a qualitative research in our study, applying a questionnaire to a class of 24 pre-service chemistry teachers course from University of São Paulo (USP), São Paulo, Brazil. These students had a range of academic backgrounds, but the most important is that 8 of them had no experience in teaching, but the other 16 had already some teaching experience. We applied a questionnaire with 12 open questions addressing some of the most theoretical concepts of this issue, such as the meaning of visualization, images, visual capabilities, models and skills to learn using visualizations. We also asked them about the frequency and the type of visualizations they usually use. The last questions of the questionnaire were concerning their educational training and their personal opinion about the importance of this issue in chemistry's teaching. The data's analyze to these questionnaires were done based on Michel Foucault (1986) contributions about speech on educational field.

The result obtained in this sample in relation to frequency is coherent with several studies (Gilbert, 2005; Ferk & Vrtacnik, 2003) that emphasize that the ready availability of powerful computers made this visualization tools very popular, and now it is very difficult to find novice students, expert students or even teachers in exercise that have never had any contact with this tools. The results of the questions addressing theoretical knowledge show us that there is a lack of training in this area. For instance they seem don't know the difference between textual and visual displays. These sources differ in the fact that, textual information presents information in a linear sequence, whereas visual information sources provide all the information to the learner simultaneously (Thorndyke & Stasz, 1980; Larkin & Simon, 1987). When we have a textual display, the cognitive processing is directed by the structure of the text, but when we have visual display the processing of information is directed by the learner, so additional attention processes for acquiring information from scientific visual information is needed (Gobert, 2007). Thus, teachers must be aware of these demands and find knowledge acquisition strategies for acquiring information from complex visualizations in chemistry. They don't show any particular understanding that students must know previously the codes of representation, the conventions that underlie the visualizations, and it seems that some of them begin to believe that visualizations could be a panacea for teaching some difficult scientific topics.

Analyzing our inquiry outcomes we also found that only four graduates said that they had read something about this issue but they don't remember specifically what. Once again this confirms that their chemistry course may not introduce these novel tools with effectiveness.

Almost all of the graduates think that it is important to have some training in this area that allows them to apply these new teaching strategies in a useful way. As a final conclusion we can say through this sample that is necessary to improve the educational training of our future chemistry teachers and supply them with all the theoretical background necessary for them to apply this new tools with effectiveness in chemistry teaching.

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Teaching chemistry with an *initial inspiration* technique

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Keywords: initial inspiration technique, motivation, interdisciplinary topics, health education

How to get students attention and interest in the lesson's subject: this is the question for every teacher. How to get students notice the fact that chemistry is all around us? The first problem is more complicated when students are not looking forward to connecting their future life with science (Kilch, 2005). We have this problem also in Polish schools. The education system is not making this problem easier for educators. The system does not update quickly enough to match the changes in science. However following the changes in science and society it is needed to improve the teaching strategies.

In my research work I am extending a study of problems connected with organic chemistry and biochemistry (Florek 2004, 2006). The most important goal was to get students curiosity, commitment, and motivation. The main purpose of this project was to prepare lesson projects and activities for students that would be useful for teaching chemistry at the post-gymnasium level.

To prepare new educational projects it was necessary to search for resources in science news, study the content of current school curricula, choose topics and find out the methodology to generate student's curiosity. The integrated part was a questionnaire study of students experience with the chemical staff. Next step involve a preparation of lesson project with didactic tools for students and teachers and verification of project via preliminary lessons.

To pay attention to students (chemistry or non-chemistry profiles) the method of the initial inspiration was designed and provided. The main idea of this method is to find out connections between the main topic of the lesson and something known by students from everyday life, commercials, TV –news. (Some preliminary studies of students relation to chemistry knowledge in commercials was made in 2008 (Florek A., Krefta K. 2008). I am designing a range of innovative topics e.g. enzymes, food additives, and cholesterol. I am developing methodology for chemistry lessons which started with Initial Inspiration methods and give the students possibilities to bring current topics together with traditional educational topics and to set the students experience within these. As an example I will be describe a project about cholesterol. Cholesterol is the best-known member of an important group of chemicals called *Lipids.* Cholesterol is a famous component of food containing fats and cholesterol is associated with a greater risk of *atherosclerosis* and *coronary atherosclerotic heart disease.* Although this has an extremely important function in the human body as one of the basic building blocks of the *steroid* hormones (including the male and female *sex hormones* and the hormones of the Stress Mechanism). Everyone has heard about cholesterol from commercials of several margarines or in discussion about health live style. (In Poland last year cholesterol was the main subject of Bannecol and Danacol product's TV-commercials).

As results the lesson project with *initial inspiration* technique and manual for teachers have been prepared. The manual for teachers contains short methodological instruction on performing the project in school, specific instructions for experiment e.g. separation of cholesterol from eggs, identify of cholesterol in food samples. The preliminary lesson proves the thesis about the increase of students' interest because they started to work with a familiar subject and can find some connection between the subject of the lesson and their own everyday experience. There is possibilities to realize some additional educational goals like ecological education and health prevention education also (Aquilali R. at all, 2007).The project can be successfully applied to chemistry teaching in upper-secondary school.

Diagnostic study of students' interest and opinions of some facts of biochemistry in everyday life showed that students want to know more about chemistry implication in everyday life and all modern scientific problems. And all the topics could be used to provide teaching by way of initial inspiration technique.

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School scientific problem solving and fostering scientific thinking competences: What do in service chemistry teachers think?[1]

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Keywords: *scientific thinking competencies, chemistry teachers*

1. Introduction, framework and purpose. In this work we presents results within the FONDECYT 1070795 research framework whose purpose was to identify and characterize high school teachers' opinions regarding *scientific thinking skills* and *school scientific problem solving*, as well as the mode in which both should be dealt with when teaching chemistry. A biased sample of 33 teachers - among a total of 117 who joined other phases of the research- were given a specially designed questionnaire which demonstrated that their image of problem solving and scientific thinking competencies is fragmented and sometimes contradictory. Scientific knowledge rises from the need to solve problematic situations requiring unknown statements and solving modes; hence**,** such need becomes a very important means to study the level reached by students' thinking and competencies as well as their development in the science teaching process. Consequently, students should have the opportunity to deal with authentic scientific *problems* with their teachers' support and by means of trying various problem solving strategies helping them to widen their knowledge. Scientific problems as a school activity develop students' *problem solving* competencies, just as scientists often do in the real world. Therefore, if we want students to actually learn, we believe class activities and exercises should be turned into problems. We insist that students become engaged in "problem solving activities" not as a mere doing but an "actual scientific activity" by which students may build fundamental knowledge to either perform as competent science professionals or as responsible, scientifically literate citizens (Hodson, 2003).

We aim here to identify and characterize inservice chemistry teachers' theoretical notions so as to analyze and understand problems stated in the science lesson. Such notions should be properly understood by students in order to develop certain key competencies needed to perform both in the corresponding discipline field and in their daily life as citizens contributing to their society. From a 'new science teaching culture' perspective, reductionist dogmatic approaches should be replaced by cognitive linguistic competencies and skills enhancing social integration, fostering creative thinking and committed citizens actively engaged in the dynamic socio economic development. Hence, encouraging scientific thinking competencies that enable students to approach various situations becomes relevant. Among others, such skills will allow students to read, write, think, explore, grasp meaning, state, perceive, argue and explain scientific knowledge in an agile and comprehensive manner. Scientific thinking competencies represent a dynamic combination of attributes related to knowledge, skills, attitudes, values and responsibilities which describe learning outcomes within a wider and much more enriching educational program where students can demonstrate - in a non reproductive way - they are able to understand science (Izquierdo &Adúriz-Bravo, 2003).

Scientific Product derived from FONDECYT research 1095149: Desarrollo, caracterización y validación de un modelo de evaluación de competencias de pensamiento científico (Abbr.) sponsored by CONICYT – CHILE.

2. Purpose of the research, main objective and method. Identify and characterize notions of school scientific problems as well as scientific knowledge competencies developed by inservice chemistry teachers. An specific objectives: Design, validate and apply an assessing instrument (Questionnaire) in order to identify and characterize metatheoretic representations (Teske & Pea, 1981), regarding students' problem solving strategies and scientific thinking competencies, held by chemistry teachers among various schools in Santiago; Establish –if present- possible relations between metatheoretic representations upon school scientific problem solving and scientific thinking competencies.

This research is stated as a project aiming to produce knowledge about teachers' thinking by means of designing professional mediations that support their pedagogical empowerment of school science. In this context, this subject is conceived as an activity to tackle scientific problem solving and foster students' competencies. We chose chemistry teachers since this is the area where our training and research has been developing for the last 5 years. The following operational design and field analysis aspects were considered:

a) Preliminary contact with interested schools and teachers in charge of delivering chemistry lessons, b) Gathering and selection of participant teachers' academic records, c) Bibliographic analysis of similar researches, d) Design and construction of an assessment instrument measuring the image of science and its teaching, e) Preliminary validation of the instrument by experts and its application to a pilot group of 20 teachers, f) Questionnaire given to the 33 teachers constituting the sample being studied, g) Gathered information is systematized and categorized and finally, h) Analysis and preliminary evaluation of findings.

3. Advances and concluding remarks. We can basically state three core ideas based on the presented findings; (i) chemistry teachers participating in the study express –with different nuances- various images about the nature of science, the chemistry knowledge being taught and the learning. (ii) chemistry teachers' vision regarding scientific thinking competencies (STC) and scientific problem solving (SPS) should be justified -to a large extent - by their initial teaching education and finally (iii) it is evident that from this built and taught science approach there is an interesting transition from a categorical epistemological vision of scientific education towards a moderate rationalist proposal (Toulmin, 1977) which would be worth researching in the future.

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Metacognitive development and epistemological reflection in chemistry problem solving environments

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Keywords: metacognition, epistemology, multi-methods, mixed-methods, general chemistry

Extensive work has led to the general acceptance that self-regulation positively impacts learning and achievement (Zimmerman, 1990; Zimmerman & Schunk, 2001). Traditional models of self-regulation explore interactions of cognition, metacognition, and motivation, while others include the interactions of personal epistemology – one's beliefs about knowledge and knowing (Hofer & Pintrich, 1997; Muis, 2007). Work continues to explore the many interconnections of self-regulation (Mason & Bromme, 2010). Some of these theories suggest that beliefs about knowledge may influence motivational predisposition for specific tasks, and may factor in one's selection of cognitive and metacognitive strategies (Hofer & Sinatra, 2010). One line of thought is that each component of self-regulation interacts and works together, and in cases, certain components may compensate others (Schraw, Brooks, & Crippen, 2005). It stands to reason that students' self-regulation can be enhanced by the thoughtful preparation of learning environments that specifically target relevant aspects of self-regulation. Our interest aligns with the desire to promote self-regulation, and in order to meet this goal, a better understanding of the impact learning environments have on self-regulatory aspects is required. Therefore, this research program was undertaken to answer the question: how do specific learning environments impact students' epistemological beliefs, metacognitive skillfulness, and problem-solving abilities?

Recent work explored the effects of two learning environments – a collaborative problem solving exercise and a cooperative problem based chemistry laboratory – on students' metacognition use and problem solving abilities. A sequential explanatory mixed methods framework was used to study the impact of each learning environment. In this framework, quantitative evidence is gathered in the first phase. Then, in the second phase, qualitative data is gathered and analyzed to explain the prior quantitative findings. During the first phase of study, the effects of each learning environment were assessed using a validated multi-method assessment. This assessment strategy used a self-report instrument, metacognitive activities inventory (MCAI), and a concurrent online instrument, Interactive Multimedia Exercises (IMMEX). Treatments groups in both environments showed an increase in metacognitive awareness, strategy usage and problem solving abilities as measured by the assessment strategy. During the second phase – the qualitative portion – phenomenology was chosen as the methodological framework due to its focus on lived experience. Eleven first year general chemistry laboratory students that were representative of the population participated in this phase of the study. Open-ended, semi-structured interviews were used to elicit information regarding students' experiences in both learning environments and IMMEX. Students were unaware of the assessment capabilities of IMMEX; therefore it was treated as a learning environment during the interviews. Three researchers completed data analysis by following Colaizzi's (1998) method. In this method, transcripts were read multiple times in order to gain a feel for the experience. Next, statements were selected that were deemed relevant to the experience. These statements were analyzed for meaning and further grouped into themes or dimensions that made up the outcome space for each experience.

Interpretations of the outcome spaces supported the quantitative evidence and provided insight into the enhanced use of metacognitive strategies. It was concluded that purposeful social interactions and reflective prompting facilitated the use of metacognitive strategies in both the cooperative problem based chemistry laboratory and the collaborative problem solving exercise. It was also concluded that each environment, including the online environment, caused cognitive dissonance in students and was conducive to reflection about knowledge. Conflict with and reflection of views of knowledge are linked to epistemological development (Kinchin, Hatzipanagos, & Turner, 2009). Future work will use a newly developed measure of epistemological sophistication to determine if these environments indeed promote development of sophisticated views of knowledge.

Another significant emergence of this work was the similarities of students' experiences within each learning environment. Although the design of each learning environment was quite different (problem-based hands on lab, collaborative paper-and-pencil exercise, online problem), students' experiences within each were similar. Students were placed in challenging situations in which they experienced cognitive, affective, and epistemological conflicts and had to rely on metacognitive skills to accomplish the task or solve the problem situation. The similarities within each experience support the claim that adequately designed learning environments are conducive to metacognition use and development and epistemological reflection. The findings of this mixed methods research program provide information for those responsible for designing learning environments and for those interested in promoting aspects of self-regulation.

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Reflections on representations in chemical education

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Introduction. In a recently published book Gilbert and Treagust (2009a) propose the triplet representation as a central model for chemistry education. The model consists of three components: macro, submicro and symbolic representations. This model was originally proposed by Alex Johnstone (1982) and have been used since then by various researchers reflecting on the chemistry curriculum and in the analysis of student thinking.

The book by Gilbert and Treagust and other publications (De Jong & Taber, 2007) show that this model is widely accepted. The triplet of representations reflects the ambiguous nature of reaction equations in symbolic language representing both macroscopic phenomena and corpuscular explanations. However, reflecting on the scheme we discovered some problems with the terminology used and the relation between macro and submicro representations.

Background. Gilbert and Treagust (2009b) distinguish between three types of representations in chemistry, which they initially call the phenomenological type, the model type and the symbolic type. As they state (ibid, p. 3): "the first type of representation seeks to represent phenomena as experienced with the senses (or sense-extensions); the second seeks to support a qualitative explanation of those phenomena, whilst the third seeks to support a quantitative explanation of these phenomena." Following from the explanation given by the authors the second, model type concerns "entities that are too small to be seen using optical microscopes" (ibid, p. 4). The third level "involves the allocation of symbols to represent atoms, whether of one element or of linked groups of several elements; of signs to represent electrical charge; of subscripts to indicate the number of atoms in an individual ion or molecule; of letters to indicate the physical state of the entity (....)" (*ibid*, p. 4). Based on a literature survey they choose as names for the representations: *macro*, *submicro* and *symbolic*.

Reflections. The model emphasises which is usually viewed as the central core of chemistry: the relation between macroscopic chemical and physical properties of substances, and structures on micro level, that is atoms and molecules. Chemists are capable to relate these two worlds and in chemical research molecular models are frequently used to predict chemical activity. One of our objections against the model is the use of the terms *macro* and *submicro*. It seems that these refer to dimensions: *macro* stands for macroscopic properties that are observable, either direct or by the use of instruments; *submicro* refers to unobservable particles. Meijer et al. (2009) propose a *meso* level between the *macro* and *submicro* levels. By analysing the practices of professionals they found that some chemical practices, like in the production of ceramics and food, meso structures are used in research. To our opinion, focusing on dimensions of particles and structures misses the point. The focus should rather be on the concept pair *properties – structures* than on *macro – submicro*.

Further, we should bear in mind that the triplet relationship originates from reflections on how chemists reason and it does not come from an educational perspective. For this reason, the model does not address the question how to guide students from observable phenomena (substance properties) to explanatory models (structures). This path leads from describing observations from intitially context-dependent to generalised language ('disappearance of sugar'-'melting of sugar'-'sugar is soluble in water') to abstractions and models (hydration of sugar molecules through formation of hydrogen bonds) to explain regularities in chemical phenomena (that certain substances containing oxygen and hydrogen are soluble in water). It is obvious that intermediate stages or levels in the learning process are necessary (Goedhart, 1999). This means that the triplet representation gives the ends of the spectrum, not making explicit the intermediate stages in the learning process.

Symbols are widely used in chemistry and symbols are certainly a blockage for students in learning chemistry. The word symbol is used in a narrow sense in the triplet representation. It is about the symbols used in names and formulas of substances, in reaction equations and symbols for quantities (like pH or K_{eq}), but names of substances and quantities are not included. Although the symbolic language of chemistry is confusing and difficult to learn for students we think that symbols are as difficult as the chemical terms (see: Sutton, 1992). For students it is not the only problem to know what the symbol 'pH' means, but also understanding the concept of pH including the underlying concepts, such as equilibrium, acids and bases.

Conclusions. Although the representation triplet is a useful tool in chemical education, we experienced some problems with the definitions of the representations. In the model proposed by Gilbert and Treagust the *macro* and *submicro* levels seem to refer to observable vs. unobservable dimensions rather than the relation between properties and explanatory models.

We do not only consider the symbolic language as a characteristic for chemical education but we like to extend this to the chemical language as such.

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KAPITAŁ LUDZKI
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The use of computer to register student's actions in chemistry learning activities.

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Keywords: learning dialogues, ICT, virtual molecular objects, simulation,

Background, framework and purpose. Information and communication technologies (ICT) has been helping the development of strategies and methodologies to study meaning promotion, since audio and video is now easily recorded in digital format and the data obtained can be accessed faster. We have developed a methodology to record simultaneously the student's actions and the screen-in-use, when they were working with learning activities mediated by a computer. We found out that the often referred essential teaching exchange 'IRF' (Fischer, 1992; Wegerif et al., 2003) may be changed depending on the kind of the activity students are asked to perform. In this case the activities performed included the assembly of concrete and virtual molecular models, besides textual answers. We also present some data that shows how much time they spend interacting with the peer, the screen, or the teacher (also in the computer lab), or combinations like peer and screen, or teacher and screen, while performing the learning activities.

Methods. Our group has developed a series of hypertext chemistry learning activities which includes texts and tools to visualize (Posso and Giordan, 2008; Giordan, 2008), manipulate (Giordan and Gois, 2009) and build virtual molecular objects (Gois, 2007; Giordan, 2008). In these learning activities students were asked nine questions that included textual answers, as well as manipulation and creation of concrete and virtual molecular models. In all questions the couples were supposed do discuss while writing the answers in the system or assembling the models. The learning activities included a tool, also developed in our group, named 'Construtor', where students can create virtual molecular objects from their condensed structural formula (eg. $CH3CH2CH3$). The data has been obtained from a simultaneous taping system, where both the screen-in-use and student's actions were taped synchronically. We have transcribed a 48 minutes class and we drawn on the speech episodes in categories related to what students were interacting. We decided to divide the data in five categories of interaction: peer, screen, teacher, peer and screen, teacher and screen, described in table 1.

Categorie	Description
Peer (P)	students talking to the other, but not interacting with computer through its peripherals (keyboard, mouse or screen)
Screen (S)	students not talking to the other, but just interacting with the computer
Teacher (T)	students not talking to the other, but talking together to the teacher and not interacting with computer peripherals
Peer/Screen (P/S)	students talking to the other and interacting with the computer
Teacher/Screen (T/S)	students talking to the teacher and interacting with the computer

Table 1. The table shows the description of the five categories chosen in this work to describe the data obtained.

Results. Table 2 shows some results obtained. As expected, students spent more time in peer/ screen (P/S) interaction, as they had to interact with the system and their peer to perform the learning activities. They also spent almost three minutes (S) only reading/re-reading the activities, without talking, and only about seven minutes (P) just talking to their peers. This time includes the periods of loosing attention and talking about other things out of the subject (chemistry), and also the time they spent assembling concrete models (about 60% of this time). The time spent talking to the teacher and using the computer (T/S) is bigger (about ten minutes) than the time spent talking to the peer, and the time spent talking to the teacher without using the computer (T) is the smallest. From the results we can say that students did loose their attention talking about other things, but they mostly used their time interacting with the teacher, the peer and the computer to solve the proposed activities. They called the teacher to help for a considerable time (second bigger time) but they preferably worked with his/her peer to perform the tasks (bigger and third bigger time).

	T/S	P/S	T	S	**P**	Total
seconds	583	1683	30	174	410	2880
minutes	9,7	28,1	0,5	2,9	6,8	48,0
%	20,24	58,44	1,04	6,04	14,24	100

Table 2. The table shows the time used in interactions with the teacher (T), the screen (S) and other, according to categories shown in table1.

We are proposing out a new interaction model, called 'IMF', from the 'IRF' (**I**nitiation, **R**esponse and **F**eedback) model. The assembling of concrete and virtual molecular objects, started from the **I**nitiation of an exercise (teacher speech turn), required them to **D**iscuss and **R**esponse at the same time and continuously while assembling the three-dimensional structure, waiting the **F**eedback from the teacher when finished. We named this long turn, what could be characterized as a specific discoursive moviment, where students talk about a molecular structure and builds it, in either concrete or virtual way, 'Modeling'.

Conclusions and implications. Students spend their time mostly talking and interacting with the computer AT THE SAME TIME in this activity.

A new pattern of discoursive interaction is proposed, Initiation, Modeling, Feedback (IMF). The IMF interaction model depends on the activities proposed to students. Proposing learning activities where students can talk and manipulate/assembly molecular models at the same time may support different kinds of meaning elaboration.

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Learning safety in chemistry in the industry to prevent accident at work and professional diseases.

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In the industry, most of the chemistry is done by non-chemist operators. Most of chemicals are used by people who never had any knowledge concerning chemistry or safety rules. In the laboratory, some chemists are more worried by their synthesis than by the risk ; just as if nothing can happen to them because they are used to handle chemicals.

Each year, workers are injured in their work by industrial accident, people are sick from professional diseases because of no-safe handling of chemicals, sometimes many years after being exposed. The costs of professional accidents and diseases is supported in France by the Social Security.

In fact, occupational risk prevention in France, under the responsibility of the ministry in charge of labor, is a dual system : State authorities on one side, and Social Security on the other side. The French National Health Insurance Fund manages, at a national level, sickness and industrial accidents/professional diseases branches of the social security general scheme.

At a regional level : 16 Regional Health Insurance Funds (Caisses régionales d'assurance maladie / CRAM) are involved in prevention and industrial accident and occupational disease pricing. They implement the policy guidelines set by the national level (Cnamts) and fit them to the regional context : **health and safety at work is our priority**. Our mission is to develop and coordinate prevention of occupational hazards, to contribute to the improvement of the working conditions and to determine the contribution rate for each firm. Several means are available such as council control, technical assistance, training, learning, documentation or financial incentives. Various topics are defined to guide our field of actions, for example: chemical safety and occupational cancer, musculoskeletal disorders, road risk, training, risks in building construction…

We offer different learning ways in the field of health and safety at work, the first one is direct coaching from the manager to the workers :

- organization and management in prevention for managers
- necessary steps and methods for every body concerned in prevention
- specific risks
- specific business sectors (metallurgy, chemistry, services …)
- learning to teachers

For all activities, we are able to help and propose specific learning, even on new topics. But for well known subject, we signed agreement with learning organisms, who relay our methods.

The other way to improve knowledge and to let companies work alone, is to give information products written by specialists to a wide public. Practical prevention solutions can be found in those brochures.

Each company have to do its risks analysis, therefore the first step is to know where are the dangers. The main difficulty with chemistry is that the dangers may change with the time and with a better knowledge of chemical. As an example trichloroethylene was not identified as a carcinogen product last century and it was massively used for cleaning in metallurgy. Nowadays, we are fighting against its employ, that require inquiry and learning but also proposal for doing else [1]. **The easiest way to reduce danger is to use less dangerous chemicals.** According to the public and to the subject, different documentations teach how to recognize the dangers of chemical : dangers for the health of the employees, danger of a fire or explosion and danger for the environment.

The second step is to identify the risk situation, it means that workers are exposed to a risk ; in our case, the worker is exposed to chemicals. The exposure could be chronic - weak and regular that lead to diseases or intense, strong and massive that lead to the accident.

The easiest way to reduce risk is to use a safer process.

As an example, solvents are frequently used in all business sectors, and their risks are little or not at all known by users such painters, printers, cleaners…. Therefore, we published a guide describing where they are and how to use them the best way as possible [2]. This is a work tool, easily understandable by everybody, even for those who have no skill in chemistry. The risks are explained starting from the substances chemical properties, following with the exposure according to the working situation and ending by prevention.

Finally, the manager have to built an action plan to reduce the risks. All solutions must be studied, even a change of practice. **The best solutions are the durable ones**.

As an example, in the “solvents guide-book”[2], a question based method can lead to substituted dangerous substances. Otherwise, many brochures are available in order to ventilate emissive operations and prevent pollution to be spread into the working area [3].

Chemical safety in industry is a huge subject. Not only chemical industries are concerned, but all kind of industries using chemicals. Chemical industries have quiet a good practice in risk analysis and in handling chemical safe, but most of the other industries use chemicals for their technical properties without having a look at the dangers, without thinking of the risks, without making any risk evaluation. A lot of accidents or diseases could be avoided if workers have an adapted learning and training, and if more people were involved in prevention. That’s why over and over again training at all level, made by different way is so important.

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New educational environment to realize e-Learning in chemistry

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Keywords: e-learning, study assessment.

The wide use of information technologies (IT) and communication technologies in the educational process of science in impacted by lack of software that would meet the requirements of modern didactics. To improve current situation it is important to create flexible and user friendly simple software. Such software should let teachers create their own educational area. It is important to provide the opportunity to fill the shell with modern and dynamic contents by teacher, as well as that should allow pupil to learn and to assess the learning process.

Traditionally the main carrier of chemistry educational information was and still is the text-book. In the last 15 years the internet has evolved and now it formed an important part of our lives. The computer is becoming vital tool for obtaining and processing of the educational information. At that, the IT became the defining factor of learning process effectiveness and student's actual learning activity.

Currently there are many approaches created in attempt to introduce the information and communication technologies into learning process. Some of those are included in the chemistry curriculum. For instance, within the project "Curriculum development and in-service training of teachers in science, mathematics and technology" (2005-2008) in Latvia a CD educational materials were created for students of form 10-12. This material supports the self-education and self-control [2]. Currently within the project "Natural science and Mathematics" (2008-2011) similar materials are developed to support chemistry curriculum for form 8-9.

The unquestionable advantage of such kind of materials, comparing to the text-book, is attractive presentation of the educational information. There is also an option for the student to choose individual course of learning. This course is supported by different exercises in order to reinforce learned material. The process of training could be adjusted to the required individual level.

In the modern world many of the scientific discoveries within the chemistry almost momentarily became new technologies, which essentially change people lives. But from our point of view it is the lacking possibility for teacher efficiently change the course and supporting materials is the vital disadvantage of the majority of currently existing e-learning educational areas. It is also impossible to widen the range of information or change the level of difficulty in the chemistry educational software.

As an alternative that keeps positive experience and choose the materials of already existing educational area we introduce the GENEXIS (2007-2009) [1]. This product realizes the idea of e-learning integration with the traditional educating in chemistry.

The main idea of GENEXIS is to resolve the two great problems of teaching and learning process. The two problems are - the lack of interest in the study process among learners, and the inability of teachers to deliver the most recent and up-to-date educational content in a simple way. GENEXIS is the e-learning product that was developed in order to give teachers possibility to create interesting content. And also it is a tool used for educating the students in a manner that corresponds to the modern internet-saturated life. The easy content editor provides teachers with the opportunity to create theoretical materials, exercises and tests – all in one place and all easily accessible for the students through the web. It allows creation of the unlimited amount of training options on chemistry as well as gives opportunity to monitor student's progress throughout the study process.

Statistical data that is gathered by GENEXIS provides full traceability of progress and performance results of each class or individual. There is no need for teachers to waste extra time on gathering and analyzing the data. The GENEXIS content can also be used on interactive whiteboards during lessons and that in itself makes this software compatible with the other resources and tools.

GENEXIS gives an opportunity for teachers to expand their creativity and to increase the productivity of their work. It has different options to use multimedia materials, insert files and web links through one simple editor. It gives teachers the new ways to make their educational materials more attractive and engaging like never before. There are also communications services incorporated within the GENEXIS that can save teacher's time and provide new ways to interact with the students.

From implementation of GENEXIS students will receive major benefits that are otherwise unavailable to them from the books or Internet alone. First of all, they would have the opportunity to learn from their personal mistakes ("learning-by-doing"). The major difference between GENEXIS and other systems such as Moodle is the content editor that allows teachers to create exercise templates. The GENEXIS generates multiple variations of one exercise using such exercise templates. This way each student can receive an individual exercise for homework or test. It also can use one exercise template to train for several times because the new variation of the same exercise is generated each time. When student completes the exercise the system evaluates the result and shows the solution enabling student to "learn-by-doing".

Approbation of the GENEXIS system was performed as a part of Leonardo da Vinci Transfer of Innovation project "Computer based Exercise Generation and Evaluation System for Mathematics, Physics and Chemistry Subjects – GENEXIS". The testing and evaluation of the GENEXIS was carried out until end of 2009 in 5 different countries. Altogether there were 21 educational organizations that were involved in the project: 3 vocational, 1 secondary and 1 primary school in Latvia, 6 vocational education schools in Lithuania, 4 vocational education schools in Estonia, 5 vocational education schools in Slovakia and 1 college in the United Kingdom.

The testing and evaluation process of the GENEX involved approbation of GENEXIS functionality, assessment of the available content and evaluation of the system user guidelines. All experts, who evaluated GENEXIS, found that it helps making the learning process more efficient by generating unlimited variations of exercises on any theme or subject. GENEXIS helps making teaching and learning process more productive and less frustrating, benefiting everyone involved in the education and training.

As a result of testing there were recommendations and suggestions from teachers for the improvements of GENEXIS system. Everyday work still continues on improving GENEXIS functionality and design to make it even better.

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Modelling students' evaluation and judgement competence in chemistry education considering external influential aspects

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Keywords: Chemistry, standards, competence, evaluation and judgement, paper-pencil-test

Background, framework and purpose. The Standing Conference of the Ministers of Education and Cultural Affairs has established National Educational Standards (NES) as a consequence of the unsatisfying results in international studies like TIMSS and PISA. These standards define competences amongst others for the scientific subjects (biology, chemistry and physics). Students should have acquired these competences when they graduate from middle schools after grade 9 or 10 (depending on the school type). The standards are described for different areas of competence (*content knowledge, acquirement of knowledge, communication and evaluation and judgement*) (KMK, 2005). The NES are evaluated and enhanced by the Institute for Educational Progress (IQB) in cooperation with institutes for science education at different universities in the project ESNaS[1] in order to compare the achievement in the different German states and to optimise the standards. This paper focuses on the operationalisation of the *evaluation and judgement competence* only.

The NES define the *evaluation and judgement competence* in chemistry as the ability to detect and evaluate chemical topics in different contexts (KMK, 2005a). Furthermore, in other research projects, the *evaluation and judgement competence* is defined as the ability to decide justifiedly and systematically in complex problem-situations at different options of behaviour (e.g. Bögeholz, Hößle, Langlet, Sander, & Schlüter, 2004).

According to Poschmann, Riebenstahl, & Schmidt-Kallert (1998), an evaluation process consists of a minimum of three elements (object, subject, connection between object and subject). During this process criteria have to be identified, evaluation strategies have to be used, and finally a decision has to be made (Jungermann, Pfister, & Fischer, 2005).

Based on these theoretical assumptions Eggert & Bögeholz (2006) have developed a competence model with the focus on sustainable development in biology to measure the evaluation and judgement competence (e.g. Eggert & Bögeholz, 2006; Bögeholz et al., 2004). This model has not been used for other subjects so far. Because of its focus on the sustainable development, it cannot be directly adapted for other subjects or topics. Furthermore, there is already a competence model in ESNaS which has been used for the areas application of content knowledge and acquirement of knowledge until now. By means of the biological competence model the competence model in ESNaS should be adapted for the evaluation and judgement competence. After that items - consistent with the model - will be constructed to investigate the research questions.

In addition, it can be assumed that the evaluation and judgement competence is influenced by several external factors as there are:

1. Subject-related aspects, which include the content knowledge and the application of content knowledge, related to the topics of the items.
2. Interdisciplinary aspects, which include knowledge and application of evaluation strategies and estimation of data quality.
3. Personal aspects, which include individual attitudes and social desirability.

1. Evaluation of the National Educational Standards for Natural Sciences at the Lower Secondary Level

The research object of this study is the students' evaluation and judgement competence in chemistry education. In the study the following research questions are investigated:

1. To which extent is students' evaluation and judgement competence influenced by external aspects?
2. Is it possible to identify a chemistry-specific evaluation and judgement competence which can be separated from that in other subjects (e.g. biology)?

Methods. A quantitative empirical design is used for data collection. The whole sample of the main study includes 600 students from 10th grade of German upper secondary schools (Gymnasium). The time needed by students to fill out the tests and questionnaires will be 180 minutes and data are collected on two days. The instruments used on the first day (90 minutes) are:

1. A newly developed test of evaluation and judgement in chemical/biological contexts to measure the general evaluation and judgement competence in biology and in chemistry
2. A test on content knowledge and on application of content knowledge in biology and chemistry
3. A test on social desirability - German version of the balanced inventory of desirable responding (Paulhus, 1998; Musch, Brockhaus, & Bröder, 2002)

The following tests are used on the second day (90 minutes):

1. The cognitive ability test (Heller & Perleth, 2000) to control the influence of the intelligence
2. A test measuring the students' estimation of data quality
3. A test on knowledge and on application of evaluation strategies in everyday life contexts
4. A test concerning individual attitudes

In addition, interviews will be performed with one part of the sample in order to validate the competence model. Because of the fact that the tests are newly developed, test parameters cannot be stated at this time. The usual criteria (reliability, validity, objectivity, difficulty) will be arised in a pilot study.

Results. At the present time (October 2009), a first pilot study is running and there are no results available yet. Preliminary results will be available and presented at the ECRICE (July 2010).

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Experience from three EU-funded projects: Pros and Cons

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Keywords: EU-funded project, science education, teacher training, innovation, crossing boundaries

At the EU Lisbon summit in 2000 the European leaders set themselves the mission of becoming the world‘s knowledge powerhouse by 2010, the world‘s most dynamic knowledge based economy. There are of course many problems related to reaching this ambitious goal. Thus they appointed the European High Level Group on Human Resources in Science and Technology to analyze the current situation and work out recommendations for future developments. In its 2004 report „Europe needs more Scientists" the group defined demands on common efforts and a networking approach of politicians, schools, universities and industry to improve Europe's science education. This report constituted the basis for calls in the European 6th and 7th Framework funding programmes in the area of science and society.

The main part of this contribution will be the report of experiences within a FP6 project compared with those from two other EC-funded projects in the Comenius and Leonardo da Vinci programmes, which could help other researchers in their considerations about whether or not to participate in a proposal to the EU. The FP6 project PARSEL (Popularity and Relevance in Science Education for Scientific Literacy, 2010), a coordinated action of partners from eight European nations, aimed at raising the popularity and relevance of science teaching and enhancing students' scientific and technological literacy. We collected and developed innovative science teaching modules, tested them in different countries, identified best practice examples and disseminated these throughout Europe.

The partners from seven European countries in the Comenius 2.1 project CROSSNET (Crossing Boundaries in Science Teacher Education, 2010) focussed mainly on the improvement of science teacher education in European countries through case studies in national school sets and the exchange and dissemination of innovative results. "Crossing boundaries" is a framework for new paths of exchange across science and science related subjects, schools and their sub-divisions, and institutions for teacher education, administration and politics in different countries. The common goal of the six partners from four nations in the Leonardo da Vinci project "Animated Science" (2010) is the Development and implementation of an online further training tutorial for primary and secondary school teachers in how to use students' production of animations as a didactic tool in science. I coordinated PARSEL and CROSSNET and acted as a partner in Animated Science projects.

If a science educator has a hypothesis of how to improve students' learning success and considers its testing through a project, or if there is a proven and tested method or material which should be implemented and distributed on a wider level, then it needs to be decided whether it's possible to realize the project through the institution's own budget, or whether it's necessary to apply for third party funding from national or international sources.

What could be the reasons for a science education researcher to write a proposal to the EC or participate in a proposal? Where do you find help in preparing the proposal? How do you find adequate partners? What is the outcome of these projects for the community? And what is the outcome for the single researcher? Is it worth to take on that additional challenge and possible troubles? What recommendations could be given to future proposers? These are questions that arose and should be illuminated and discussed.

All these questions can be answered very differently depending on the personal situation of the researcher, his/her institution and the home country. In this presentation I will show how I answered these questions for myself referring to the above mentioned projects, what outcome the projects produced, what added value the community gained and what profit I myself and my partners attained. Recommendations to future proposers based on our experience will be given and discussed.

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The suitability of history of science in chemistry textbooks. The opposite positions of Lavoisier and Fourcroy

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Keywords: chemistry education, textbooks of chemistry, science teacher training, history of science, Lavoisier, Fourcroy.

Chemistry has been an institutionally teachable science the since early seventeenth century. At that time chemistry was taught as a discipline allied to medicine, natural history and pharmacy. Faculties of medicine, schools of pharmacy as well as private courses became the usual sites to disseminate an ancient knowledge that had been transmitted mostly from master to apprentice in the workshops of apothecaries, acids and spirit of wine distilleries, dye-works, metallurgical smelters and assayers, glass and ceramic manufactures, soap-makers; and so on. This long teaching tradition was accompanied by a large textbook tradition rooted in the publication of Andreas Livabius' *Alchemia* (1597) which transformed chemistry into a practice that could be taught systematically. Therefore chemistry textbooks became an indispensable means to instruct people entering the discipline, people who in turn could become chemistry teachers later. In this last sense, textbooks of chemistry as teacher training resources from seventeenth century onwards should not be dismissed.

During the seventeenth and eighteenth centuries France led the publication of chemistry textbooks. Accordingly, it was in this prolific chemistry textbook tradition where discussions about the teaching of chemistry appeared sooner than in other companion sciences. A salient discussion was the one about the presence of the history of science in chemistry teaching. The French chemists Lavoisier and Fourcroy kept opposite positions on the suitability of history of science in chemistry textbooks. Lavoisier was not so much in favour of incorporating the history of science in chemistry teaching as Fourcroy. This early discussion on the usefulness of history of science in science teaching resulted premonitory for the future debates on the same issue up to the present days. The presentation of this historic episode pretends to provide a historical referential frame for the contributions to this symposium concerning the role of history of chemistry in both chemistry teaching and science teacher training.

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Heuristic Thinking makes a Chemist Smart

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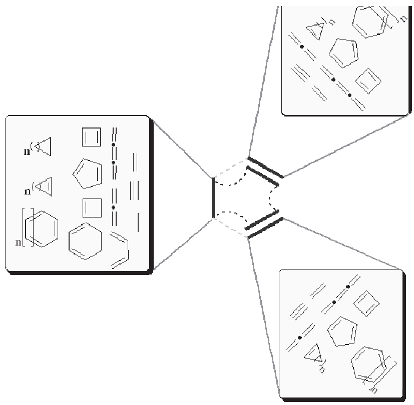
Keywords: heuristics, teaching organic chemistry, curricula analysis, pericyclic reactions

We focus on the virtually neglected use of heuristic principles in understanding, predicting, and teaching of organic chemistry. As human thinking is not comparable to computer systems employing factual knowledge and algorithms – people rarely make decisions through careful considerations of every possible event and its probability, risks or usefulness – research in science and teaching must include psychological aspects of human decision making processes. Intuitive analogical and associative reasoning and the ability to categorize unexpected findings typically demonstrated by experienced chemists should be made accessible to young learners through heuristic concepts. Heuristics as strategies or rules of thumb guide and organize human problem-solving and deciding procedures, for example with patterns and analogies, and prototypes. Since research in the field of artificial intelligence and current studies in the psychology of cognition have provided evidence for the usefulness of heuristics in discovery (Gigerenzer, 2007), the status of heuristics has grown into something useful and teachable.

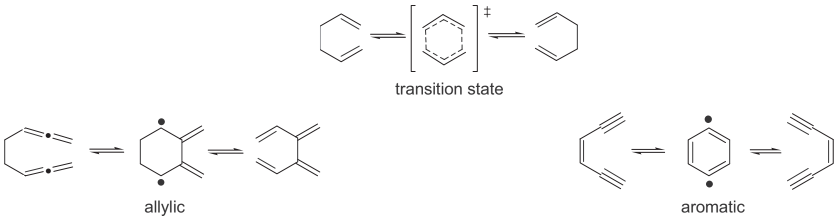
Teaching organic chemistry is, with the daily practice in mind, often far from providing adequate concepts for an efficient reasoning or the creation of new compounds or ideas. Students often have problems with structure-reactivity relationships (Mayr & Ofial, 2006) or with solving or proposing organic mechanisms (Bhattacharyya & Bodner, 2005). Their knowledge is often factual rather than operational (Nakhleh, Lowrey, & Mitchell, 1996). Most of the chemistry curricula have evolved in a deeply historical way. Therefore the general structure of classical organic chemistry textbooks lacks an extensive revision regarding the aged focus on functional groups and the missing assimilation of recent research findings.

Here we present a heuristic analysis of pericyclic reactions as one fundamental process in organic chemistry and propose a concept for the cyclic six electron case (Graulich, Hopf, & Schreiner, 2010). For this new family of reaction a structure and a reactivity principle had been developed that is not only applicable to pericyclic reactions but can be enlarged to cycloaddition or other reaction involving six electrons. The minimal structural element of pericyclic reaction is represented by the famous Cope reactions. This 1,5-hexadiene pattern is the necessary unit to undergo thermal rearrangements. With the help of computational methods Schreiner et al. computed a large variety of unsaturated hydrocarbons with the structural unit and deduced a simple principle that a "non-concerted reaction takes place when



Scheme 1: Minimal structural requirement of pericyclic reactions

biradical intermediates are stabilized either by allyl or aromatic resonance" (Schreiner, Navarro-Vásquez, & Prall, 2004). Important pericyclic reactions, like the Bergman or Myers-Saito reaction, that do not proceed concerted, but stepwise via biradical intermediate have been treated poorly in organic chemistry textbooks, but can be easily included with the new concept.



Scheme 2: Thee types of reactivity for the six electron case.

The purpose is to provide a simply and comprehensible concept that can be used as a tool in judging and evaluating the reactivity of unsaturated hydrocarbons that comprise the necessary structural element for this family. Pericyclic reactions are in general presented in textbooks to be concerted and are classified in intramolecular sigmatropic and electrocyclic reactions or intermolecular cycloadditions, with differences in bond breaking and bond formation, with no regard of the electron involved. Our heuristic concept is therefore more intuitively accessible, as it only considers the six electron case and an easily memorable structural pattern. Due to its open character the heuristic concept is transferable to a variety of reactions. In order to gain insight into the enhancement of understanding pericyclic reactions and the prediction of mechanisms, a qualitative case study design are under way with undergraduate chemistry students.

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Towards an effective use of MBL through analyse of video films of an activity with conductivity sensor in a teacher training course.

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Background and framework. Microcomputer Based Technology (MBL) consists on one or more sensors connected to an interphase and this to a computer. Such equipments allow users to have the graphs of an experiment in real time. This technology has been strongly recommended by many science educators who adopt a constructivist approach to education (Tortosa et al, 2008). MBL has demonstrated the ability to improve students understanding of science concepts and cognitive skills such as observation and prediction The ability of the computers to display the data graphically is cited as one of the reasons why MBL is so effective (Friedler, Y et al. 1990). However, the effectiveness of ICT is linked to pedagogical models and strategies surrounding ICT activities. The use of MBL in chemistry lessons has increased en last years among secondary teachers en Catalonia, but the use of sensors is not generalized and teachers usually don't feel confident of the use of this equipment (Pintó, R.; Sáez, M, 2006).

Reflexive practice is a teacher training methodology, based on the experience of teachers in their own practice, in which teachers share and contrast their teaching. Teachers learn from each other "peer to peer learning" and the teacher trainer is as the other participants, but at the same time he has the role of expert and delivers the theoretical information (Korthagen, F.,2001). The use of reflective practice methodology in teacher training promotes the formation of learning's communities (Tigchelaar et al, 2005).

The pilot course designed during the Comenius project "Effective use of ICT in science education" (Demkaninn et al. 2008; Guitart, J. et al., 2009) uses reflexive practice as a teacher training methodology and includes the results of the analysis of good ICT practices. Some analysis and reflections point toward the use of MBL to develop general skills and scientific competencies in students (Lope, S. et al., 2009).

Purpose. What are the most relevant aspects of MBL activity to achieve an effective use? How teacher training strategies promote an improvement of the use of MBL in classroom? These are some of the questions which the communication deals. The main purposes of the communication are the analysis of main features of an MBL activity using the conductivity sensor focusing in the classroom management, and also the analysis of some videos filmed when teachers perform an MBL activity with high school students. Some of video films were used in the teacher training course based on reflexive practice methodology to improve the effective use of MBL. It is also analysed feedback from teachers engaged in the teacher training course.

Methodology. The results were collected from questionnaires of video film analysis and from worksheets used in the teacher training course. The teacher training course was developed with reflexive practice methodology and engaged sixteen teachers. The teachers saw video films in where other teachers performed ICT experiments in classroom. The results of this work are about the analysis of one of the video films of an experiment (Tortosa, 2008) in which students collect data using a conductivity sensor connected to MBL equipment. Students could calculate, from their results, the amount of iron in a polluted water in order to remove the metal of it. The laboratory worksheets were designed as a learning cycle. The analysis of video films was focused on classroom management, but also included questions about the laboratory worksheet. The analysis of the comments and opinions of teachers who were engaged in teacher training course, were drawn from feedback by participants during the course.

Results. Communication brings the results of analysis questionnaires of classroom video films used in this course and feedback from participants. The questionnaire responses lead the participants to highlight the many factors and aspects related to the effective use of ICT. The results of questionnaire shown that teachers clearly identify in the video film presented aspects such as a good distribution of equipments, enough time so students can make hypothesis and predictions, the discussion of their predictions between them, the dialogue between students and teacher, the contrast between predictions and the graph and how conclusions are drawn.

Conclusions and implications. Communication brings conclusions about an effective use of ICT based on the results of analysis questionnaires of classroom video films, the comments from teachers involved in the course, and feedback from participants in the teacher training course. From our results we conclude that one relevant feature is related to the design of student worksheets and the context in which the activity is presented to students. Another finding from the analysis of the video films is the importance of classroom management. Another important aspect is that the participants in the reflexive teacher training course consider that to see video films of activities and the videotaping of their own activities as an important tool to learn about how to perform these activities and how to improve their practices. The comments of teachers after the course were positive and they highlighted the importance of MBL in the graph plotter and importance of didactic and pedagogical aspects involved in the use of MBL. Effective use of MBL activities is largely determined by aspects as classroom methodology and a teacher training that promotes reflection about teacher's own practice.

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Educació Química *EduQ*: a journal of Chemistry education from Catalonia that wishes contributions and dissemination across Europe

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Introduction: Chemistry education and the chemistry teachers in Catalonia

In Catalonia, students begin to learn about chemistry in primary school education (6-12 years old). This introduction to chemistry is included as part of their social and natural science education.

In compulsory secondary education (12-16 years old), students study Science, which includes all experimental sciences: Chemistry, Physics, Biology and Geology. It is a compulsory subject for the first three years of secondary education. In their fourth year, students interested in Chemistry have the opportunity to choose this subject to keep on learning this science.

In upper-secondary education (16-18 years old) students who choose scientific studies, generally study Chemistry for two years, although it isn't a compulsory subject for all students who will study technical or scientific subjects at university.

In a higher level, Chemistry is studied by most university students of sciences (Chemistry, Biology, Physics, Biochemistry, etc), health sciences (Medicine, Pharmacy, etc.), and engineering or other technical sciences (Materials Science, Environmental Sciences, etc.).

All these different levels in the chemistry education mean that there are very different professional profiles of chemistry teachers. All teachers have the aim of get students involved in chemistry, help them to overcome the difficulties of learning chemistry, etc. And, they also need to promote their own professional development to keep updated in teaching and learning resources and methodologies.

Chemistry education journals: innovation and research. Pre-service and in-service teacher training has an important role in the professional development of teachers in each educational level. But sometimes it's no enough. Teachers also need other ways to exchange experiences, to improve their teaching methods and to know about innovative resources and strategies.

Moreover, teachers haven't often had many opportunities to develop professionally and learn about other types of Chemistry education across all levels of teaching. Teachers of chemistry in different levels of education have a lot of shared ideas and problems, but they know very little between them.

The importance of innovation and research is paramount to the professional development of teachers. Generally teachers at primary and secondary school don't have enough time and enough opportunities to know the results of research in science education and to improve their own practice with new ideas and resources.

It is important to refer to specialized publications in teaching and learning chemistry, which help teachers grow and provide their students with the best possible education. The role of this kind of journals is to offer teachers the opportunity to know innovative experiences, an approach to the results of chemistry educations, curricular projects, strategies and resources, etc. Although there are journals with this type of aims available in other languages, the journal EduQ is the first Spanish publication to specialize in Chemistry education.

The main goals of EduQ. Chemistry is a fascinating subject, but teaching and learning chemistry can be a challenge. Chemistry teachers of similar levels of education, for example, primary education, secondary education etc. have more possibility to converse. It is often more difficult to communicate across these different levels of education. EduQ wishes to be a link between teachers of chemistry to help them in teaching chemistry.

The aim of Educació Química EduQ is to provide a medium that will enable teachers of all levels of Chemistry to communicate and exchange research, experiences and ideas. The journal also aims to be a focus point for new teachers who are completing or have completed their master degree in education.

EduQ is a specialised journal for the teaching of chemistry across all levels, with a special emphasis in secondary education (12-18 years-old), and for the discussion of relationships between chemistry and society. It is a tool to facilitate strategies and innovative teaching resources in chemistry education, and to help teachers improve their working day and continued teacher development.

EduQ would like to be a way to exchange experiences between chemistry teachers and to create a link between all types of chemistry teacher, as well as to provide an interest for the teachers of other sciences.

Origins and characteristics of EduQ. Educació Química EduQ is committed to delivering the highest editorial and ethical standards in the publications of the Institut d'Estudis Catalans (IEC). It is edited by the Catalan Chemistry Society (SCQ), which is an affiliated society of the Institut d'Estudis Catalans (IEC).

With its sections and affiliated societies, the Institute promotes and develops research in different fields of science and technology, but mainly of all the elements of Catalan culture. The institution is, above all, a centre of Catalan culture with long-range projects, such as making documentaries or large corpus critical editions.

EduQ is journal created under the auspices of the editorial board, who are assisted by associated editors, collaborators, and an advisory panel. The prestige on the IEC ensures the highest quality of publication and the possibilities to spread this publication among teachers of chemistry across different countries.

The journal EduQ is structured in a way that allows a wide range of information to be discussed across the broad spectrum of Chemistry education. These areas are:

- Chemistry Today,
- Curriculum based projects
- The innovative classroom.
- Concepts in chemistry
- Teaching resources and strategies
- Working practises in the lab.
- New technical innovations
- History and the nature of chemistry
- Chemistry and society
- Chemistry and environmental education
- Chemistry teaching research
- Teacher development
- Students´ research
- Chemistry and other sciences
- Language and terminology

The technical characteristics of EduQ are as follows. It's a journal written in Catalan, although in each issue there will be articles in other languages, such as Spanish, French, Portuguese, Italian and English.

EduQ is published three times a year, with sixty-four pages, and contains between seven and nine articles all printed in colour. It also contains a section for book, magazine and online material, and a calendar which will detail recent and future events.

We will publish new, previously unpublished, articles, and from time to time will include special monothematic editions.

EduQ is available in print and online from the web page of publications of the IEC http://publicacions.iec.cat/PopulaFitxa.do?moduleName=revistes_cientifiques&subModuleName=&idColleccio=6090) or from the web page of the Catalan Chemistry Society (http://scq.iec.cat/).

Future Perspectives

We have continued success in Catalonia, in which most of secondary school have got a subscription of the journal. The journal is sent to all the members of Catalan Chemistry Society. Also we have got subscriptions from teachers of the rest of Spain and from some teachers of other countries.

We seek to increase the profile of this journal internationally to share and converse with the largest audience possible, across Europe and Latin America. Although the journal is predominantly in Catalan, we seek and encourage contribution from all languages and countries to create a truly international journal.

This journal has been presented in different conferences and cities of Catalonia, in other parts of Spain, in Portugal, in Colombia, and this year will see presentations in Chemistry education conferences in Poland, Mexico and Brazil. We aim to continue promotion this journal on the international stage because this is a good way to spread the journal and to encourage teachers of chemistry to send contributions.

We invite Chemistry teachers from all countries, levels, disciplines and interests to submit articles for future publication.

Aureli Caamańo and Fina Guitart, Editors SCQ of EduQ

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

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International cooperation of the Institute of Chemical Education

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Keywords: chemistry, curricular basis, key competences, distant teaching, multimedia

The Institute of Chemical Education at Adam Mickiewicz University in Poznań for many years has been cooperating with numerous universities as well as other research and educational institutions in Europe. The cooperation covers the following research topics: 1. Scope and manners of visualizing chemical issues, 2. Multimedia structure and form of textbooks, 3. Interactive board and its state-of-art educational form, 4. Internet set of chemistry experiments and its application aimed at improving the quality of chemical education on all levels of education, 5. The application of miniature portable devices such as the palmtop for developing students' experimental skills and abilities, 6. Scope of application of e-learning and b-learning for chemical education, 7. Efficiency of implementation of remote learning platforms in chemical education, primarily within intramural and postgraduate studies.

Since 2005 research projects within the Leonardo da Vinci program have been carried out in cooperation with such institutions as St. K. Ohridski University (Sofia, Bulgaria), Twente University (Holland) and Genoa University (Italy). Our activities have been aimed at working out a methodology for junior high school and high school general chemical education using information technology and, at the same time, examining the efficacy of IT tools for developing students' social skills. The project involved numerous teachers from all of the above countries who were trained to work within the new e-learning system (Miranowicz, 2009.

In 2007 our cooperation with Universidad Nacional de Educación a Distancia (UNED) in Madrid started within the Life Long Learning – Erasmus program. Based on the bilateral contracts our students and undergraduates spent several months doing research at UNED whereas our academics gave numerous lectures at that University. The cooperation involves exchanging experience related to the use of remote learning platforms on various levels of Science teaching (van Diepen, Stefanova & Miranowicz, 2009).

Our Institute has been cooperating with Charles University in Prague for almost twenty years. In 2005 several agreements were signed which resulted in cyclical meetings and exchanges for students and academics who have gained substantial experience in the field of application of chemistry experiments in education as well as multimedia textbooks (Gulińska, 2009).

Our positive experience encouraged us to enter into another agreement within the LLL Socrates-Erasmus program, this time with Hradec Kralove University. The cooperation covers research work into the role of chemistry experiment in teacher training as well as into assisting the experiments with new technologies on various levels of education. Additionally, both universities are working on the implementation of didactic means in order to improve the quality of chemical education involving students with impaired hearing and speech as well as on the application of theories of experiment in Chemistry teaching (Jagodziński & Wolski, 2009).

In 2005 an agreement between Karlstad University in Sweden and the Institute of Chemical Education was signed. The cooperation covers the improvement of chemical education on all educational levels by working out innovative curricula and developing new manners of visualization of chemical issues. The following projects on computer assisted chemistry teaching have been worked upon: 1. Interactive forms of classical tools for quantitative and qualitative data visualization – a set of internet diagrams, 2. Hypermedia tools for presenting tests with various types of tasks in the GIFT standard - a testing module, 3. Adjusting the module of "fill in the gaps" tasks in balance equations ("Stechem") for balancing ionic and redox reactions (Miranowicz, 2009).

The cooperation between our Institute and Tokyo University of Science has been going on since 2006 which allowed many Polish students and academics to carry out comparative studies on the efficacy of problem teaching exercised in Polish as well as in Japanese schools (Jagodziński, Wolski, Čipera & Kusokabe, 2009).

Within the international educational program implemented by Microsoft, two distance learning platforms have been developed to meet the needs of courses designed for Chemistry students and teachers. More courses for students and teachers may be also found on Microsoft SharePoint platform at http://www.partnerstwodlaprzyszlosci.edu.pl/lms. We also participated in several international conferences where new distance learning technologies were presented. Additionally, the conferences provided the opportunity to present the results of research into the efficacy of distant learning techniques in teaching Chemistry at university level (Gulińska, 2009).

All of the discussed research and exchange work carried out within the agreements resulted with numerous publications. The following literature was published in 2009 alone.

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Promoting microlevel understanding of water :web-based material for classroom teachers

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Keywords: Web-based material, classroom teachers, surface tension of water

Background, framework and purpose. National (Finnish) core curriculum for basic chemistry education was introduced in autumn 2004. One of the new aspects in this curriculum was to emphasise cross-curricular themes connecting science with phenomena of everyday life. Cross-curricular themes connect school's culture and priority areas, overcome subject borderlines and represent educational challenges with social significance. Besides introducing important societal contexts, science education was also extended to the 5th and 6th grades (11 and 12 year-old students) with separated chemistry and physics as subjects. In lower grades physics and chemistry have been integrated within environmental and natural studies.[1]

Introducing a new curriculum raises many questions that concern teaching and learning science in the framework of the new guidelines. In this work, the main research interest lies in which kind of influence does these cross-curricular themes have on basic education. One of the cross-curricular themes is water, which represents a familiar and important topic in 5 - 6 grade science educations.

To support training of in-field and student classroom teachers, web-based material about water and its properties has been developed ("Water in the Net" **http://virtuaaliyliopisto.jyu.fi/oppi/ako/**). The material is in its final stage of development and targeted for general training and reference usage to support classroom teachers in their educational needs. The material covers water and its properties, as well as a descriptive account on phenomena such as surface tension, hardness and electrical conductivity of water and microlevel representations of chemical bonding taking place in water.

Methods. Recently, the web-based material was preliminary tested with nine classroom teacher students. The students were asked to answer a questionnaire after familiarizing themselves with the material. Thereafter, a slightly modified questionnaire was introduced to a second group (N=12) of teacher students.

All answer sheets were analyzed in order to find out whether the web material was suitable for teaching purposes. Also, the answers and feedback from the tests were used to modify the material and to find out possible sources of misunderstanding and misinterpretations regarding the chemical concepts and phenomena involved.

In this presentation the focus is on the outcome of two open questions included in the questionnaire. The questions are

(i) What is the meaning of water molecular structure for surface tension?
(ii) What is the consequence of bonding of water on surface tension?

Results. In general, the web-based material was regarded suitable for revising scientific views of water. It was also considered to be easily accessible and easily adopted in support to the used textbooks. On the other hand, when asked two research questions above, a surprisingly few detailed anwers were received.

For question (i) 12 answers out of 21 were classified as wrong or not an answer at all. Additionally, none of the responses cited or reflected the view presented in the web-based material.

For the second question (ii) only four (4/21) respondents gave a resonable answer of bonding of water upon surface tension, and seven (7/21) respondent described it with their own words but showed an understanding of the hydrogen-bonded network formed by water.

Conclusions and implications. Preliminary results on the web-based teaching material on water and the research regarding it indicate that the material appears quite functional and applicable. The strength of the material seems to be that when difficult subjects are approached, versatile methods can be used. Both the development of the material and the research regarding its teaching and learning impacts are still in progress. More research and development work is needed in the future. Multiple representations are needed to support the connection between different levels of scientifical knowledge, i.e. between macroscopic and microscopic levels in this case.

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Factors affecting the take-up of third level science in Ireland with special reference to the Transition Year

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Keywords: Science education; Transition Year Programme; Third level Science; Subject choice; Irish education system

Background, framework and purpose. *"Traditionally science teaching in Ireland has been largely didactic with teachers and students performing clearly defined experiments as prescribed"* (Forfás 1999, p.20)

The recent TALIS report (2009) noted that Irish teachers are more likely to use didactic and traditional teacher-centred methods than teachers in other countries, particularly in Mathematics and Science, as opposed to student-oriented practices and enhanced activities (Gilleece et al., 2009). This can turn pupils off the subjects and away from career paths in Mathematics and Science. The Irish education system is *"highly standardised with nationally specified curricula and examinations at both Junior and Leaving Certificate levels"* (Smyth 2004, p.7) allowing little room for innovation.

However, the Transition Year Programme (TYP) is an optional year between the junior and senior cycles in Irish second-level schools and offers the school the autonomy to design their own TYP curriculum. (Transition Year Second Level Support Service, 2006) The TYP is considered to be particularly innovative in its emphasis on *"personal development, self-directed learning and the absence of standardised assessment procedures."* (Smyth et al., 2004, p.1) This research study seeks to examine the factors affecting a student's decision to undertake a third level Science based course, and in particular, to examine the influence of the TYP on this decision. Studies have shown that there can be many variables affecting a student's enrolment in a Science course (Milner et al., 1987; Politis et al., 2007)

This is part of a broader project investigating the place of Science in the TYP and the impact of doing science during the TYP on students' subject choices and career decisions. (Childs et al., 2009)

Methods. A questionnaire was developed for the 400 3rd level first year General Chemistry students at the University of Limerick, guided by the following research questions:

- How can taking science in the TYP influence the uptake of science at senior cycle?
- How can taking science in the TYP influence the uptake of science at 3rd level?
- What are the influences acting on students who take a Science based course at 3rd level?

This module is taken by students from a number of Science, Science Education and Engineering courses. The questionnaire was designed to examine what factors were important in influencing the student to take a Science based degree. It was also critical to the larger study to gain a snapshot of these students' experiences of the Transition Year programme during their second level course and to gain insight into what effect this had on their decision to study the sciences. There was a response rate of 88.75% (N =355) to this questionnaire. The findings of this questionnaire were analysed using SPSS 16.0.

Results. The preliminary analysis of the results shows a number of interesting findings. Parental influence towards taking a science based 3rd level course was the strongest influence

(48.2%) for all students ($p < 0.005$). The subject teacher is also a significant influence ($p < 0.001$) for students when deciding whether or not to take a science-based course at third level. Interestingly, the type of school that students came from had a significant impact ($p < 0.001$) on the course area they entered, particularly for the students in Engineering and Science.

Just under half the sample surveyed (43.0%) had taken the Transition Year Programme, which is close to the national TYP uptake (50.7%), and considered it to have been important factor when deciding what subjects to take at Senior Cycle, though when related to science- based subjects this is not a significant influence. However, taking the Transition Year Option has had a significant effect on the grades achieved in the physical sciences for the Leaving Certificate, thus impacting on the courses taken by students at third level.

The cohort strongly believed that it is important to do a Science subject for the Leaving Certificate, with 92.6% of students rating it important or very important. However, girls believed this more strongly than boys ($p < 0.05$). 84.8% of students also considered Mathematical understanding to be important or very important.

Conclusions and Implications. It is clear from this analysis that subject teachers are almost as influential as parents when students are making the decision of what subjects to take for their third level education. Transition Year does not have the type of significant impact that one would expect, given that it is a curriculum free year, with the opportunity this presents to develop a real interest and passion for science. Osborne (2008) notes that *"the standard school science education has consistently failed to develop anything other than a naďve understanding of the nature of science"*. Previous work (Childs et al, 2009) has shown that the majority of teachers (67%) do not take the opportunity to innovate but instead teach from the senior cycle science courses. The types of activities undertaken in Transition Year science will be examined in order to address the lack of impact that the year is having.

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Different Types Of Ion Chromatography: A Comparative Study With Educational Purposes

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Keywords: Upper-Division Undergraduate, Analytical Chemistry, Hands-on Learning, Chromatography, HPLC

Chromatography methods are defined by the chief separation mechanism used [1]. Ion chromatography is one member of this large family of chromatographic methods. It can be used – to put it very simply – to determine all ions which carry one or two charges. The technique has been applied successfully for the determination of inorganic and organic anions and cations [2-3]. Analytes are separated by means of their different retention in an anion or cation-exchange column. Typical operating procedures use isocratic and very small sample injection volumes.

Nowadays there are three types of Ion Chromatography. Ion exchange chromatography is simply known as ion chromatography (IC), while ion pair chromatography (IPC) and ion exclusion chromatography (IEC) are regarded as being more specialized applications.

There are many papers about education on IC and its history and evolution in 20th century [4-8], but to the best of our knowledge, no papers dealing with different educational aspects of ion chromatography have been reported. For the proposed study, pupils in the classroom were divided into two groups for appreciating the active learning gained versus traditional lab activities.

In this work we propose that students do a comparative study of different types of ion chromatography. The characteristics, applications and advantages and disadvantages of such types were evaluated by undergraduate students for meaningful and interactive learning. The use of so-called chemical suppressors for the reduction of the conductivity of eluent is also studied for improving students´ attitudes toward, and their conceptual understanding of, Ion Chromatography.

Pupils were focused on the underlying principles of IC, IPC and IEC. For this purpose, they made some posters explaining the three different types of ion chromatography. Drinking water samples were analyzed by IC. Analytical results were compared with those obtained by molecular absorption spectroscopy and potentiometric methods [9] by applying the ANOVA test at the 95 % confidence level.

After the instruction, a post-test was applied to determinate their knowledge related to Ion Chromatography. The test was running using the Learning Management System Moodle.

The proposed study is suitable as a teamwork exercise for enhancing some analytical and chemometric concepts. It also provides instructors feedback on the degree of assimilation by the students of the taught material. In our laboratory this experiment is scheduled in three to four three-hour lab sessions, but, as the experiment is modular, work can be easily tailored to the structure of each course and the time availability.

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Students' Abilities in Transferring Mathematical Knowledge to Chemistry

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Keywords: transfer, mathematics in chemistry.

Anecdotal evidence as well as some publications (Berressem 2005, Yates 2007,) either state explicitly or allude to a 'maths problem' in chemistry. With this background in mind, it justifies the purpose of the following research questions, namely: 1) Can students transfer mathematical knowledge from a mathematics context to a chemistry context? (hereafter referred to as the transfer question) and 2) What are the factors associated with students being able to transfer? (hereafter referred to as the factors-associated-with-transfer question).

The possible factors associated with transfer that were investigated were twofold. Firstly, the study sought to determine if students who are able to explain their mathematical reasoning for a particular mathematical item in a mathematics context associate with transfer more so than students who are not. The second factor probed was that of 'graphicacy' whereby it was investigated if students who are able to translate algebraic-type mathematical items—algebraic items which can be used in a chemistry context—into their graphical representation in a mathematics context associate with transferring these algebraic-type items more so than students who cannot.

Because our questions are concerned with the transfer of learning, the framework which we adopted to answer them is that of the traditional view of the transfer of learning as described by Lobato (2003). Our research questions mirror with the questions constituting the 'research question dimension' of the traditional view of the transfer of learning. Our question of transfer resonates with the first traditional-view-of-the-transfer-of-learning question, namely: was transfer obtained?; while our factors-associated-with-transfer question strikes a chord with the second traditional-view-of-the-transfer-of-learning question namely: what conditions facilitate transfer?

Our research methodology involved the design and administration of Diagnostic Tools to a group of 30 2nd year undergraduate students in order to determine their ability to transfer mathematics pertinent to chemical kinetics and thermodynamics from a mathematics context to a chemistry context. The tools have been designed on the basis of students having completed a 1st year calculus course (which should have equipped them with the necessary mathematical knowledge relevant to a chemical kinetics and thermodynamics course) and a 2nd year chemistry module, which encompasses thermodynamics and kinetics. The mathematical items probed, included for example: the calculation of slope, interpreting derivative, and the graphical representation of an integral; they numbered 15 in total.

In terms of determining if students who answered each mathematical item correctly in a mathematics context tended to associate with transfer, categorical statistical tests were used. For each item, either the Chi-Squared Test or Fisher's Exact Test was used. Likewise, similar tests were used to investigate the factors-associated-with-transfer question.

Investigating if students who evidenced an ability to explain their mathematical reasoning for a particular mathematical item in a mathematics context associate with transfer more so than students who could not, involved using the principles of qualitative data analysis as described by Cohen et al. (2000). This type of analysis comprised of a number of stages. Essentially, it involved categorising a students' response with being either indicative of an ability or an inability to explain their reasoning in a mathematics context.

Results wise, in terms of the transfer question, of the 15 mathematical items investigated, students transferred 9 of these. With respect to the factors-associated-with-transfer question, it was found that students who evidenced an ability to explain their answer for 8 of the 11 mathematical items requiring an ability to explain reasoning, associated with transferring these 8 items. Lastly with respect to the 3 algebraic-type mathematical items which had a graphical equivalent, students who could answer the graphical equivalent did not associate with transferring any of these algebraic items.

For each of the 9 mathematical items, which students transferred, the implication that can be drawn is that if students possess the necessary mathematical knowledge for these particular mathematical items, they will be able to transfer. For the 6 mathematical items, which students did not transfer, the question of why this is so cannot be answered at present because of the theoretical framework that underpins the study. Instead, an actor-oriented approach to the transfer of learning would be necessary.

Investigating the factors, which may associate with students being able to transfer leads one to conclude that fostering an ability amongst students to explain their mathematical reasoning in a mathematics context may allow them to transfer.

Overall, a tentative conclusion is that the teaching and assessment of the undergraduate calculus course which this sample of students were exposed to needs to be focussed on getting students to explain the underlying mathematical knowledge which is being presented to them, in order for them to be able to transfer. How this is being achieved for certain mathematical items in this study will be discussed in tandem with research results thus far.

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A Study On Identification Of Science Teachers Level Of Following, Understanding And Use Of Educational Research

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Keywords: Science teaching, educational research, research-practice gap

Research suggest that there is a gap between research and practice, teachers do not benefit from research done and therefore the impact of research in practice is quite weak (Costa, Marques, & Kempa, 2000; Çepni & Küçük, 2003; De Jong, 2004; Ekiz, 2006; Greenwood & Maheadly, 2001; McIntyre, 2005). The primary purpose of research in education is to improve the quality of education by providing solutions to the problems encountered in practice. Therefore it is expected that teachers get benefited from the education research in overcoming the problems they face in classroom.

In this study, it was aimed to investigate the science teachers' attitudes towards educational research, whether they follow research done in education or not, if they follow whether they understand it and finally how they implement the results of research into practice. For this purpose a qualitative approach was employed. The data were collected through semi-structured individual and focus group interviews. An interview protocol was developed in the light of the research papers (Costa et al, 2000; De Jong, 2004; Ekiz, 2006; Everton, Galton, & Pell, 2000; Küçük & Çepni, 2005; Shkedi, 1998) by the researchers. The interviews were performed by face to face with total of 80 (38 female and 42 male) science teachers who work in two main cities in the eastern Anatolia.

All interviews were transcribed and the interview data were analysed through descriptive and content analysis by use of Nvivo qualitative data analysis software. The analysis results are grouped under the following two broad headings:

- 72.5% (58 teachers) of science teachers are either not aware of educational research or do not follow it. The rest of 14 of them (17.5%) are aware of the educational research but they only follow them if they needed. Only 8 out of 80 science teachers (10%) stated that they are aware of educational research and follow in a regular basis.
- Majority of the science teachers (72.5%) reported that they do not know how and where to reach to the education research reports. Most of them (59.1%) also do not believe that educational research will help them for overcoming their problems encountered in practice.

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How Learning Styles, Chemistry Attitudes and Experiences, and Demographics Affect Academic Success in Students Taking First and Second Year Chemistry Courses

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Keywords: Learning Styles, Kolb, First Generation, Chemistry Attitudes and Experiences Questionnaire, Confidence

At Brock University, the Faculty of Mathematics and Science has the highest percentage of students on academic probation. Students report the most difficulty with Introductory Chemistry in first year and Organic Chemistry in second year. In order to identify strategies to improve students' performance in Chemistry and reduce the number of students on academic probation, a multi-year research project was undertaken. Students in first year Chemistry courses were asked to complete three questionnaires on two occasions during the academic year, once near the beginning of the term in October, and again at their last lecture in April. Those students who took Organic and Analytical Chemistry in their second year were again asked to complete these questionnaires. The purpose of retesting was to identify differences from the beginning of first year to the end of first year, from first year to second year, and differences in strategies among students taking both Organic and Analytical Chemistry.

The three questionnaires included the Kolb Learning Styles Inventory (Kolb, 1984) which was modified slightly to include specific reference to chemistry in each question. The Kolb Learning Styles Inventory classifies students' learning styles into one of four quadrants based on their ranking of responses to twelve statements regarding learning preferences. These quadrants are shown below in Figure 1.

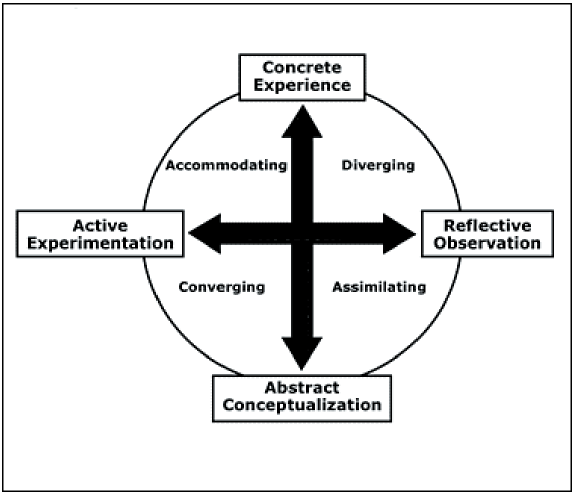

Figure 1. Kolb Learning Style

The second questionnaire was Dalgety, Coll, and Jones' (2003) Chemistry Attitudes and Experiences Questionnaire (CAEQ), and lastly, a demographic survey prepared by the researchers with input from Brock University's Department of Psychology.

The results of the Kolb Learning Styles Inventory showed that in first year chemistry, the majority of the students were Convergers (Active Experimentation and Abstract Conceptualization), or Assimilators (Reflective Observation and Abstract Conceptualization). Differences were identified among females and males, with more females being categorized in learning styles which favoured Reflective Observation over Active Experimentation. Differences were also noted among females and males in terms of academic success, number of failures, and number of withdrawals from the course. When the Learning Styles of the students were plotted versus grades, it was noted that students in the Assimilator and Convergers generally outperformed the Accommodators and Divergers.

These results revealed that those students who prefer learning through concrete experiences are generally not as academically successful in first year chemistry as those who prefer abstract learning. Efforts to improve teaching to these students through more in-class demonstrations, real-life examples, and the use of model kits and computer modeling is encouraged. These strategies would benefit all students, but would be of particular assistance to those in the Accommodator and Divergers categories.

Results of the CAEQ show that while confidence increases with ability (as measured by academic success), males reported a higher level of confidence than females. This was true even for females who were quite successful with their studies in Chemistry.

The Demographic data revealed differences in First Generation students' success as compared to those students who had a parent or sibling who attended university. Differences included grades, pressure to succeed, and withdrawal percentages. Drop-in help for Chemistry showed remarkable results for students who attended on a regular basis; once per week or more. It was noted that this service is particularly helpful for First Generation students who are often intimidated by their instructors. Future work will study these students in more detail to identify other methods to assist this group of students. Additional tutorials have been implemented and students are showing further improvement in exam results. The data of the students from second year is in the process of being analyzed.

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Identification Of Students' Understandings About Radiation And Radioactivity

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Nuclear science is an important subject in science and especially undergraduate chemistry and physics education that have been active in the development of technological applications. By the way, nuclear science have an central role in many fields of our lives such as medicine, producing electricity, geology, agriculture, sterilization, food irradiation, archaeology, and industry etc (Hutchison & Hutchison, 1997). However, the recent studies have shown that students at the different level from elementary school to university have many scientifically incorrect conceptions that labelled as misconceptions about the subjects of *radioactive decay* and *half-life* (Eijkelhof & Millar, 1988; Huestis, 2002; Nakiboglu & Tekin, 2006; Prather, 2005), *ionising and non ionising radiation* (Millar, Eijkelhof & Eijkelhof, 1990; Mubeen et all., 2008) *irradiation and contamination* (Millar R., Gill, 1996), nuclear waste (Zevos, 2002) in the context of nuclear science (Millar, 1994; Millar & Gill, 1996). Misconceptions adversely influence construction of knowledge and so learning process (Bodner 1986; Ben-Zvi, Eylon & Silbertein 1986; Brown 1992; Jonassen 1991). For this reason, before the instruction, determination of students' misconceptions about related subject is very important processes to provide construction of knowledge effectively (Stavy, 1991; Harrison & Treagust, 1996; Acar & Tarhan, 2008). This study was accomplished in the light of this fact, and aimed to investigate university students' misconceptions related to *radiation and radioactivity*. Totally 682 university students enrolled in science, chemistry, and physics departments from different universities were participated in this study. Students' understandings and misconceptions were identified by using a two tier diagnostic test, which was developed by the researchers and ensured the validities and reliabilities (KR-20=0.72). The ANOVA results of the test showed that there were significantly differences between science, chemistry, and physics departments in terms of mean scores obtained from diagnostic test. Students' responses were also analysed by the researchers to identify their misconceptions and misunderstandings. According to these results, it was found that while students in all the departments had similar misconceptions related to the concepts of *ionizing radiation, non-ionizing radiation, nuclear and chemical reactions, radioactivity, radioactive material, radioactive decay, nuclear binding energy, stable and unstable nucleus, contamination and irradiation*. These findings indicate that although university students learn the subjects of radioactivity and radiation in their regular chemistry and physics lessons, they could not understand the nature of these concepts and have difficulties in associating their theoretical knowledge with everyday applications. This situation underlines ill-success of traditional educational system and the need of changing the instructional methods. For this reason, in the further research, it is aimed to develop new instructional materials to teach radioactivity and radiation concepts.

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The construction of a Didactical fact from a Historical fact: The Chemical Atom

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Keywords: atomic theory, school science, history of chemistry, pedagogical content knowledge (or 'didactical transposition')

Background, framework and purpose. The aim of our proposal is the elaboration of research-informed instructional units for preservice chemistry teachers education (at secondary level, 12-18 years). Our research about history of chemistry provide us a critical perspective that may inform pedagogy in very useful ways (Adúriz Bravo et al., 2009).

Recent curriculum recommendations emphasise the requirement of 'competences to apply knowledge'. Current science teaching aims at generating scientific activity in those who learn in order to make them 'competent': capable of acting as citizens. To achieve this, science teaching today should provide understanding of the complexity of the situations in which scientific entities were generated and achieved their meaning.

Chemistry teaching at secondary level starts with atomic theory but, for students, this 'atom' is a physical particle with a structure and not, as History of Chemistry shows, a chemical entity that gives meaning to this physical particle (Izquierdo et al., 2009).

In previous papers (Izquierdo et al., 2003) we have commented the absence of authentic processes of 'theoretical modelling' in chemistry teaching: chemical facts are explained as examples of an atomic theory of which the main entity is a physical particle. In this paper we present a set of 'stories' inspired in history of Chemistry (in the 'tradition of substances', since the XVIIth century onwards) that constitutes instructional units to the teaching of atom and Periodical Table of Elements (Bensaude-Vincent, 1994, 1979).

Method. Our research is qualitative. There are two different working ways: content analysis of textbook and design of didactical units as 'modeling', that have to be implemented in our courses of preservice secondary teachers education (Sensévy et al., 2008), with a specific aim: developing chemical activity in the classroom. The relations between them constitute our main focus of our research and inspire us to write 'stories' which gives occasion to think about the need of a 'chemical (quantitative) atom' to explain and the chemical change

Results. In our research we identified the differences between the 'chemical atomism' (Rocke, 1984) / Medeleeiev's 'System of Elements' and the information about 'atomic theory' / current 'Periodical Table' in chemistry textbooks. We identified also evidences that many students and their compulsory education without grasping the basic concepts of chemistry (substance, element, atom, chemical change...) and its own 'magnitude' (the quantity of substance), even if they are able to talk about the structure of atoms. (Furió et al, 2006). The periodic table is no longer, for students (Linares, 2004) a 'system' of chemistry and, for they, atom is a scientific discovery in XX century and not a chemical entity that structured the knowledge in XIX century, and organise the new physical ideas in XX century (Scerri, 2007)

Our main result is a new didactical proposal to introduce atom as a 'quantity of substance' and to give them an internal structure step by step, when specific chemical changes has been introduced, with a sequence of 'stories' (related to the context of J. Béguin, J. Black, J. Dalton, A. Laurent) for asking the good questions about an atom – chemical element

Conclusions and implications. Chemistry cannot be introduced only via physical entities;

the praxis of chemistry is irreducible to that of physics. Our 'stories from history' (our didactical units) seem to work powerfully in terms of enhancing preservice science teachers understanding of the core concepts of chemistry

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Chemistry experiment in educational films for students with speech and hearing deficiency

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The need to communicate is one of the most important psychological needs of human beings. Communication is also the only way to learn about the surrounding world. For people to be able to communicate, a common code or system of signs that are understood and accepted by everyone is needed.

In 1994, the Salamanca Declaration was signed by numerous countries, including Poland. The document outlined the framework of policy and practice regarding special education needs as well as stressed the importance of sign language as a means of communication for people with hearing and speech deficiency. Furthermore, it was agreed that each deaf person should be provided with access to education in their own native sign language.

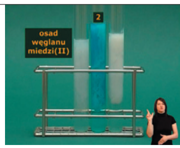
In 1997, a document "Directions of change in education for disabled students" was issued by the Minister of Education where bilingual learning, i.e. sign language in combination with mother tongue, is believed to be the best educational method for deaf students. In order to facilitate communication of people with hearing and speech impediments with the world of non-handicapped people around them, it is advisable to use educational films. World literature does not provide many publications on the use of didactic means, including instructive film materials, to support teaching chemistry to students with hearing and speaking impairments.

It is possible to use educational films for chemical education of students with the above deficiencies and therefore a set of films presenting chemistry experiments was prepared for junior high school and high school deaf students. Special versions of the films call for special approach to demonstrating chemistry experiments. The pace in which the information is presented must be modified, as well as the icons used in the films or the narrator's voice intonation. What is needed here is an abundance of graphic signs which make it easier for the students to perceive visual elements of the films. One of key novelties here is the translation of the narrator's commentaries into sign language. Unfortunately, this language does not have many signs to describe chemistry terms which makes the translation extremely difficult. To address this need, a glossary of chemistry terms in sign language has been prepared.

Below are some frames form the films.

Examining electrical conductivity of saline solutions

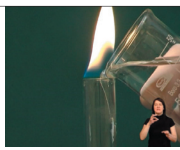
Obtaining salts



Precipitating salts of slight solubility

Detection of carbon in organic substances

Detection of multiple bonds in unsaturated hydrocarbon molecules


Examining chemical properties of ethene

Preliminary research carried out with the participation of teenagers with hearing deficiency with the use of films translated into sign language has proved high educational efficacy of these films. A survey has also been also done where students commented on the pace of presenting information and potential advantages of such films in chemical education. The students were to decide whether the comment translated into sign language made it easier for them to understand the issues presented in the film and whether that was of any help whilst doing hands-on experiments at school.

The teaching effectiveness of instructive films was studied on high school students from the experimental group and compared to the results of the three control groups. Students from the experimental group worked with films in full version. Students from control group 1 worked with the films without the sign language interpreter, those fro group 2 worked with the films without instructive inscriptions and those of group 3 with the films with inscriptions but without the sign language interpreter. The results of learning the information from the films were compared among the groups to estimate the teaching effectiveness and the effect of the sign language interpreter on the degree of understanding of certain chemical problems. The results were subjected to statistical analysis.

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The improvement of chemistry teaching through international scientific and educational cooperation

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Keywords: Chemistry teaching, international cooperation, EU scientific and educational programmes

The increase in international scientific and educational cooperation has had a growing impact on the process of teaching chemistry and its effects in a number of countries. This cooperation stems from an increasing awareness that problems related to education have similar causes no matter which country they concern. Many countries, particularly developed ones, have observed common problems such as the decrease in students' interest in science subjects (OECD, 2006), difficulties in curriculum design and teachers' reluctance to improve their teaching methods. The similarity of identified problems has been confirmed by the results of international studies designed to compare the effectiveness of education systems such as PISA (What PISA is, 2010). Reports draw up by international teams include an analysis of these problems together with suggested solutions addressed to all the countries interested in the issue (Osborne & Dillon, 2008). At the same time, cooperation is facilitated by rapid information exchange, easy direct contact and above all financial support which is provided under an array of programmes.

International cooperation can take various forms. It usually starts with informal ties between persons from different countries who are trying to solve common problems. The next stage can be to formalise such cooperation, particularly if it is long-term, by signing an agreement between particular institutions. At present, especially in EU member states, international cooperation is developing thanks to special scientific and educational programmes, which require the participation of partners from different countries.

"Science in Society" was recognised as one of the fields of activities within the 7th Framework Programme. In 2010 the following topics, which could potentially benefit chemistry teaching, were planned under Activity 5.2.2. Young people and science (Science in Society. FP7 Capacities Work Programme, 2010):

- SiS-2010-2.2.1-1 Supporting and coordinating actions on innovative methods in science education: teacher training on inquiry based teaching methods on a large scale in Europe;
- SiS-2010-2.2.2-1 Reinforcing links between science education and S&T careers in the private sector through reinforcing the partnership industry/education;
- SiS-2010-2.2.3-1 Science curricula and their objectives: balancing the needs between training for future scientists and broader societal needs.

Comenius is another EU programme which creates opportunities for international cooperation. It focuses on the first phase of education, from pre-school and primary to secondary schools. It is relevant for all members of the education community: pupils, teachers, public authorities, parents' associations, non-government organisations, teacher training institutes, universities and all educational staff (Comenius Programme, 2010). The following Comenius actions managed by the EACEA (Education, Audiovisual and Culture Executive Agency) could lead to the improvement of chemistry teaching:

- Comenius Multilateral Projects - undertaken to change initial or in-service training of teachers to develop strategies or exchange experiences to improve the quality of teaching and learning in the classroom;

- Comenius Multilateral Networks - designed to promote European co-operation and innovation in specific thematic areas of particular importance to school education in a European context and have to represent as a minimum organisations from 6 countries.

An example of an international comparative research project not supported directly by the EU is ROSE (2010). Its aim is to establish the key factors in learning science and technology. At present over 40 countries are taking part in it.

If international cooperation is to bring benefits to the partners involved, it needs to meet a range of conditions. First of all, a relevant theme which will be the subject of cooperation must be established. The theme must be of interest to all the partners, who should also have some experience in it, preferably mutually complementary. The intended end result should take into account the needs and the situation of each partner. The second condition, closely related to the first one, is the choice of partners who will participate and an appropriate distribution of duties. This points to the issue of organising work efficiently, which is particularly difficult when a number of diverse partners are cooperating with each other. The last important condition to be met is the acquisition of financial means needed to perform the tasks which the cooperation involves. Although the programmes mentioned above facilitate this, some other difficulties arise. The partners have to find the necessary information about the programme under which their cooperation could be financed, to put considerable effort into preparing their applications and to manage the project later on in the process. Thus, international cooperation requires taking several additional actions. However, considering the benefits it offers, which include not only achieving its immediate objective, but also exchanging experiences, taking advantage of the potential of all participating partners and mutual support in the activities they undertake, it is definitely worthwhile.

During the microsymposium the speakers will present their experiences of participating in various forms of international cooperation aimed at the improvement of chemistry teaching.

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Analysis about the organic chemistry teaching in secondary school[1]

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Framework and purpose. In this work we present the results of an investigation made in a girls' lyceum where we present the didactic unit of organic chemistry. They appear from the perspective of the teacher in formation, giving a criticized look from the theory and the practice about the work and how it was got for the teenagers which were employed. The general idea of this investigation is to promote the scientific language but from a green offer, that is to say, motivating to the student body to seeing the science from an amicable and environmental look, beside producing changes in their paradigms with regard to the science itself (Sutton, 2003).

In this investigation we base on the Pragmatic Naturalistic Realism, from which it is interpreted to the world from different points of view, doing of the sciences a deeply human activity, and which contributes to the knowledge and to its transformation. (Toulmin, 1972). The education of the chemistry has different edges, is because of it that to teach chemistry is necessary to have presented the way of teaching from the proposed focus, this education of the science tries to interpret the world, and this one is the reason for which it is so important to have the suitable model of education of the chemistry. This investigation showed us that the students had different conceptions about of the organic chemistry, from this; we manage to improve the designs of the activities that they were proposing, from changes to the suggested for the curriculum, up to the incorporation of the contributions of the philosophy of the sciences, to improve the way of doing pedagogy. The general approximation is that the activity in classroom, centered on the design and in the development of the didactic activities that seek to establish bridges between the previous ideas and the explanatory models, took as a final point of which the student is the builder of her own explanatory models.

Method and intention of research. The didactic implications of this one Didactic Unit (DU) had as one of their objectives of bearing in mind what the student knows and this way to derive the use what they know how:

a) The use of representations in order that the students communicate their models
b) The use of representations or intermediate models
c) The use of different representations of phenomena, of combined form supporting mutually
d) The incorporation process of regulation of the representation

The second objective is the reflection on the same practice of DU, observing the proposed activities, departing from the planning, the second objective is the reflection on the same practice of DU, observing the proposed activities, departing from the planning, in which remains clear and which they can be possible problems and solutions, since this science is new they adapt the frames that are known in other areas to adapt to the classroom, in order to identify obstacles. Another important aspect is the teacher, who was working as mediator between the knowledge achieving the didactic transposition from to be able wise person towards knows teaching (Chevallard, 1985). From this perspective and bearing in mind that DU of "Organic Chemistry ", were trying to give a perspective where a student anyone could be caps of skills develop cognitive linguists, if to obtain a significant learning (Sutton, 2003).

[1] Scientific Product derived from FONDECYT research 1095149 (Abbr.) sponsored by CONICYT – CHILE.

Results and advances. The skills that are worked, initially were difficult and required special attention Since the students have not been systematic and sustained work in the time, why to within of the didactic sequence proposes it submit some texts that will serve to achieve different skills cognitive-linguistic, grouping and defining follows;

a) Describe is to produce statements to enumerate qualities, properties, features an object, etc. body or phenomenon of what is.
b) Explaining is to relate the facts together and to the ideas.
c) Justify is relate the facts with the theoretical model.
d) Argue is discuss the model used to interpret the phenomena will relevance of convincing.
e) Define is describe concepts to based on their properties or characteristics more relevant.

From the Nature of the Science can be the integration of different areas of work involving reflections, implicitly noting the conceptual changes, such as resolutions of the problems in work more practical, in the internal gaze. We must reflect on the classroom and as this conceptual framework help to improve practices teachers get to teach the necessary content in the curriculum, but from different, giving him not only a drawing eyes instrumental, also a significant and social level.

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The use of X-Ray Fluorescence as an educational tool

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Background, framework and purpose. One of the most important advantages of the Energy Dispersive X-Ray Fluorescence (EDXRF) is its ability to take multielemental spectra in relatively short time. This can give the possibility of an easy qualitative analysis that can be used as a “direct optical view” of many elements of the periodic system. Many of these element usually are unknown to the students but really present in ordinary samples. The spectra can be used for interpretation of the atomic model (connection of the observed lines with the respective atomic energy levels), as well as with the absorption and Moseley laws. Additional advantages is the possibility of direct argon analysis (argon is a principal component of the atmosphere -almost 1%- but this is more or less unknown to many students) and radioactive decay demonstration (of the used radioactive sources).

Methods. The samples were analysed by energy dispersive x-ray fluorescence; they were excited by a radioactive ^{109}Cd, ^{55}Fe, ^{241}Am annular x-ray sources. These sources gave the possibility of simultaneous analysis of practically all the elements (with the exception of light ones) from their K and/or L lines. Elements with atomic number lower than 14 (Si) was not possible to be analysed due to strong x-ray absorption effects. The secondary x-rays, produced by the samples, were detected by Si(Li) semiconductor detector and Si-PIN detectors with resolution 150 eV and 200eV respectively at 5.9 keV. The signal was amplified by suitable electronic systems (including pile-up rejection and dead time correction), and collected in PC with a multichannel analyser. The time of analysis was a few minutes (1-5).

Results. In the Figure 1 the periodic table of the elements was divided in 3 different regions: the no detected elements (black background), the detected with moderate detection limits (grey background) and well detected (white background).

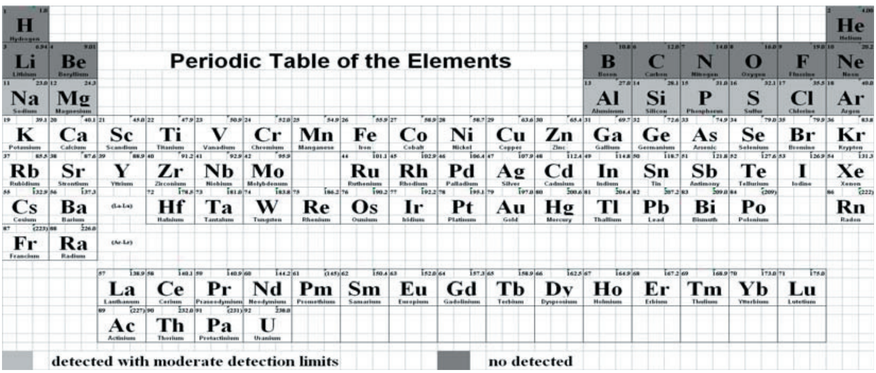

Figure 1. The X-Ray analysed elements

The well detected elements are better analysed by a ^{109}Cd radioactive source for the analysis of K-Zr elements (from their K lines) and La-U (L lines). ^{241}Am gives better results in the analysis of Rb-Eu (K-Lines). The moderate detected elements (grey font) and the no detected elements (black font) that are better analysed with ^{55}Fe source. A characteristic x-ray spectra srom soil analysis is given in Fig.2.

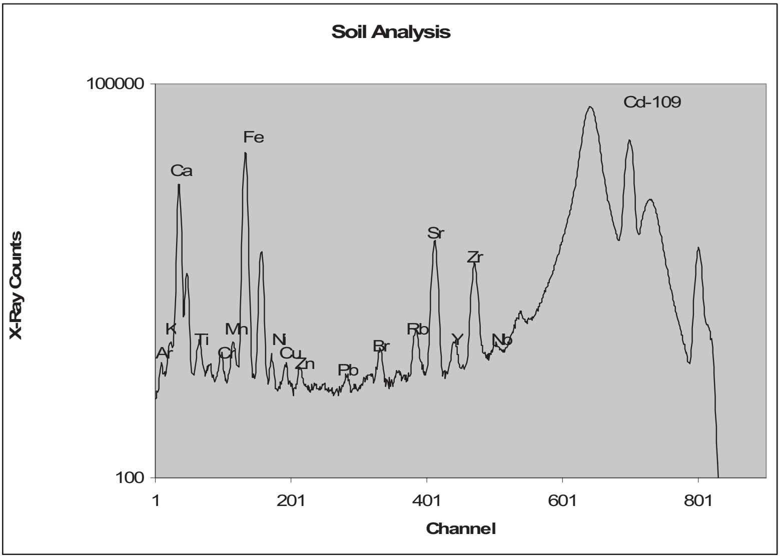

Figure 2. X-Ray Spectrum from soil analysis; Ka lines of many elements are noticed (La for Pb).

The x-ray absorption law ($N=No.e^{-\mu.x}$) can be verified by using thin foils of various thicknesses, as absorbers (e.g. paper, aluminium and plastic foils)

Conclusions and implications. EDXRF can be used as a dynamic tool for a direct "optical" representation of the elemental matter composition. The spectra can be collected in time durations compatible with student laboratory teaching (e.g. in few minutes) and their interpretation can be connected with fundamental physical laws. Radioactive excitation sources (or low intensity x-ray output generators) can be used with satisfactory safety (from radiation protection point of view). New Si-Pin (thermoelectrically cooled) detectors give additional possibilities without the need of liquid nitrogen cooling.

Introduction of modern didactic methods to students - future chemistry teachers

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keywords: microteaching, multimedia board

Computers are a useful tool in teaching of chemistry. They may be used among others for presentation of chemistry experiments which due to various reasons cannot be conducted in class, presentation of animations explaining processes taking place in macro and micro world or for examining students. Together with a multimedia board, computers are a perfect tool which enriches chemistry teacher's workshop and positively influence the motivation and chemistry knowledge of pupils [1, 2]. Decreasing price of these tools as well as appreciation of their possibilities cause that a computer, a multimedia projector, a multimedia board and appropriate multimedia textbooks slowly find a place in more and more Polish schools. It is very probable that the mentioned above set will become a standard equipment in every classroom in the future. Due to this it is important that students gain the skill of free and easy use of these multimedia didactic tools during their preparations to becoming a teacher.

In the academic year 2008/2009 students of University of Gdansk, the Chemistry Department, began to familiarize themselves with the multimedia board during their Chemistry Didactics classes. All students (eighty persons, four groups) were trained in the area of multimedia board usage. They learnt how to use the multimedia board. They were also shown examples of how to use this tool during chemistry classes.

Students were asked to give their opinions on the multimedia board at the end of the class. Although, all students found the equipment useful, only a small percentage of students (7 persons) declared the will to use the board in their future work as a chemistry teacher. Remaining students found the equipment too complicated. They also stated that preparation to a lesson where a multimedia board is used is too time consuming. For these students a traditional black board is sufficient during a class. Another reason for not using the multimedia board is due to the fact that none of the students has seen a teacher using the multimedia board during their classes, and despite the lack of this tool the teachers were still able to get the students interested in chemistry.

Due to such a low interest in the multimedia board among students, the tutor decided to raise the requirements towards the next groups of students in the next term of academic year 2008/2009. During their Chemistry Didactics classes they were asked not only to learn how to use the multimedia board but also to prepare two chemistry classes in the area of microteaching using the board. During the classes students (16 persons, two groups) were familiarized with the use of multimedia board, shown available on the market multimedia chemistry textbooks and CDs attached as an appendix to traditional textbooks, presented with multimedia lessons available on a free portal Scholaris financed by the Ministry of Education. E-lessons for teachers available on the portal were also pointed out to them. These lessons differ from standard e-lessons for self-study by having all films, animations, pictures, texts and work problems on a single screen [3]. A teacher has the possibility to choose from available screens and arrange them in a chosen order. Also, he/she may add more information or paste in necessary pictures or graphs.

Then, students were asked to prepare a lesson on a chosen subject (from any teaching program approved by the Ministry of Education) using the multimedia board. Students were encouraged to prepare their own multimedia lesson. During their preparations, none of the students has created his/her own e-lesson. Most of them used ready multimedia lessons. During their lessons, students discussed subjects according to titles of slides shown, at times omitting some of the points shown on the slides. Three students prepared 'traditional' lessons (without the use of multimedia lessons). Their classes were led according to a lesson which is an example in one of the textbooks for teachers. In these cases, the computer was used for presentation of pictures and graphs. During their first lessons, all students used the multimedia board to show presentations and to write on the board.

After their first classes, students said that they do not feel afraid of using the multimedia board and stated that they are willing to use the board in a greater or lesser degree in the future. They were not enthusiastic, however, towards creating their own multimedia lessons. They said that it is too difficult because it requires them to think over the slides' context and moreover it is too time consuming.

In order to get out of the students more creativity, instead of a simple copying, they were asked to prepare their own multimedia lesson as their second task. Despite their first fears, students completed the task well. Moreover, two students created their own control problems for the multimedia board. At the end of their classes, students had a positive opinion about the idea of showing them the multimedia board and asking them to create their own e-lessons from single elements.

Preparing two chemistry classes with the use of a multimedia board, made them look at the board as a tool which can be used to reach a goal, instead of a goal itself.

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This work is supported by DS - 8260-4-0090-10

NCU approach to small scale chemistry

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Keywords: small scale chemistry; curricula chemical experiments

Our numerous contacts with teachers and students (previous pupils) show that very frequently chemistry teaching on different education levels in Poland is carried out without use of educational chemical experiments. The explanations which are pointed out as main reasons are connected first of all with technical conditions at schools and safety, as well as overloaded teaching groups and shortage of chemistry lessons. To overcome this deep educational problem we focused our attention to well known abroad small scale chemistry technique [1] which among other things increases safety, gives opportunity for individual experimentation, allows to carry out experiments almost everywhere, saves time during preparation and carrying out of experiments, gives more time for evaluation and communication, reduces amount of waste and lowers costs of chemicals and equipment**.**

Taking advantage of published SSC solutions and adding our ideas we developed coherent system of equipment and glassware which allows individual performing of all school chemical laboratory activity and all experiments recommended by Chemical Curricula.

We found out that for performance of all high school experiments just the following commercial equipment and glassware is needed: test-tube stands, test tubes (8 cm high, 14 mm diameter), PE Pasteur pipettes (different types), LPDE droppers (10 ml), small Petries dishes, small plastic beakers (50 ml), small plastic boxes and rubber stoppers (14 mm diameter). Besides some everyday objects are useful: candle heaters. coffee filters, cotton, clothes pegs. disposable plastic syringes and needles, elastics, paper clips, plastic hoses from medical drip, plastic straws, small plastic spoons, tinfoil, tissue, shashlic sticks and. toothpicks.

Main features of worked out system are the following: chemical reactions are carried out in glass; many of classic school experiments are modified and considerable simplified; there are many everyday objects and household chemicals used; required equipment and small glassware are cheap and easily available.

The Centre of Small Scale Chemistry at NCU was founded and conducts workshops for teachers and pupils all over Poland to spread out the idea of small scale chemistry teaching based on our system. We presented our results in the literature [2] and finally published handbook for teachers about experiments in small scale chemistry technique [3].

The whole SSC system will be exhaustively presented together with selected school experiments.

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We have chemistry! Chemistry, Industry, and the Environment in the eyes of the individual and society. A national project to encourage chemistry studies in Israel

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Keywords: Chemistry, high school, competition, research projects, media projects

According to the literature on education, students are more motivated to study a subject matter when they find it more relevant to their lives and to the society in which they live (Bennett, J & Lubben, F, 2006). We found that it is important to emphasize the relevance of chemistry to daily life, in order to make chemistry studies more meaningful to the students(Kesner et al., 1997; Hofstein & Kesner, 2006; Frailich, Kesner & Hofstein, 2007).

Recently, chemistry teaching throughout the world has been increasingly influenced by new trends that attempt to create an appropriate curriculum suitable for general education in chemistry. The most popular approach is the context-based approach (Pilot & Bulte, 2006).

Our project was aimed at motivating students to participate in parallel national competitions regarding Chemistry and its contribution to everyday life. It also sought to encourage them to study chemistry by demonstrating its relevance and applicability to various areas in our daily life.

The project was initiated two years ago and its success encouraged the Israeli Industry - Education link center and ICL industries that initially supported the project to continue to support it.

High-school students from all over the country are invited to take part in various competitions, all of which are aimed at highlighting the importance, relevance, and influence of chemistry to individuals and to society.

Four parallel competitions were offered in the first year:

- Preparing a short video
- Preparing a poster
- Preparing a short newspaper report
- Laboratory inquiries
- A riddle of the month

In the second year the monthly riddle competition was replaced by the photograph competition.

Each competition had different assessment criteria. At the end of the project, students must submit their work for assessment and those who prepared posters or laboratory inquiries were also asked to give a five minute oral presentation in front of the judges.

Student competitions are known all over the world. The chemistry Olympiads are aimed at excellent high-school students and are mainly based on content knowledge. In the 'Internetsymposium' 16-17-year-old students from several schools carry out a chemical experiment and discuss their research (http://www.pieternieuwland.nl/Menu_Items/Projecten/Symposium/index.htm). The FameLab competition (http://famelab.org/home.html) is intended for graduate students who are requested to speak about scientific topics in three minutes. The YUPAC internet site (http://www.chemistry2011.org) notes a few ideas about competitions for the International Year of Chemistry 2011 . This includes an essay competition "Chemistry-our life, our future", and an international picture contest "Everything is Chemistry".

The innovativeness of our project can be summed up as follows:

- It calls for the participation of high-school students, at all levels, who study chemistry and want to perform a project regarding "chemistry, industry, and the environment for society and the individual".
- The chemistry students can involve students who major in other areas when the project warrants it.
- In the various competitions students who have different learning styles and abilities can choose their projects according to their interests, abilities, and talents.
- Students are encouraged to participate in a one-day seminar (held in three regions) in which they receive guidance and participate in different workshops according to the competition in which they enroll.
- The students can meet and receive support and advice from experts in the relevant areas including scientists from chemical companies and science educators.
- There is a follow up process in which the outlines are checked and commented if needed. All this is done in order to produce high-level projects and to ensure that they are really meaningful to the students.
- All students who arrive to final stage of the competition participate in a one-day conference in which they also present their work in five minutes; they can choose their own unique way of presentation.

All together, about 130 students reached the final stage of the competitions in the first year. In the second year the number of students almost doubled, and a few of them also participated the second year.

Both the teachers and students were very enthusiastic about the project.

Examples of lab research projects are the effect of the acidity of wine on its color, how flame retardants incorporated in different types of clothing affect combustion, the reaction between coca cola and mentos, and fermentation. Some examples of short videos are polymers, Dead Sea products, and global warming. Examples of reports are recycling, Chemistry in police work, and Chemistry used for our beauty. Examples of posters are chemistry of love, acid rain, and fuel from water.

Details, sample products, outcomes and initial evaluation results will be presented.

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Predicting the direction of incomplete chemical changes: grade 12 students' reasoning

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Keywords: Model - students' reasoning – reaction quotient –incomplete chemical change

Context. Numerous studies showed that students fail to predict equilibrium shifts (Hackling & Garnett, 1985; Banerjee, 1991; Quilez-Pardo & Solaz-Portoles, 1995; Tyson et al., 1999; Kousathana & Tsaparlis, 2002). Others stressed students' difficulties to predict the direction of change in the case of any chemical system i.e. not after an equilibrium state has been disturbed (Niaz, 1995; Stavridou & Solomonidou, 2000). Teaching a systematic and rigorous procedure such as calculating the reaction quotient of the system and comparing it to the equilibrium constant - that we shall call 'the change criterion'- appeared then to be an opportunity to avoid such difficulties (Kousathana & Tsaparlis, 2002). In France a new curriculum has been implemented in grade 12 introducing a new way of studying incomplete chemical changes and the change criterion.

Theoretical background. According to the methodology of didactic engineering (Artigue, 1988) and the model of educational reconstruction (Duit et al., 2005) a preliminary analysis of the subject matter is necessary to clarify the content to be taught, and is as important as the analysis of the students' reasoning. We made a content analysis in terms of models and phenomena firstly to determine to what extent the didactic intentions expressed by the authors of the curriculum – making a clear distinction between experimental facts and models (Davous et al., 2003) – were achieved and secondly to provide a grid to interpret students' reasoning. According to Tiberghien et al. (1995) three interrelated levels may be considered: the theoretical level, the model level and the empirical level. Our present analysis focuses on what we called the thermodynamic model deriving from the thermodynamics of irreversible processes. The thermodynamic model comprises a pair of opposing reactions, symbolized by a chemical equation, and the change criterion. Predicting the direction of a chemical change may be summarized with five steps describing how the thermodynamic model functions and illustrating what can be an elementarisation of the chemical content (Duit et al., 2005).

Our aim is to determine whether the students use the change criterion to predict the direction of a chemical change and whether they make a clear distinction between the empirical level and the model level.

Methodology. Therefore we designed written tests composed of a chemical equation and an equilibrium constant, the description of the system and its composition, and a question: would the mixture change or not? Three kinds of systems were proposed: one with all the chemical species involved in the chemical equation, a second one with a missing solute and a third one with a missing solid. These open-ended questionnaires were administered to French students (N=102 or N=144) after teaching.

Results. A majority of students used the criterion to predict the direction of chemical changes (63% to 71%). Nevertheless in the case of a missing reactant two typical mistakes were found.

If a solute is missing some students (one out of four using the criterion) removed the solute concentration from the expression of the reaction quotient instead of writing zero for this concentration. For them, a missing solute in the beaker seems to be the same thing as a missing concentration in the formula. The most significant feature of the empirical level is reproduced in the model as if it were a copy of the experimental situation.

If a solid is missing some students (33%) predicted a change in spite of the lack of this solid reactant. Applying the change criterion may lead to a direction of change that cannot be achieved (a limit of the model), therefore it is more crucial to look at the composition of the system to check whether a change is possible.

Conclusion. These results show that students do not seem to make proper links between the model level and the empirical level. Special attention should be paid to explaining the differences between these two levels and determining the significant features of each level.

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Approaches of Turkish Pre-Service Science Teachers toward Chemistry Problem Solving

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Keywords: Algorithmic problem solving; concept-based (logical) problem solving; conceptual knowledge; operational knowledge; science education.

Introduction. The primary aim of education is to give individuals skills to overcome problems they could face later. It is suggested that providing students with these skills is only possible through giving most importance to problem solving in education. Two aims are generally tended to be achieved with science teaching: (1) to gain organized knowledge structure in a specific field and (2) succeeding in problem solving in this field [1-3]. Some researchers [4, 5] mention some types of knowledge needed in problem solving. These are conceptual and operational knowledge. Conceptual knowledge includes concepts and principles about the subject, operational knowledge consists of strategies and methods necessary for applying these concepts and principles.

Correct problem solving has an important role in achieving Chemistry courses. But, students have difficulties in solving Chemistry problems. Although various researchers have different groupings about types of problems, Chemistry problems can be brought together in two general groups as algorithm and concept based [6].

To develop pre-service science teacher's chemistry problem solving skills are crucial important before their graduation. Within this context the purpose of this study was to investigate approaches of Turkish pre-service science teachers toward subject of chemistry problem solving in science education.

Method. In this study pre-service science teachers' approaches on chemistry problem solving have been investigated. The results of this study have been carried out with the participation of pre-service teachers from Department of Primary Education, Science Education and taking courses of General Chemistry. A questionnaire was improved in order to ask pre-service science teachers opinions on solution of logical (concept-based) and algorithmic problems in Chemistry courses. The data was analyzed by SPSS 13.0 and the results were discussed.

Results. 85.7% of the participants who disagreed with "I find concept based questions in General Chemistry courses easier" said "no" also for "I have difficulty in understanding concepts of Chemistry" and this difference was found to be significant statistically.

91.7% of the participants who said 'yes' for 'I choose to solve algorithmic problems in General chemistry courses' disagreed also with 'I do not choose to solve algorithmic problems in General chemistry courses due to lack of math knowledge' this finding was significant statistically.

90.3% of pre-service teachers who agreed with 'I review my method of solution I applied after finding the result of the problem and complete missed parts of it' said 'yes' also for 'Solutions of chemistry problems consist of math knowledge and skills along with chemistry knowledge' And agreed with this at large scale.

55 participants (84.6%) who disagreed with 'I use the data correctly but find wrong result because of operation error' said also 'no' for 'I both do not use the data correctly and leave the problem unsolved because of operation error'. However, 60% of ones who agree with this

perception said that they have difficulty in solving problems that require using more than one algorithm and the same number of participants said that they had anxiety during solving 'concept-based' problems.

89.7% of participants who said 'no' for 'I both do not use the data correctly and leave the problem unsolved because of operation error' base having difficulty to solve problems that require using more than one algorithm on lack of their math knowledge'.

Conclusions and implications

The approaches of Pre-service science teachers on their chemistry courses' understanding and algorithmic solution of the problem have been examined Within this context it was determined that though pre-service teachers choose to solve algorithmic problems, they have difficulties in understanding concepts of Chemistry, they should have adequate math knowledge and that they worry about finding wrong result due to operation error and this could arise from lack of their math knowledge. When they choose to solve concept-based (logical) problems, it is understood that they do not have sufficient math knowledge and worry about finding wrong result because of operation error and they have difficulty in especially problems requiring more than one algorithm. It is interesting that pre-service teachers who chose concept-based problems had difficulty in understanding Chemistry concepts as much as those who chose algorithmic ones. Thus, not understanding problem text is also in question. These pre-service teachers' who have been taught Chemistry since primary school still having difficulty to understand concepts shows that the concepts are not known sufficiently and students tend to memorize.

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Green Chemistry Applications in Chemistry Education

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Keywords: Green Chemistry, environmental pollution, chemistry education, chemistry courses.

Introduction. Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and/or generation of hazardous substances. Green Chemistry is the use of chemistry for pollution prevention. More specifically, it is the design of chemical products and processes that are environmentally benign. Green Chemistry encompasses all aspects and types of chemical processes that reduce negative impacts to human health and the environment. At its best, Green Chemistry is environmentally benign, linking the design of chemical products and processes with their impacts on human health and the environment [1].

Twelve principles of Green Chemistry: Prevention of waste, atom economy; less hazardous chemical synthesis, designing safer chemicals, safer solvents and auxiliaries, energy efficient, renewable feedstocks, reduce derivatives, catalysis, design for degradation, real time analysis for pollution prevention [2].

Green Chemistry course must be in the chemistry curriculum. Besides, it must take an interdisciplinary approach and teach the basic tenets of Green Chemistry and sustainability to those who are majoring in other disciplines such as business, political science, and philosophy. Although it is scientist and engineers who will practice Green Chemistry, business leaders will guide the course of companies on the path of sustainability, and political leaders will set the tone for government policy on these issues [3].

In this study, the answer is looked for the question of what could be done about the Green Chemistry applications in various chemistry laboratories in the chemical education?' and the opinions of the students are called upon.

Method. This study has been carried out with the participation of the students from chemistry, chemistry engineering and environmental engineering taking courses of chemistry and laboratory of chemistry. A questionnaire is formed with the aim of evaluating student's information level of Green Chemistry, acquiring the knowledge of how they get this information and getting their opinion about Green Chemistry. The questionnaire also includes the opinions about the things that can be done for the subjects of health and environment while working in various chemistry labs, joined through the education period. For content validity of questions in the questionnaire experts' opinions were asked and it was formed with these feedbacks. The data was analyzed by SPSS 13.0 and qualitative description techniques.

Results and suggestions. It is known that students generally use chemical substances in Chemistry labs. They were asked whether they use natural substances besides chemical ones, and a small number of natural substance usage was identified.

The students stated that they mostly preferred natural substances if it was possible to perform an experiment with natural substances. And they noted that all the chemicals were harmful, there was no chemical which was not harmful, only if they work mostly with natural substance then it was possible to save the human health and the environment.

The quesiton of ‘What is the meaning of Green Chemistry?’ was largely unknown by the students. A small number stated that they know it from the media, from a friend or because of their interest in it but they do not learn it from the curriculum. Majority of the students suggested that chemical substances should be saved in special stores or released after making them harmless to the nature, they shouldn’t be thrown directly into the environment. The students were generally sensible to the nature but they were not well-informed about the concept of Green Chemistry. Through the questionnarie some of the students have seen the connection between Green Chemistry and environment but many of them couldn’t make the connection. And the students who know the concept of Green Chemistry thought that the application was only a dream which is not giong to come true.

As the analysis of the study is incomplete, only the first findings of the analysis completed till now takes place in the study. Therefore the study lasts in order to be able to get clear findings.

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Development of a Three-Tier Multiple-Choice Diagnostic Instrument to Evaluate Students' Understanding of States of Matter

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Keywords: three-tier tests, states of matter

Theoretical Framework and Rationale. Science education literature has had a great deal of studies relating to the identification, explanation, and remedying of students' misconceptions. To identify students' misconceptions, interviews and multiple-choice tests are successful methods. However, these methodologies have limitations for practical use in classrooms. For example, although interviews provide in-depth analysis of students' understanding, they require large amount of time to conduct and analyze. Multiple-choice tests can be administered to large samples, but it is not possible to determine students' reasoning behind their choices. A student can give a correct answer with a wrong reasoning, or a wrong answer with a correct reasoning. Hestenes and Halloun (1995) described correct answers with wrong reasoning as "false positives" and wrong answers with correct reasoning as "false negatives". They suggested that minimizing false positives and negatives provides a more valid assessment. In addition, they indicated that the major problem for conventional multiple-choice test was to minimize false positives and negatives. Because of these limitations of conventional multiple-choice test, two-tier multiple-choice instruments were developed by researchers (e.g., Tan, Goh, Chia & Treagust, 2002). The first part of each item consists of a conventional multiple-choice question and the second part of each item contains a set of possible reasons for the given answer in the first part. Furthermore, differentiating misconceptions from error and lack of knowledge is crucial. Three-tier tests enable researchers to achieve this by an additional tier asking for students whether they are sure about their answers for the first two-tiers. Three-tier test scores are more valid since they provide researchers to understand students' reasoning behind their answers, distinguish misconceptions from lack of knowledge, and estimate percentages of false positives and negatives. Three- tier tests are novel in the literature. There are only a few studies in physics on the development of three-tier tests (Pesman & Eryilmaz, 2009). No study on the development of a three-tier test in chemistry has been reported in the literature. Therefore, the purpose of this study is the development of a three-tier diagnostic test to measure tenth grade high school students' understanding of states of matter concepts. This study focuses on the following research question:

- Does the States of Matter Diagnostic Test (SMDT) measure students' conceptual understanding of states of matter in a way that provides valid and reliable scores?

Method. The SMDT was developed using procedures employed by Pesman and Eryilmaz (2009). The development of SMDT involved three phases: i) defining content boundaries, ii) identification of misconceptions by examining related literature, conducting interviews, and administering open-ended questions, and iii) the development and administration of SMDT. The SMDT is a 19-item three-tier diagnostic test consisting of three tier items for assessing students' understanding of states of matter concepts. Because of the space limitations, we could not give sample questions. The first tier consists of a conventional multiple-choice question with three or four choices. The second tier includes one correct reason and alternative reasons. The alternative reasons are based on misconceptions identified from semi-structured interviews and open-ended questions. In addition to alternative reasons, a blank space where students are asked to write an explanation of their reasoning different from the given reasons is presented. The third tier is asked to assess how examinees are confident about their answers for the first two tiers. The content validity of the SMDT was established by a group of experts (four chemistry educators and one chemistry teacher) in terms of the objectives and misconceptions intended to be assessed. Nineteen three-tier multiple choice items were administered to 195 tenth grade students in one class hour lasting up 45 minutes. The Cronbach alpha and Kuder Richardson Formula 20 (KR-20) reliabilities were calculated for the SMDT scores. Exploratory factor analysis of the SMDT scores were reported as a construct related evidence of validity. Furthermore, the percentages of the false positives and false negatives (Hestenes & Halloun, 1995), and the correlation between scores based on the first two tiers of the SMDT and confidence levels based on students' answers to the third tier only were investigated for the validity of the SMDT scores.

Results. The reliability of the SMDT scores was estimated by Cronbach alpha and KR-20 and both reliability indexes were found to be .78. Hestenes and Halloun (1995) described correct answers with wrong reasoning as "false positives" and wrong answers with correct reasoning as "false negatives". They reported that minimizing the probabilities of false negatives and positives was important for validity of the test. They suggested that the probability of false negatives needs to be less than ten percent. When the items were checked for false negatives, it was found that all the percentages were below 10 with the average of 4.0. The correlation between scores based on the first two tiers of the SMDT and confidence levels based on students' answers to the third tier only were calculated for the validity of the SMDT scores since it is expected that students with high scores must be more confident than students with low scores. It was found that there was a moderate and positive correlation between them ($r = .34$, $n = 195$, $p < .01$). Moreover, exploratory factor analysis showed that there were two meaningful factors represented macroscopic and microscopic level of questions.

Conclusions and Implications. It could be concluded that the SMDT scores provides a valid and reliable three-tier diagnostic instrument for evaluating students' misconceptions and conceptual understanding of states of matter concepts. Identification of misconceptions with three-tier tests is more successful than two-tier tests since they differentiate misconceptions from lack of knowledge. Furthermore, this study demonstrated that three-tier test scores are more reliable than two-tier and conventional multiple choice test scores since the reliability of the SMDT scores was estimated to be .61, .70, and .78 for first tier, two-tier, and three-tier, respectively. The SMDT whose scores are valid and reliable enables teachers to quickly assess students' understanding. In addition, by using the percentages of lack of knowledge, teachers can evaluate their instructions. The large percentages of lack of knowledge mean that the instruction is not helpful for students to understand related concepts.

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Investigating the Predictors of High School Students' Chemistry Self-Efficacy Beliefs

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Theoretical Framework and Rationale. Perceptions of students about their ability to achieve chemistry tend to influence their academic self-efficacy beliefs (Dalgety & Coll, 2006). If students have low self-efficacy beliefs in science, their choices in performing science-related tasks, their efforts to do them, and their perseverance when encountering difficulties are affected negatively (Bandura, 1997). Self-efficacy is defined as "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" (Bandura 1997, p. 3). Bandura (1986, 1997) theorized that students form their self-efficacy beliefs as a result of interpretation of four sources: Mastery experiences, vicarious experiences, verbal and social persuasion, and physiological state. In science, self-efficacy was found to be significant predictor of students' science achievement at various grade levels (Britner, 2008; Kupermintz, 2002). In the literature, there is no consistent pattern for the relationship between gender and self-efficacy. Some researchers indicated that there were gender differences in terms of students' self-efficacy in science classes (Britner, 2008), while others reported that that there was no significant difference by gender (Capa Aydin & Uzuntiryaki, 2007). Self-efficacy beliefs should be examined by considering optimal level of specificity within a specific domain (Bandura, 1997). Therefore, the purpose of this study was to investigate the contribution of academic achievement, the number of chemistry courses completed, involvement in a chemistry project, expected grade, and gender to high school students' chemistry self-efficacy beliefs.

Method. In this study, High School Chemistry Self-Efficacy Scale (HCSS) developed by Capa Aydin and Uzuntiryaki (2009) were administered to 298 students (57.1% female and 42.9% male) in mid-western high schools in USA. The ages of the students ranged from 15 to 18 with a mean value of 16.2 and a median of 16. HCSS consisted of 16 items in two dimensions: chemistry self-efficacy for cognitive skills (CSCS) and self-efficacy for chemistry laboratory (SCL). The internal consistencies of scores on the two factors were estimated by Cronbach alpha coefficient as 0.88 for CSCS and 0.81 for SCL.

In addition, HCSS included demographic questions asking participants to report their gender, age, grade point average (GPA), the number of chemistry courses completed, whether or not they participated in a chemistry project, and expected grade from their current chemistry course (A, B, C, etc.).

In order to investigate the role of gender, GPA, the number of chemistry courses completed, involvement in a chemistry project, and expected grade in predicting high school students' chemistry self-efficacy beliefs for two dimensions, CSCS and SCL, two separate simultaneous Multiple Linear Regression analyses were conducted via SPSS 15.0 program for Windows. Expected grade variable was dummy coded taking grade A as a reference level. Dummy 1 refers to pairwise comparison between grade A and grade B. Dummy 2 refers to pairwise comparison between grade A and grade C.

Results. Participants' mean scores of self-efficacy were found to be 6.19 for CSCS and 6.76 for SCL. The mean score of GPA was 3.43 out of 4 and the median score of chemistry courses completed was 1.

The results of the multiple regression analysis for CSCS showed that the model explained 26.7% of the variation in CSCS ($F(6, 244) = 14.82$, $p<0.05$). Involvement in a chemistry project ($\beta = 0.149$), gender ($\beta = 0.152$), GPA ($\beta = 0.144$), and expected grade ($\beta = 0.168$ for dummy 1, $\beta = 0.409$ for dummy 2) were significant predictors of CSCS. In terms of SCL, the model accounted for 8.8% of the variation in SCL ($F(6, 244) = 3.93$, $p<0.05$). Expected grade ($\beta = 0.200$ for dummy 2) was significant predictor of SCL.

Conclusions and Implications. The results of this study indicated that involvement in a chemistry project, gender, GPA, and expected grade were significant predictors of CSCS; expected grade was a significant predictor of SCL. In terms of academic achievement, the results were parallel with the findings of researchers claiming that there is a relationship between science self-efficacy and achievement (Britner, 2008; Kupermintz, 2002). Gender was found as a significant predictor of CSCS in favor of males; however, it was not a significant predictor of SCL. In the literature, there are contradictory results regarding gender differences in students' self-efficacy beliefs (Britner, 2008; Capa Aydin & Uzuntiryaki, 2007). In addition, it was found that while involvement in a chemistry project was a significant predictor for CSCS, it was not a significant predictor for SCL. This finding could be resulted from the content of chemistry projects in terms of the cognitive and psychomotor skills they involved. However, in this study, the chemistry projects in which students participated were not examined in detail. As asserted by Bandura (1997), students form their self-efficacy beliefs through aforementioned four sources. It is crucial for teachers to be aware of the self-efficacy sources and the contribution of variables such as academic achievement and gender to students' self-efficacy beliefs to design their courses effectively.

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Keywords: self-efficacy; multiple linear regression; chemistry; high school students.

The influence of the quality of subject-specific statements on the learning outcome in small-groups

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Keywords: communication, small-groups, chemistry, video-analysis

Background, framework and purpose. This project deals with the analysis of student-student communication in cooperative group work. The aim is to clarify the influence of subject-specific statements in small-groups on the learning outcome. The following research questions are due to the objectives:

1. Which characteristics of subject-specific communication can be found analysing the statements of successful and unsuccessful small-groups?
2. Is it possible to increase the quality and amount of communication by well-directed instructions of subject-specific communication situations?
3. Is it possible to enhance the learning outcome by the improvement of the small group communication?

Since there are different instruments for the analysis of cooperative group work, but no quantitative instruments dealing with the quality of subject specific statements in detail, a new category system is invented based on related instruments. The few existing systems for categorising students' statements are insufficient to investigate the quality of the statements in detail, because they are not sensitive enough for a detailed analysis. For this purpose existing instruments were adapted and enhanced. The adapted instruments are:

- instruments to analyse the amounts of speech of each participant,
- instruments to describe inquiry processes (process plots: e.g. Walpuski & Sumfleth, 2009),
- instruments to analyse content-related quality (e.g. Hänze &Berger, 2007; Franke-Braun, 2008).

Studies dealing with the quality of subject-specific communication in small groups and analysing the aspect of the influence of the quality of the statements on the learning outcome are rare.

Developing an instrument to analyse the content wise quality of statements it is not far to seek to follow models of competence and to adapt them. In Germany, a model of competence to test the national standards was developed. With this model of competence (Walpuski, Kampa, Kauertz, & Wellnitz 2008) the difficulty of tasks can be predicted by describing two aspects which influence the item difficulty. The *complexity* describes the amount of information and their linkage (level of facts, relations or concepts). In addition to this, the *cognitive processes* (reproduction, selection, organization, integration) define which aspiration level is needed to solve the task. Furthermore, a similar model has been already used for video analysis in the project "Vertical Linkage" (Lau, Neumann, Fischer, & Sumfleth 2009). The inter-rater-reliability was satisfying ($0.55 < \rho < 0.81$)

According to this, the model of competence (Walpuski et al., 2008) was adapted to estimate the quality of subject-specific statements. For this reason, the *complexity* and the *cognitive processes* of statements are analysed. We assume that – in addition to the complexity and the cognitive processes – the correctness of the statements is also relevant for the quality of subject-specific communication. On the basis of this assumption a category system was developed.

Method. The topic of the small-group work is acids and bases in the 7th grade of secondary schools (high-level). The small-group work consists of five lessons. The study is divided into two parts. In the first step, existing video data of a preceding research project are reanalysed in order to see, if the assumed characteristics for successful small groups (more right statements on a high level of complexity and high cognitive processes) can be retrieved in fact. In this context, success refers to the learning outcome of the small-groups. In order to analyse the videos, a category system was constructed. This category system contains among others the category *content* which includes the correctness, the complexity and cognitive processes of the content-related statements. To test the category system, 30 videos (15 videos of very successful groups and of 15 very unsuccessful groups) of the preceding project were reanalysed turn-based using the program videograph®.

The assumed characteristics for successful small groups were found in reanalysis (see results). But due to the fact that this reanalysis does not prove any causality an additional intervention study is needed. Therefore, in a second step, it will be investigated in an intervention study if it is possible to increase the quality and amount of subject-specific statements by modified instructions for the small groups. . Furthermore, it will be analysed if the learning outcome can be enhanced at the same time. Therefore in the school year 2009/2010, 48 different small groups (4 students each) will be videotaped. The investigation of the effectiveness of the revised instructions will be realised in a classic control-group-design so that no artefacts will be produced. As control variables the cognitive ability test (Heller & Perleth, 2000) and a test on scientific procedures (NAW) (Klos, Henke, Kieren, Walpuski, & Sumfleth, 2008) will be performed. In addition to this, a test on chemical content knowledge is used (pre-test and post-test). Accompanying the small-groups will be video-taped. Additionally, in each lesson a test on content knowledge, referring to the contents of the corresponding lessons, will be conducted.

First Results and Conclusions. In the first step of the study, two trained raters coded independently 10 videos. The results of the inter-rater reliability are between $.82 < \kappa \leq .99$, so the amount of agreement of the category system is very good. The successful groups state more right ($p < 0.01$) content-based statements than the other groups. Regarding only the right content-related statements the successful groups reveal a higher rate of statements in all cases. These differences are significant in the subcategory "*selection of a relation/relations*" ($p < 0.05$) and very highly significant in the subcategories "*organisation of a relation/relations*" and "*integration of a relation/relations*" ($p < 0.001$).

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KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

Varying contexts and their influence on learning chemical concepts

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Keywords: Context, interest, learning outcome

Theoretical Background. In consequence of the low interest of students in learning science – especially in learning chemistry and physics – teaching with connection to real life phenomena – so called contexts - came into the focus of attention. Correspondingly, over the past years, countries like Great Britain, the USA, Germany or the Netherlands have implemented context based instructional approaches to counter the consistent decrease of students' interest, and thus to increase the quality of science education.

In this regard, Krapp (1998) suggested that learning environments which are embedded in situations that are closely connected to students' everyday lives can enhance students' situational interest and, thus, affect students' long term knowledge. Accordingly, research has shown supportive effects of context-orientation on students' interest and motivation (e.g. Benett, Lubben, & Hogarth, 2002; Osborne & Collins, 2001; Yager & Weld, 1999). However, the effects of context-orientation on students' learning outcome are not clear so far. For example, Fechner (2009) showed within a chemistry domain that real-life contexts encourage students' situational interest. Additionally, effects on learning outcome were completely mediated by an increased situational interest. However both effects varied depending on the implemented contexts. Based on these results, the proposed study intends to clarify the effects of contexts on students' interest and on the learning outcome in more detail by investigating these research questions:

1. Which influence do a subject-specific context and a real-life context have on the learning outcome with regard to two different chemistry concepts?
2. Which influence do a subject-specific context and a real-life context have on learning outcome with regard to chemistry concepts compared to biology concepts?

Method. In order to investigate the research questions, two contexts – one real-life and one subject-specific context – are used. A real-life context is defined as a context which is close to students' everyday lives and should be relevant for them. In contrast, a subject-related context is constructed with strict orientation towards the subject's structure. Students will be randomly assigned to one of these two contexts.

Each student will be confronted with two chemical concepts and one biological concept. The chosen chemical concepts are dealing with water as a solvent and with the structure of water, the biology one is not specified at the moment (Fig. 1)

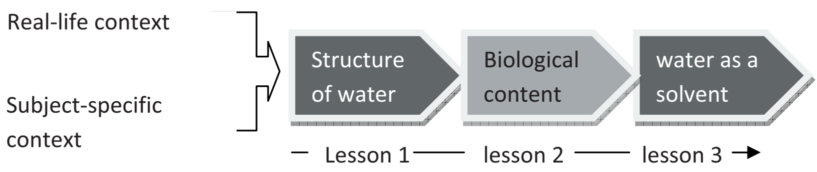

Figure 1: Overview of context groups and concept

To investigate the research questions the following instruments are used:

– **To measure control variables**:
  - Cognitive abilities test
  - Prior knowledge test
  - Subject-specific interest test
  - Subject-specific beliefs test
  - Task effort test
  - Task motivation test

– **To measure effects of both contexts:**
  - Learning outcome test
  - Situational interest test
  - Task specific learning strategies test

Effects of both contexts will be analyzed in a pre/post-design. In the pre-test all control variables will be assessed. The pre-test is scheduled to take 90 minutes. Then the students will participate in the intervention study at three successive days. Each day, they will learn individually with worked-out examples for 45 minutes. Each of these examples deals with one of three concepts. To adjust influences of interest the worked-out examples containing the chemical concepts will be rotated. After each lesson, a paper-pencil test measuring learning outcome and situational interest will be administered. This post-test is scheduled to take 45 minutes.

Results. The pilot study will be conducted in April 2010. First results will be presented on the poster in July.

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What Is Wrong With Base Oil? – Research Project For Undergraduate Chemistry Students Intending To Get Job In Industry

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Keywords: base oil analysis, student project, undergraduate student, problem solving, laboratory work

Within the chemistry studies (B.Sc.) at our Faculty all students *inter alia* have one course of Industrial chemistry during their third year. In addition, the second course of Industrial chemistry was developed in the fourth (last) year of studies for all undergraduate students intending to find job in industry. It was compulsory for them and optional for other students. The course consisted of theoretical lessons (three hours per week) and practical work in the laboratory (six hours per week) during one semester. Practical work of students was mostly based on small research projects with a lot of problem solving activities. During the projects students were working individually and as a team. One segment of the mentioned course was reported earlier [1].

The project described in this paper was based on the real life case study. It was adopted for practical work of students and they were informed about it. Students were also informed that, within the small research project, each of them would be in the role of chemist employed in independent research institution. Their task was to find out what was wrong with base oil which one refinery bought from foreign partner. Two base oil (light and heavy) were produced in the refinery in Italy, transported by boat (tanker) across the Adriatic Sea and later by road tankers to another refinery in Serbia (Yugoslavia) which use them as the raw material for production of lubrication oil. The laboratory of the refinery in Serbia analysed two base oils and found that heavy base oil did not meet the specification. Samples taken from the first ten road tankers which arrived to refinery had somewhat lower flash points. Also the turbidity was found in some samples of light and heavy base oil. As the base oils were the objects of international trade the management of the refinery asked independent institution to analyse the samples. They provided 80 samples of two base oils from various phases of transportation: refinery in Italy - before pumping in oil tanker, oil tanker before and after sailing, reservoir at the port in Yugoslavia, oil tankers for continental transportation at the terminal in the port and in refinery plant - final destination. The problem was discussed with students. It was obvious that the first task of students (in the role of chemist employed in independent research institution) would be to determine the flash point of heavy base oil samples from road tankers at the refinery in Serbia (Yugoslavia) and compare them with results obtained in the refinery. Students obtained similar results as the professionals from the refinery. Next step was to find out where the quality of base oils was lost and who was responsible. Each student had to write down his/her plan for selection of samples for further determination of flash point and provide corresponding arguments for it (there was no need to analyse all samples). Proposals were discussed and the optimal one was used in the laboratory. Comparison of result indicated in which phase of transportation the oil was damaged. The final part of this task was to propose how it happened (lower flash points mean the presence of traces of low molecular weight compounds, i.e. hydrocarbons and their origin as contaminants was the question).

Another complex task for students was to find what could cause the turbidity in base oil samples, suitable methods for investigation (work in the library and on internet) and to use them in the laboratory. They did it successfully and found that presence of water or higher

n-alkanes could be the cause of turbidity. They also found corresponding methods for determination of water or higher n-alkanes. Results of preliminary investigation indicated that presence of the water was the cause of turbidity. Again it was necessary to make a plan for selection of samples for determination of water. This time it was easier for the students as they already knew which samples did not have the correct values for flash point and the reasoning was similar. After the analyses of selected samples it became obvious which samples contained water. The students made the hypothesis how the oil was contaminated with water. It was the same as the result obtained in original case study. All results were discussed with students as well as their impressions and difficulties in solving of problems within the project. They found it interesting and not too difficult. One of the conclusions was that they were able to solve it without the use of internet but they would need more time in that case. Finally, students had to write short report for their project.

The project reflected the importance of chemist in industry and international trade. Students got the experience how proper sampling in all phases of transportation of base oils combined with corresponding analyses could be used to provide the control of all partners in transportation, to indicate where and how the quality of oil was lost as well as who is responsible for the damage. Within the project students were combining their previous knowledge and skills in the analyses of industrial oils with some new information from the literature (including some new analytical method). Application of these methods by students and careful interpretation of results provided the solution of the problem – where, how and by whom the oil was damaged. They also learned how experimental plan and problem solving technique could be applied for solving complex problems in industry.

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The Effect Of "Context-based Arcs Model" On Secondary School Students' Success, Motivation And Attitude Towards Chemistry

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Keywords: Context-based ARCS Model, Motivation, Chemistry, Achievement

Science subjects, especially chemistry has appeared to failing to stimulate children's interest. To remedy for this problem too much studies have been done. Context-based approach is seen one of the solution. Context-based approach to teaching science in high school has become widely used over the past two decades (Bennett, Lubben & Hogarth, 2007).

As a curriculum development context-based approach was. Context-based curriculum projects were implemented in mainstream chemistry courses, for instance, ChemCom and CiC in USA, Salters Chemistry in UK, ChiK in Germany, ChiP in Dutch and Industrial Chemistry in Israel (Pilot & Bulte, 2006). The aim of these projects is to make chemistry more attractive and interesting for students, in particular, by connecting chemical knowledge with real world contexts which are relevant to the students (Bennett, 2003). After then achievement of these projects context-based approach has been used as a teaching and learning model.

Context-based approach studies in chemical education commonly focus on students' learning outcomes, motivation and attitudes. Context-based approach motivates students in their science lessons and enhances more positive attitudes towards science more generally but do not adversely affect students' understanding of scientific ideas (Bennett, Hogarth, & Lubben, 2005).

In this study the context-based approach as an instructional design based on ARCS motivation model believed to be increased students' success, motivation and attitudes towards chemistry. As ARCS was the only motivational model that is based on instructional design, it was deemed critical in improving teaching effectiveness (Hardre, 2005; Ogawa, 2008). Another reason that ARCS was chosen its flexibility and ease of import into existing frameworks for instructional design (Keller & Suzuki, 2004). In this study context-based teaching and ARCS motivation model were combined and called "Context-Based ARCS Model". Although the literature suggests that context-based approach has positive effects on students' motivation, there is no study that used ARCS motivation model. In this regard this study could be accepted as unique.

The aim of this study was to determine the effects of the Context-based ARCS Model on student's success, motivation and attitudes towards chemistry (De Jong, 2008). A model for the unit of Turkish secondary school chemistry curriculum from year nine entitled "Chemistry in our life" was developed according to this model. In the model contexts daily life about the chemistry were given at the beginning of the lesson to increase students' attention toward to subject (A-Attention) and to show students relevance of chemistry to their daily life (R-Relevance). Then chemistry contents in this context were explained. The students were allowed to practice in activities and experiments using newly acquired knowledge or skills (C-Confidence). According to students' performance feedback were given immediately. This helped students to feel positive about their achievement (S-Satisfaction).

The study was administered for 7 weeks period with 60 grade nine high school students from two different classes taught by the same teacher at a state high school in a city in Eastern Anatolia. Pre-experimental research method with single group pre-posttest design was used.

The quantitative data was collected through two questionnaires "Instructional Materials Motivation Survey", "Attitude towards Chemistry" and achievement which was applied as post-test and retention test. The qualitative data was collected through observation and semi-structured interviews. The quantitative data was analyzed by SPSS statistical package. The data for the post test and retention tests and attitude test were analyzed with dependent sample t-test. The qualitative data was analyzed by NVivo software package. The results showed that the model increased student's motivation and retention of the knowledge that was learned but did not significantly affect student's attitudes towards chemistry.

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Introduction of ICT into Middle School Chemistry and Physics Education in Morocco

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Moroccan science and technology education is facing a lot of challenges while the country is striving to produce more engineers to accompany its industrial development. In general, the performance of a large proportion of students in secondary school mathematics and science has been below expectations. In order to contribute to the efforts aimed at improving S&T education, our research group has completed a three-year project to develop competencies and IT-based instructional materials in mathematics and science for use by middle school students and teachers. The aim was to explore how IT-based education could improve both motivation and performance of students in middle and high school.

This presentation describes the approach used and results achieved in improving motivation and performance of students as well as teachers in physical science (physics and chemistry) education.

The project was carried out with middle school science instructors and inspectors from two pilot schools in the cities of Ifrane and Fes and a representative of the Ministry of Education. Equipment for the project has included a development laboratory and studio at the University and six multimedia classrooms in schools.

The instructional materials, which consisted of Powerpoint presentations, Flash animations, interactive exercises, film sequences, virtual experiments, video sequences, educational games, etc, were developed by the teachers, validated and reviewed by University faculty, and passed to technicians for implementation. Monthly workshops were held to bring together teachers from the different schools to review materials already produced and to improve techniques for producing them.

The course materials were used in an applied classroom setting. In each school, a single teacher taught one group of students using the ICT-based approach and a second group in the traditional manner. Both groups were randomly selected and included 20 students. The results of each group were tracked and compared.

The results of the study were measured in terms of quantitative and qualitative indicators which demonstrated positive impact in the following areas: competence and motivation for working with ITC of the teachers, use of ITC materials by students, learning by students using the materials, and availability of materials for wider dissemination.

Acknowledgement: The authors would like to thank the Korea International Cooperation Agency, KOICA, for its technical and financial support.

Two Decades of Microscale Experimentation – What's Next?

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Keywords: Undergraduate laboratories; Curriculum; Microscale; Green Chemistry; Materials Science

Background. There are four general explicit laboratory goals that we want to achieve in laboratory courses:

1. 1. To illustrate and clarify principles discussed in the classroom, by actual contact with materials. (In short: **O**bserving/Assuring principles of science)
2. To give the student a feel of the reality of science by an encounter with phenomena which otherwise might be to him no more than words. (In short: Actuality).
3. To make the fact of science easy enough to learn and impressive enough to remember.
4. To give the student some insight into basic scientific laboratory methods, to let him/her use hands, and to train the student in their use. (In short: Practice in Methods/Techniques/ Instruments).

It is extremely important to aim a specific lab course to the relevant group of learners. All the goals mentioned here are aimed at undergraduate chemistry majors. For non-chemistry majors or high school students, it may be enough to concentrate on goals 1 and 3. Nevertheless, sometimes a few elements of practice should be offered to these students too. Students usually like to perform on their own in the lab, and hands-on experience is essential to any scientific subject (although perhaps not in mathematics).

Now, let us ask ourselves what happened in educational laboratories during the last two decades? It is clear that methods and techniques have constantly changed with time, **but the goals are still the same**. So how is this reflected in modern labs? And what can we expect and plan for the coming years in this branch of science education?

As the Coordinator of the Undergraduate Labs at BIU for many years, I can definitely see that there are four modern approaches that are slowly being incorporated into educational laboratories for all ages and groups of learners. These are:

1. The microscale (smallscale) laboratory.
2. Computerized laboratories.
3. Green and environmental experiments.
4. Experiments in Material Science and Nanotechnology (smart materials)

This abstract relates briefly to microscale and green chemistry only, but the oral talk and the full paper will deal with computerized and nanochemistry experiments as well.

The Microscale (smallscale) approach

Microscale experiments in chemistry have become popular in science eductaion since the 1980s. Initially it was started in colleges and universities, but then rapidly began to spread to high and middle schools, and in some places to kindergardens too. The microscale approach was first developed in relation to organic chemistry, mainly in the USA. Later it spread to inorganic and general chemistry labs. Today "Microscale Experimentation" is worldwide, and is discussed and presented at most conferences that deal with chemical education.

Green Chemistry

Green Chemistry means preventing pollution before it happens rather than cleaning up the mess later. The green chemistry approach fits well the microscale approach, and both approaches have common principles and attributes. One of the mottoes of green chemistry is: **"Nowadays what one does not produce from a chemical reaction is almost as important as what one does produce".**

As an example; The industrial synthesis of Ibuprofen (ADVIL) was done in the 1960s in 6 steps with a 40% atom economy, but in 1991 a new synthesis was patented. The synthesis now needs only 3 steps and the atom economy is 77%.

Since "Green Chemistry" has lately become very important, in industry as well, it should also be reflected/mentioned in high schools and in undergraduate lab systems.

Conclusions and Implications

1, The four experimental approaches to educational laboratories in chemistry must today be considered by any lab coordinator and policy maker.

2. These approaches are basically technical and deal with HOW to do an experiment and not in the DIDACTICS of carrying it out. All known didactic ways that are used in the labs can be used in each one of the four approaches.

3. Not much research has been done on the effect of these techniques on learning. Such research is important and can be challenging to participants in conferences that deal with research in chemical education.

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Creation and Assessment of a Portable Biochemistry Course with an Active Learning Emphasis

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Keywords: *Biochemistry, active learning, POGIL*

Background and Purpose. Recent recommendations by professional societies and scientific agencies encourage college and university instructors to consider making changes in the content and structure of their biochemistry courses to improve student engagement. Biochemistry at Seattle University has been taught without lecture using a structured small group format with instructor-designed activities for the past twelve years (Minderhout, 2007). These activities are written to follow a process-oriented guided inquiry (POGIL) model. The long-term success of this course has allowed us to support other biochemists in adopting the approach. We are currently half-way through a National Science Foundation funded project to test, improve, and disseminate our materials at diverse institutions throughout the United States and to assess student learning in participating classrooms.

Methods and Results. This project consists of two major components: 1) testing, optimization and dissemination of biochemistry active learning materials for use in a diversity of majors-level college/university biochemistry courses and 2) assessment of student learning in majors-level college/university biochemistry courses.

1. Preparation of materials for dissemination:

The first step in optimizing the active learning materials for use in diverse classrooms was to determine whether topics included align with subject areas typically included in biochemistry courses intended for biochemistry, chemistry or biology majors. To accomplish this, a group of expert biochemists mapped the curriculum suggested by American Society for Biochemistry and Molecular Biology (ASBMB) onto our set of classroom activities. In order to address deficiencies identified, additional activities were prepared by a set of core collaborators (biochemistry instructors) at a summer workshop.

Over the past two years all active learning activities have been used at a number of public and private colleges and universities in the United States in a diversity of classrooms including large classes (greater than 150 students), small classes (typically 15-40 students), and in courses offered through chemistry, biology, and biochemistry departments. To date, the activities have been used at nearly 20 institutions by over 1000 students. Formative feedback from students and instructors was used to improve activities, which were recently published as a workbook (Loertscher 2009). Sample activities are available at http://www.pcrest2.com/biochemistry/flyer.htm.

2. Assessment:

Two assessment instruments have been developed and are in the final stages of testing and optimization: an instrument designed to produce valid and reliable results measuring gains in student understanding of fundamental concepts from general chemistry and general biology and an embedded exam question designed to measure student understanding of a core biochemical concept in a new context. Starting in academic year 2010-11 these instruments will be used to assess student learning gains associated with the use of POGIL biochemistry activities.

Prior knowledge is both expected and built upon in biochemistry courses, yet little is known about specific content knowledge that students bring from prior coursework into the biochemistry classroom. The instrument we are currently developing is designed to measure student retention of general chemistry and general biology knowledge in key concept areas. The areas chosen for study are associated with common student misconceptions that chemistry and biology faculty have observed. While our instrument is in early stages of development, we are able to draw some conclusions about the preparedness of students in discrete aspects of prior knowledge. Specifically, preliminary data give new insight into student understanding of foundational concepts including bond energy, intermolecular forces, pKa, free energy changes, and protein structure. Ultimately, this instrument will be used as a pre/post-test to measure gains in student understanding of these foundational concepts as a result of using POGIL biochemistry materials.

The embedded exam question is designed to be included on the final exam for a course. This question is intended to measure student understanding of Michaelis-Menten enzyme kinetics, a core concept in biochemistry, using a context (binding protein affinity) that students would not have specifically learned as part of their biochemistry course.

Conclusions and Implications. We have developed a set of active learning materials for the biochemistry classroom that are optimized to function in diverse settings. This set of activities has been field tested at a number of institutions and covers a range of topics that experts agree should be included in a majors-level college/university biochemistry course. We are in the final stages of developing assessment instruments to measure student learning associated with use of these materials. These materials offer new options for instructors interested in increasing student engagement in their biochemistry course and data resulting from this study could guide curricular reform in biochemistry in the future.

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Using a quantitative approach to investigate teaching and learning of undergraduate chemistry.

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There are many challenges in teaching and learning of science at tertiary level including declining student engagement, provision of teaching environments and appropriate assessment and student transition into university. A study investigating these factors in relation to undergraduate chemistry has been carried out. The first element of the study explored student-learning profiles (SLP) where an SLP considered both cognitive and non-cognitive factors including students' motivations, preparedness for university, expectations of university, interaction with learning supports, approaches to learning, gender and previous chemistry experience. The second element of the study examined the implementation and evaluation of a new laboratory framework that focused on student knowledge, critical thinking and professional skills through the use of small-group teaching, problem-solving tasks and innovative assessments.

The study has identified varied and changing SLP's. It has been shown that factors including student 'interest', 'learning responsibilities', 'student attendance' and their 'approaches to learning' are positively correlated with academic achievement and that these factors which correlate well with academic achievement are also those that become problem areas by the end of both first and second year. The study has also shown that it is possible to introduce a laboratory framework with large a heterogeneous cohort that has positive effects on student learning, engagement and development of key laboratory and professional skills.

This talk will focus on the use of quantitative analysis for the purpose of investigating student profiles in undergraduate chemistry. The talk will detail the analysis tools utilised, their validation and the advantages and limitations of the quantitative approach. Furthermore findings from the study on student profiles will be discussed in the context of the research approach employed.

Differentiated promotion of interest and talent with experimental tasks in chemical education

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The differentiated promotion of pupils' interest and giftedness gets more and more into the focus of education development at school. In this point of view, several programmes of acceleration and enrichment of education were proposed [1]. For chemical education, this also means the targeted development of experimental possibilities to enrich a differentiated promotion of giftedness. Experiments are highly adequate to promote the different talents and capabilities of students not only on a cognitive level [2].

The aim of this study was to develop experimental exercises which allow different ways of problem solving. The possibilities for experimenting and problem solving require different levels of pre-knowledge, cognitive capabilities and manual skills during experiments. The first experimental exercise on "the warming up of various substances in a microwave oven" [3] was developed and tested for 10^{th} grade pupils on the basis of multidimensional models of giftedness [4] and with the inclusion of developed criteria for the design of open experimental exercises. This exercise has then been tested in a design of qualitative study. It has been analysed how highly cognitively skilled pupils plan, work on and solve the experimental exercise, compared with pupils having average cognitive skills.

A total of 14 pupils grouped into homogeneous pairs of highly intelligent pupils as assessed by an IQ test, potentially highly intelligent pupils as assessed by their teachers as well as averagely intelligent pupils participated in solving that exercise. The central aim was to find out whether characteristic strategies to solve this open exercise can be differentiated between the highly and the averagely gifted pupils and, if applicable, what the differences are.

First results show that the designed exercise allows for both simple and complex approaches and can be solved both by highly and averagely gifted pupils. Various approaches to solve the exercise were used by the pupils, ranging from the non-reflected "trial-and-error" approach to the systematically scientific approach. It can be pointed out that the averagely gifted pupils use approaches with a lower reflection level than the highly gifted ones. The cognitively highly skilled pupils observed in the study plan their experiments in a more structured way and thus also solve the task faster. However they avoid more frequently the way of problem solving by experimenting than averagely skilled pupils and prefer problem solving by consulting appropriate literature [5].

It is a special challenge in the development of experimental exercises for learning groups with heterogeneous performance and talent levels, to find topics for experiments which offer all pupils an equally high potential of motivation and where the solving of experimental tasks is adapted to the different cognitive capabilities. For talented and capable pupils, the experimental exercises should provide a strong incentive for execution. Less skilled pupils require experimental exercises which allow a planning and execution that can be structured well.

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Learning the scientific method through a very simple experiment

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Keywords: small-group discovery-based learning, experiment with a burning candle, nature of science

One of the basic topics in science teaching should be the relation and relevance of science to cultural and societal development. But, the reality of classroom practice is different; in the majority of cases predominant teaching method is instructional (deductive, top-to-bottom approach), i.e. the teachers present the concepts, their logical implications and give examples of applications. Correspondingly, science appears to students as a rigid system of trivial facts that should be memorized. As a result wrong perception of science is developed.

In contrast to that, the use of a small-group discovery-based learning strategy (Judaš, 2010) as general teaching method makes it possible to show that science is a creative process in which everyone can participate.

A cross-age ` was performed with the intention to examine alternative concepts that were developed by Croatian students in explaining the results of an experiment and describing observed chemical change through the concept of a chemical equation. The experiment in question was the simple and well-known experiment with the candle burning under a glass vessel. We have also performed an extensive analysis of available text-books, that indicated that this experiment is often used misleadingly in teaching. An example of this is using the experiment to demonstrate the volume-percentage of the oxygen in a sample of air.

To provide better understanding of the nature of science and of the phenomena occurring during the burning candle experiment we have developed a workshop based on small-group discovery-based learning. The goal of the workshop was to test the volume-percentage hypotheses by a series of carefully conducted experiments. The results obtained by students' team-work were discussed and have unambiguously shown that the results of the experiment are very dependent on the experimental procedure and that it cannot be used to demonstrate the percentage of oxygen in the air. This was also clearly demonstrated by conducting the experiment in a closed system: the candle could be repeatedly lighted, demonstrating that flame exhaustion is not related to complete oxygen depletion, but by the other factors (Tawarah, 1987; Peckham, 1993; Birk & Lawson, 1999; Krnel & Gložar, 2001).

The students' response to the workshop confirmed the opinion that, if properly conducted, the burning candle experiment should definitively be used in teaching Chemistry at the introductory level (as well as at the higher ones) because of its extremely high educational value. Through this experiment, students are faced with a real and interdisciplinary scientific problem. To solve the problem, they must use the knowledge of physical and chemical concepts they have acquired so far, discuss the facts, confront ideas and discard them on the basis of facts. Doing all this with a simple and inexpensive experiment that can be conducted in every classroom they train themselves in scientific method, they learn the true and exciting nature of science enabling every one of them with an equal chance to participate.

Facts must be memorized, but, more importantly, experience of science should be made possible. Direct experiences with science allow students to realize how scientific ideas arise and become valid truths and allow them to confront their stereotypes of scientists and to reflect on the role of science and technology in society.

Small-group discovery-based learning presents science as a creative, dynamic, intellectually and emotionally involving, endeavour. It dispels the stereotype of socially inept scientists, allowing students to develop a personal identity as a scientist.

Natural phenomena and the laws that govern them know no national, cultural, or social boundaries. Correspondingly, in order to appreciate diversity, whether it is cultural, linguistic, gender-based, or otherwise derived, it is necessary for the dialogue participants to speak a common language. The ability to understand and talk about science (science literacy) is that kind of language.

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Transition Metals – The Transformation of a Scientific Text to a Learning Text

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Keyords: chemistry education, secondary schools, creation of a textbook, transformation of a scientific text

Introduction. Chemistry is a fast-growing field with many modern applications. Everyday chemistry brings new results – whether in the form of new compounds or finding new properties and use for known ones. The question is how to familiarize high school students with the most important chemistry information. Of course the technical issues are not accessible to the students in the form of scientific publications and it is therefore necessary to process the data into a form that would be easily accessible for them. Textbooks of current high school chemistry, which would present some current chemistry knowledge and which would combine chemistry with normal life, are needed in most European Union countries. Therefore, we focused on the establishment of scientific principles which can transform a scientific text into a learning text and their actual use in making a textbook on some of the transition metals and its verifying at school. This theme was chosen because it is one of the most dynamic and really quickly developing parts of chemistry and was often neglected in teaching.

Methods of transformation of a scientific text to a learning text. The fundamental step in making a textbook is the definition of the topic, an area of chemistry that we want to process. The next step is to determine the general objectives of education of every topic on which basis the specific objectives of the textbook are fixed [1]. Educational objectives should be specified in the student's point of view, not in the teacher's. That means, what we want the student to know, to be able to represent and to perform [2]. It is necessary to determine these objectives in order to realize an educational and psychological level of the target group of students for whom the learning text is intended. The next step is the determination of the content and structure of the curriculum. For the selection of the curriculum we use a system approach and the method of logical analysis and synthesis. As an appropriate instrument for organizing the curriculum, we can use conceptual maps. It is a graphical representation of the curriculum structure, namely the key concepts that should be introduced and explained in the learning text. Then the real transformation of the scientific text to the learning text based on the following principles and guidelines comes:

First, it is necessary to condense the text, to dispose of redundant terms, to add some clarification of abstract terms and explain them using some examples from the student's immediate surroundings where possible. It is also necessary to increase the attractiveness of the text by adding images, photographs, diagrams, tables and graphs through which the students can imagine and remember the topics easier [3]. Experiments, which should be put into the education, serve the same purpose. Experiments are not only an important motivating factor in teaching but they should also show the spirit of certain chemical processes and properties of substances. Students may not experience just an amazing event, but also gain knowledge and understanding of some chemical principles and phenomena. Even the formal and graphic form of the learning text is important. We should think of colour, font style, font size, etc. It is not easy to balance the attractiveness of the text with its practicality. It may happen that the text contains a rainbow of colours and different fonts and sizes of letters, so it is very interesting, but it becomes almost unreadable and incomprehensible. From literature [4] it is known that the student must have a constant feedback and because of that each topic should be terminated with a set of control tasks and exercises to practice the theme. One remembers the topic the best if he/she had to attempt to use the gained knowledge to solve a task. To verify that the students can apply acquired information we include tasks for individual study. The aim of education is to lead students from knowledge to skills and competencies and therefore to individual information retrieval and use, not only to memorize. Therefore, at the end of each topic students can find links to available literature, where they can deepen their knowledge in case of interest in the topic (popular scientific publications, web links, professional literature, etc.).

Results and conclusion. The article summarizes basic rules of transformation of a scientific text to a learning text according to the mentioned methodology. We use this procedure in creating our textbook focused on transition metals. We prepare learning texts about elements from the 11th and 12th group (I.B and II.B). The textbook should then be verified in schools, modified according to the requirements of teachers and students of secondary schools and prepared for the use in real education. So the result will be a verified set of learning texts for students of secondary schools.

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Concept mapping as an enriching learning tool in the Inorganic Chemistry Laboratory.

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Background, framework and purpose. The underlying learning theory of concept mapping is the symbolic representation of how students process information and organize knowledge in their cognitive (thinking) domain. In simple terms, the elements of a concept map relate to how cognitive knowledge is structurally developed by a learner: hierarchical structure, progressive differentiation, and integrative reconciliation. Ausubel(1963).

Concept mapping is one way to implement classroom pedagogy which promotes meaningful learning and at the same time helps develop students thinking skills. Novak and Gowin(1984). Key components of concept maps are the propositional relationships or links, two of more concept labels linked by words that read as a unit. Those links are usually action words explaining the meaning of their relationship. In the early stages of developing this skill, links may be less important than basic concept identification. Novak and Cańas(2006).

In our teaching experience at the Laboratory courses at the Chemistry Faculty of the National Autonomous University of Mexico, we have noticed in some students lack of meaningful learning during their laboratory work; for that reason, the implementation of the use of concept mapping as a pedagogical tool that promotes meaningful learning and also helps develop students thinking skills have been proposed. With this pedagogical tool, students organize information and develop higher order thinking skills, as they elaborate a concept map at the beginning of the experimental work showing their previous knowledge; then, they carry out the experiment and must produce a second concept map, which should show the relationship between the previous knowledge and how they have processed the new information in their cognitive domain. Boggino (2001).

Methods. The Laboratory Course of Inorganic Chemistry at the Chemistry Faculty, UNAM Mexico, is organized by twelve lessons each of three hours per week with a group of almost fifteen pupils with one teacher; experiments are carried out in nearly two and a half hours. At the beginning of each class session, the previous knowledge of the students is questioned by means of individually elaborating a concept map.

Then students make the experiment and produce a second concept map in which they have to organize their knowledge, insert the new knowledge and relate them with their preview knowledge. In this research, six laboratory experiments were selected to test concept mapping pedagogy. Cotton, Wilkinson and Gaus (1995)

Results. The sixteen students of the 3th semester of the 5 careers of the Chemistry Faculty, who worked in the Inorganic Chemistry Laboratory using the methodology of concept mapping, showed in a clearer way the identification of the basic concepts involved in the 6 experiments: 1- Metals oxidation and periodic properties. 2- Ionic compounds properties and covalent compounds. 3- Acidity of metallic cations. 4- Hydrogen and oxygen preparation and properties. 5- Properties of elemental chlorine. 6- Coordination compounds. The 2nd conceptual map that they made at the end of the experiment had a gradual improvement as long as the course went on.

In every experiment students learned more concepts to add them in their cognitive structure; in the 1st experiment they added 4 new concepts, in the 2nd experiment they added 3 new concepts, in the 3rd experiment they added 5 new concepts, in the 4th experiment they added 5 new concepts and in the last experiment they added 6 new concepts.

We believe that the results were satisfactory, as students were induced to relate their prior knowledge to the experiment shown and increasing in their knowledge, relate them and give them a hierarchical structure.

Conclusions and implications. In elaborating concept maps, which are graphic diagrams, students learn progressive differentiation between learning semantic concepts, prioritize concepts and knowledge, restructure cognitive precedent which will help them perform the experimental part. At the end of the experiment, with the basic information linking substantially new concepts and propositions into existing cognitive structures, they are developing a final concept map, and verifying the enrichment of their knowledge.

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Keywords: Concept mapping, Meaningful learning, Innovative pedagogy, Inorganic Chemistry Laboratory.

Tema: – Teaching and learning chemistry at all level of education (from elementary schools to universities, general and vocational schools).

Pre-service elementary teachers' conceptions of matter concepts: the case of physical transformations

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Keywords: students in formation, primary school, conception, physical transformations, qualitative research

The science education literature includes few studies that described conceptions held by the pre-service elementary teachers. Those we listed show that their conceptions of energy and matter (Kruger & Palacio, 1992); astronomy (Frede & Venturini, 2006; Atwood & Atwood, 1996); electrostatics (Métioui & Trudel, 2007); electric current (Webb, 1992) are inconsistent with the scientific concepts they are expected to teach. However, research could not be found on the pre-service elementary teachers' conceptions of matter concepts. Thus, the present research will be focused around the two following questions: "What conceptions are held by Quebec pre-service elementary teachers about matter concepts?" and "How do they make sense of scientific phenomena related to the physical transformations of matter?" The present research has been conducted in the context of a formation of pre-service elementary teachers on the didactic of the science and technology at a Canadian university (in Quebec). The research sample was constituted of hundred-twenty nine (129) trainee teachers registered in the second year of a teaching program of a length of 4 years. To identify their conceptions, we have them completed a paper-pencil questionnaire of a length of sixty (60) minutes. The questionnaire contains three multiple-choice questions where they have to explain their choice and four open questions where they have to justify their answers. All of these questions are related implicitly to the particulate model of matter. Moreover, the phenomena raised in the questionnaire are familiar to the participants but could not easily be approached and solved in an algorithmic way. Thus, they must refer to their conceptual framework. To identify their conceptions, we compiled the answers, a question at a time. For each of them, we regrouped the answers in distinct categories (Métioui & Trudel, 2007). For example, in the case of the multiple-choice question, an experimental situation is presented in which one knows the weight of a copper ball, heats it, and notes that it has enlarged. They have to choose if its weight is the same, more or less. An analysis of the answers of trainee teachers allowed us to identify three categories of answers:

<u>Category 1</u> – With respect to the distance and the movement of the particles - A minority (13%) gives an answer that we considered to be partially scientific, even though for some trainee teachers the copper exists at the molecular state, while referring to the particulate aspect of matter to explain the increase of the volume of the ball as follows : "The particles of copper are going to take more place only. »; "The molecules speed up with the heat and their displacements require more space."; "The particles that compose the ball increase in size with the heat."

<u>Category 2</u> - The weight of the copper ball is not conserved - 25% of the respondents associate the augmentation of its volume to an increase (19%) or a reduction (7%) of its mass using an implicit conception of heat as a substance. Thus, they don't separate the concepts of mass and volume. Let's note that the distinction between mass and volume requires the acquisition of the emptiness notion. The reasons advanced by some trainee teachers show a wrong appropriation of the concepts of matter and heat as follows : "If the volume of the ball increases, its mass will be necessarily greater."; "The expansion of the ball is due to bubbles of air produced in the copper ball by the heat, therefore the ball having more air in itself weighs more."; "The hot matters are heavier than the cold matters because the particles of heat make the ball inflate."; "The atoms move away from each other because of the heat, therefore there is an increase in the volume of the ball and there is a loss of matter because of the heat."

Category 3 - The mass of the ball will remain constant - 62% of the respondents don't use the particulate model, but instead a homogenous model of matter, similar to the Thomson's model (Métioui, 1987), to justify the conservation of the mass in spite of the increase in volume. In fact, it is the molecules or particles that are influenced by the heat (through their increase in size) rather than their speeds or their distances. The different answers revealed many wrong conceptions as follows: "The heat dilates the molecules of copper, that grow in thickness."; "The particles increase their size."; "While absorbing the heat, the ball seems bigger, but since the heat doesn't weigh anything, then the ball keeps the same weight."; "One didn't add nor removed copper from the ball and, as a consequence, the density remains the same."; "The particles of metal become bigger."; "The mass of the ball remains the same so that it won't change the state of the matter."; "The molecules of copper grew and do not multiply."

Finally, we are going to see that some misconceptions identified in this research are similar to those revealed in the study of pupils' misconceptions (age 12-16) about matter and its transformations (Anderson, 1990, Galili, 1994, Çalik and Ayas, 2005, Canpolat, 2006). Also, we are going to see that these misconceptions could help us elaborate a sequence of teaching using conceptual conflict (De Jong, Van Driel & Verloop, 2005). This teaching sequence would consist of situations that would have as a goal to confront the conceptions of the students with those of the scientists. It would allow the trainee teachers to become aware that some of their explanations may come up against the observed reality or the theoretical framework with respect to the atomic and molecular aspects of matter.

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Evolution of student teachers' conceptions about light following constructivist didactic activities

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Keywords: Canada, training teacher, primary school, constructivist didactic activities, light

A review of various researches on the sensitive issue of sciences in elementary schools indicates that students show a fascinating curiosity to understand the material environment with which they interact and, consequently, they develop different conceptions prior to any formal teaching. However, despite the functional and operational role of these conceptions, they are misconceptions that conflict with accepted scientific theories (Sharp, 1996; Selley, 1996; Potari & Spiliotopoulou, 1996). In order to change these misconceptions, a few studies reveal that it is possible to implement instructional and learning strategies eliciting both students' naďve conceptions and scientific conceptions (Canal, 1986; Invernizzi, Marioni & Sabadini, 1989; Ravanis & Papamichaël, 1995). Still, we have noticed that, in spite of the evident contribution of these researches, teacher's education constitutes a major obstacle to their implementation in the classroom. Indeed, researches conducted among others in England and Australia (Kruger & Palacio, 1992) show some astounding analogies between children's spontaneous conceptions and teachers'. The present poster aims at, on one hand, studying the misconceptions of student teachers' enrolled in a preschool and elementary education bachelor's program, in relation to the rectilinear propagation model of light. On the other hand, an approach based on the idea of conceptual conflict was experimented with these student teachers in order to facilitate the learning of the model. Thus, we managed to bring a significant proportion of student teachers to realize the conceptual path necessary to assimilate the rectilinear propagation model of light, the steps of which shall be introduced here.

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1984-2009. A Retrospective Survey on 25 years of JIREC, the French Conference on Innovation and Research in Chemical Education.

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Keywords: Education, Chemistry, Innovation, Conference, France

For its 25th anniversary, the JIREC conference was held in Mulhouse (France) [1], with a great success. At ECRICE 2010 we will present a survey of the 25 years of Conferences, on behalf of Bernard Monfort, the "live memory" of the JIREC and original writer of this story - a hard job compiling all available archives - and of course the "Société Chimique de France" (SCF) [2] Education Division which contribute actively every year for the success of the event.

Back to 1983, in order to answer a growing interest and quest of information, exchanges, dissemination of pedagogical experiments and didactical researches, Paul Arnaud (past president of the SCF Education Division), Maurice Chastrette and Roland Lissillour founded the "JIREC" « *Journées de l'Innovation et de la Recherche dans l'Education en Chimie* » that could literally be translated as « Days on Innovation and Research in Chemical Education ». Looking at it more carefully, the purpose, the audience, etc … seems relatively similar to the European ECRICE philosophy – but French way.

The first meetings occurred in Biviers (France) in 1984 and 1985, and were the foundation act, of the creation of small pedagogical university teams, highly motivated by teaching and training, under the auspice of the Education Division of the SCF. Since 2001, every 2 years, the organization run a joined meeting with MIEC "*Journées Multimédia et Informatique pour l'Enseignement de la Chimie*" (Multimedia and Computer for the Chemical Education).

Part of the success is also the combination of the Division price ceremony, awarded by the Education Division at each JIREC edition to valuable didactic approaches and experiments. We are currently working on a possible English translation of some awarded works and papers, in order to make it available to the wide chemical education community.

The full JIREC story will certainly be completed in the future. Several articles were already published in the past in various Journals, but a recent set of visible results has been made accessible, thanks to Katia Fajerwerg, Françoise Rouquérol, Claudine Follet and the editorial team of *L'Actualité Chimique*; they received the congratulations of the SCF Education Division for the great job done in writing and publishing 6 fundamental and pedagogical articles taken from the JIREC 2008 edition [3] – see the summary online under reference [4].

The JIREC 2010 will be held in La Grande Motte (France), on June 2-4, 2010, and will target the Nuclear Chemistry Teaching and Use in the Energy Field. The 2011 edition, is scheduled on May 24-27, 2011, in Orsay (France), with the « Chemistry and Life » thematic.

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Acknowledgements

Bernard Montfort et al. for the valuable effort in retrieving all JIREC archives, and his kind authorization to use this material at ECRICE 2010.

- *SCF for funding the ECRICE Participation.*
- *With a great pleasure and my warmest regards, to Prof. Maurice Chastrette, as my former Thesis Supervisor and Head of the Laboratory, who enlighten my view on Chemistry, Society, Information and Didactic.*

Virtual environments of remote work and lifelong learning

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Background. The ability to work on remote learning platforms and to use them in lifelong learning have become the most important abilities which should be developed by students and teachers/ instructors as well. European knowledge-based economy depends on well educated citizens, i.e. those who can react to the needs of the economy and change their qualifications according to its needs. It is e-learning which can guarantee a rapid and high quality change in qualifications.

Eight competences have been defined which are vital for lifelong learning. The competences constitute a combination of knowledge, skills and stances which respond to particular situations. Key competences are those needed by everyone to fulfill their ambitions, to pursue personal development, to be active as citizens, to participate in social integration and to find employment. Therefore eight key competences have been determined [1]:

1. mother tongue communication,
2. foreign language communication,
3. mathematics and basic scientific and technological competences,
4. information technology competences,
5. learning skills,
6. social and civil competences,
7. innitiative and enterpreneurship
8. cultural awareness and expression.

Methods. Information technology skills occupy the important fourth position here but can they be developed in a virtual environment? The Department of Chemical Education has two Moodle learning platforms where on-line courses for students and teachers as well as complementary teaching courses have been taught since 2005. Since the end of 2008, Microsoft SharePoint platform courses have been administered as well. According to the requirements of the European Union aiming at preparing the citizens for lifelong learning there have been classes for students, teachers and educators which teach them how to independently create remote courses to be published on various platforms. There have been some classes on e-learning methodology which prepare future teachers as well as current teachers for teaching classes in virtual environments of distant work. The use of remote learning platforms for education on different levels makes it easy to manage the educational process, it offers greater possibilities related to creating and publishing educational materials. By making use of virtual environments of remote work, one may raise one's qualifications and at the same time help others to do the same e.g. by carrying out classes.

Results, conclusions and implications. These skills are being developed in courses held by the Department of Chemical Education. Certified remote courses run in cooperation with Microsoft Education offer their participants the opportunity to acquire skills which might be used in lifelong learning. In order to join a distance learning class, potential students need no more than basic computer and Internet skills. In subsequent weeks of the course, its participants are familiarized with the principles of creating multimedia materials, animations, interactive instructions as well as presentations to be used in remote courses. The virtual classes take from eighth to twelve weeks depending on the subject of the course and the participants' levels. During the course and following it, students are asked to fill in questionnaires in order for the teachers to evaluate the development of their skills as well as discover and eliminate potential problems.

Owing to appropriate tools available on the remote learning platforms, it possible to reach every single participant. The materials are prepared in various forms so that each student could use the elements which they find most useful. Interactive instructions seem to have gained the most popularity as they individualize the pace of work.

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An Internet 3d Module For Demonstrations And Practicing Laboratory Procedures

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Although computer laboratory simulations cannot replace practical exercises in real life laboratory, they can be used with much success if they serve the purpose ofpreparation for such hands-on experiments. Given access to such simulations via the Internet, students can prepare for laboratory tasks better and when the simulations are complete with elementsof evaluation, the correct understanding of those tasks seems to be improved [1].

The**Labscript** module was designed to present virtual laboratory tasks in the form of realistic 3D environment. The user can makeinteractive decisions within this environment within the scope definedin the scenarios. The three modes in which the module may function allow the following: (A) presenting laboratory experiments, (B) practicing the experiments, and (C) testing the students' familiarity with the procedures.

The**Labscript** module prepared as Internet **Shockwave** software makes use of the advantages of **AdobeDirector**for flexible programming of interaction with respect to 3D objects. The environment of virtual laboratory designed in the module consists of interactive 3D components. They are controlled according to the scenario provided by the author of simulations via a simplecode and some full sentence comments for the user. Following educational tasks, one hundred and ninety-seventasks collected in fifteenchapters were prepared in 2009 [2]

The Internet moduleextendsthe research and educational work carried out at the Faculty of Chemical Education within whichthe modules for exercising skills of balancingchemical reactions [3], calculatingconcentrations of chemicalsolutions [4], composing the structure of simple molecule models[5], drawing structural formulae [6] and of team building of idea-maps [7] were prepared.

The**Labscript** project is aimed at increasing individualization of preparatory work for laboratory classes that needs to be done by students as well as at increasing the efficacy of such work. For the instructor, the module constitutes a toolthatmakes it easier to organize and visualizelaboratory problems. Owing to its Internet form,the module may be included in the strategy of e-learning.

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Problem Solving with LEGO®-Method – new Calculation in Chemistry

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Keywords: Chemistry, problem solving, LEGO®-Method, building block, basic panel

The skills of chemistry problem solving are necessary to the scientific fundamentals; therefore those may not be questioned in the university studies. Nevertheless the secondary school teachers have a different opinion on the extent of chemical calculation teaching, because the stoichiometric problems have always been difficult for many students. Namely, solving a chemistry problem requires both precise, analytical thinking and mathematical skill.

There are some classical and many times effective strategies used in chemistry education for calculating:

- Dimensional analysis (also called Factor-Label Method or the Unit Factor Method) is often used in the US and Canada for problem-solving (Zumdahl 2000), but it is not common in Europe. The way of dimensional analysis is too often used without consistency and understanding, which ends in a series of multiplications by randomly selected conversion factors (Borkowski 2005).
- Proportionality-method or rule of three (method of finding the fourth term of a proportion when three terms are given) is common used in Hungary, because it is clearly discussed in most of chemistry textbooks (Siposné et.al. 2003). Students often compare different type of quantities, which led to false results, and they lose count in consequence of missing units, too (Fach et.al. 2007).
- Mole-method is based on the conversion of mass/volume/concentration of given substance to mole, comparison the moles of given and demanded matter, and then convert mole to mass/volume/concentration again. This problem solving strategy contains some needless calculative steps and uses large number of different relations. That is why the inexperienced students can use this method with difficulty, and only qualified students choose this problem solving strategy (Tóth & Kiss 2005).

LEGO®-method is based on mole-concept, but has been invented for easier problem solving (Molnár & Molnárné 2006). The relations of mole and the molar amounts, as small perspicuous units (building blocks), are applied on a fundamental relationship (basic panel) and the problem can be solved as an algebraic operation.

The relationship of **basic panel** is suitable to solve almost any type of chemical problems:

$$n_{unknown} = \frac{\mathrm{u}_{\mathrm{unknown}}}{\mathrm{u}_{\mathrm{given}}} \cdot n_{given}$$

The “u” coefficients of the given and the unknown amounts are whole numbers (e.g. the coefficients of balanced chemical equation or numbers of a selected atom in a molecule).

The **building blocks** are simple relations, which connect the mole with different physical amounts (e.g. number of particle, mass, volume):

$$n = \frac{N}{N_{\mathrm{A}}} \qquad n = \frac{m}{M} \qquad n = \frac{V_{gas}}{V_{STP}} \qquad n = \frac{p \cdot V}{R \cdot T} \qquad n_e = \frac{I \cdot t}{F} \qquad n = \frac{\pi \cdot V}{R \cdot T} \qquad n = c \cdot V_{sol}$$

The building blocks of the expression of different concentrations, ratios or percentages, and density are added to these in the case of mixtures or solutions e.g.:

$$c_i = \frac{m_i}{V_{solution}} \quad c_R = \frac{n}{m_{solvent}} \quad X_i = \frac{n_i}{n_{total}} \quad w_i = 100\frac{m_i}{m_{total}} \quad \rho = \frac{m}{V}$$

LEGO®-method does not break down the calculation into unnecessary steps, and it does not require students to memorize lots of final formulas, but only to use consistently the panel and building blocks. Both understanding of the problem and correct use of definitions and units have a significant role in application of this method. LEGO®-method is performed in four steps:

1. Find out what substance and property is unknown and what is given; and find out what kind of building blocks are required in the relationship.
2. Fix the coefficients, and find out what constants are needed.
3. Build up the blocks to the panel, and solve the formula for unknown.
4. Replace the quantities by number values and perform the math on both the units and the numbers.

Tóth and Sebestyén (2009) stated that only ca. 40 percent of the Hungarian secondary students (7th to 10th grades) use any strategy in solving the complex stoichiometric problem.

On the other hand, our non published measurements have demonstrated that 8th to 12th graders (N = 255), who learned the LEGO®-method in the school, have used this strategy more frequently (ca. 60 %) than mole or proportionality methods for solving a stoichiometric problem. The success of these students (ca. 77 %) indicates that the LEGO®-method is a useful alternative strategy for teaching calculations and for a more complete understanding of problem solving.

Comparison of the strategies with each other and some typical examples for LEGO®-method will also be demonstrated on the oral presentation. E.g. '*How many grams of hydrochloric acid (M = 36.5 g/mol) gives 10.0 dm³ of carbon dioxide at STP (V_m = 24.5 dm³/mol) according to the following chemical equation?* $Na_2CO_3 + 2\ HCl \rightarrow 2\ NaCl + CO_2 + H_2O$'

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Chemistry Lesson on the Field – Common Use of Renewable Energy Sources

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Keywords: renewable energy, Energy-Day-program, school trip, pros and cons,

The European Commission put forward a proposal for a new Directive on renewable energies, which demand each member state to increase its use of renewable energies – such as solar, wind or hydro energy (Directives 2009). Use of these energy sources is very low nowadays in Hungary (EurActiv 2007-09); therefore the next generation has to be acquainted with the pros and cons of the renewable energies during their school age.

My 14-year-old students belonging to class 8.A wanted to know more than they could find in the Chemistry textbook about the renewable energy sources (Siposné et.al. 2003). That is why we planned an Energy-Day-program during our three-day school trip last September.

This Energy-Day-program included visits in four plants working with green energy

- Wind Power in Vép (Fucsko 2008) – electricity generated in the regular wind farm is fed into the public utility electricity network and provides the public lighting costs of the village (3000 inhabitants),
- Biomass based Village Heating in Pornóapáti (Purker 2009) – the system is supplied by heat from two woodchip and sawdust firing furnaces; the length of the heat pipeline system is 3900 running metres,
- Micro Hydroelectric Power Station on Pinka river in Pornóapáti – this small hydro plant is operated by 2 generators and is connected to the distribution grid,
- Solar Water Heating System in Szentgyörgyvölgy – the 128 m^2 flat plate collectors produce the hot water for the swimming pool and hot-water supply of the Go-Na Őrség Leisure Centre.

The students took notes at the stations and showed significant interest in using these renewable energy sources. Their questions were answered by experienced engineers at every station.

On the following days we stayed at Szalafő and the renewable energies were cited before the "students' court". Some students previously prepared for showing the advantages of one of the energies, they were the lawyers; and others, the accusers, stated the disadvantages of using that energy source. The Chemistry teacher, the arbiter, was not in a favourable position, because the students represented the pros and cons enthusiastically. Their cons were considerable and surprising, because they brought on the question of

- the costs and the environmental pollution of the production of the equipments (e.g. wind towers, turbines, furnace, pipelines, collectors),
- the extra quantity of CO_2 emission of the vehicles in the course of transporting of biomass,
- the damaging environmental action of any occasional accidents at the workplace,
- the possibility of energy storage.

The students reached the conclusion that the usage of these renewable energy sources is limited in Hungary (because of the small number of the sunny hours; there are not great falling rivers in our country). Furthermore, their utilization is more expensive than the usage of fossil fuels. Nevertheless, these energies have to be used, because they are renewable and most of them decrease the CO_2 in the atmosphere effectively, which is beneficial for the greenhouse effect.

The next day we visited the open air Village Museum of Szalafő-Pityerszer (the most archaic village in the Őrség region from the 18th century), where the houses were built by piling up girders on each other and the girders were matched at the corners by cross finite or swallowtail tapping. These harrow wall houses were plastered in-and-out with hayseed swampy sludge and the roof was thatched with rye straw (Márkus 2004).

The common usage of the energy came up again. The importance of heat insulation and the orientation of the harrow walled houses was the recurring topic of the students' conversation. They understood that the use of a thatched roof was mostly a necessity; on the other hand its insulating power caused the constant temperature throughout the house.

Due to this school trip the students became more observant. They took notice of interesting objects, which would have been passed earlier. During our homeward journey it was interesting when they got to see the solar cells of an electric fence; they started to enlarge upon the pros and cons of the usage of solar energy.

On the project-day of the school the students gave an account of their acquired energy-knowledge through posters and oral presentations.

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The school trip and the energy-day program were supported by the "Environment and Energy" Operational Programme of National Development Agency (KEOP-6.1.0/A/09-2009-0017).

Critical Analysis of Greek Secondary School Curricula for Chemical Laboratory Teaching

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Background, framework and purpose. The Greek Secondary School Educational system is divided in the following levels: A) 12-15 years of student age: Lower secondary general education and B) 15-18 years of student age as following: B1) General upper secondary school including 77% of the students [1] (divided after 1st class in three sub-directions, science, technological and humanistic) and B2)Vocational upper secondary school or Vocational training schools

The curricula are determined by the Ministry of Education.

The purpose of this work is to analyse the conditions under which take place the laboratory exercise of the students and how they affect their ability to understand and perform themselves basic chemical laboratory operations.

Results. The chemical laboratory exercises are determined by the Ministry as follows (in parentheses the total chemistry hours per week):

Lower secondary general education

1st class: no chemistry courses at all. 2nd class (1 hour per week): solubility of materials-compounds in the water, preparation of solutions of given concentrations, separation of mixtures in their components, preparation of oxygen with electrolysis of water. 3rd class (1 hour per week): the red cabbage as indicator, the reaction of acids with marble, comparison of iron and copper activities, detection of Cl, Br, I ions with $AgNO_3$

General upper secondary school

1st class (2 hours per week): determination of pH with indicators, pH-paper, pH-meter with the use of multi-log, chemical reactions and qualitative analysis of ions, preparations of solutions of given concentrations. 2nd class (2 hours per week): ethanol oxidation, acidic character of carboxylic ions, preparation of soap. In the science discipline there are three additional exercises in heat of reaction, chemical kinetics and oxidation reaction. 3rd class: (only for science discipline) buffer solutions, volumetric titration of acetic acid in vinegar.

Prefecture of Chania is a representative sample as it is the 1.5% of the Greek population. It has 26 lower secondary schools and 17 general upper secondary schools. 10 Lower secondary schools (38%) and 5 general upper secondary schools (29%) have not any laboratory of physical sciences (Lab.). Additionally there are 9 vocational upper secondary schools; 8 of these (89%) have not any Lab. Most of the existing Labs they are also used for teaching other (no physical) courses too. Concerning Lab. equipment, it is in a very good level for General upper schools but in a no satisfactory level for Lower secondary schools and almost no existing for vocational upper schools.

In school curricula there is not separate laboratory time; the chemistry hours are a few (usually 1) and many subjects shall be taught so it is very difficult an adequate lab. exercise. As one chemist teacher has to teach 20-30 students the case becomes much more difficult.

In the year 2002 the Laboratory Centres of Physical Sciences (LCPS) were established (usually one LCPS in every Prefecture); additionally one responsible teacher in every Lab. school was set. LCPS succeed to cover a part of the existing problems in Physical Sciences Laboratory Teaching. LCPS organise training courses for teachers responsible for the Lab. of schools, they provide on site assistance and equipment support and they provide their Lab. facilities especially for schools without their own. At the end of the school year they collect the information about the Lab. exercises that they were performed.

Conclusions and implications. The Chemical Laboratory Teaching in Greek secondary school suffers from many problems (lack of laboratory rooms, suitable equipment, exercise time, number of teachers per practiced students etc. The establishment of LCPS as well as one responsible teacher per school Lab. have improved the situation but many steps forward shall take place in the future.

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Enhancing students' chemical literacy by using the spatial mind model

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Keywords: chemistry, chemical literacy, spatial mind model.

Students' unwilling to learn chemistry is a problem of the 21st century for many European countries (Jidesjö, 2008). Therefore promotion of scientific & chemical literacy at schools has a significant meaning with future prospect (Kelly, 2007). It rises up the issue to look for balance between the interest, knowledge and understanding in sciences education, included chemistry. Practically it is uneasy to realize at school. Research results shows that great part of students is less interested to learn chemistry therefore students` investment is comparatively low in a studying progress (Mozeika, Cedere, Gedrovics, 2008). Meaningful learning could be carry out by active learning (Prince, 2004). Students` interest may enhance if the chemistry lessons becomes understandable based on well-know examples from real life.

The study is oriented to test the new teaching method (model using) for enhancing chemical literacy.

For promoting students` chemical literacy on the nature of substances and their transformation, we offer to use a spatial mind model. As an analogue to 3D mind maps this model has the possibility simultaneously systematize information and also show connections among various topics. The form of spatial model is the simplest polyhedron – tetrahedron (Fig. 1, a), which has similarities to the associational and interconnected world around. The action of spatial mind model is oriented to find and finally to understand relations.

Example, the topic Substances. During the lessons students are involved in active discussions (also group work) for choosing the most important four connected topics (Fig. 1, a).

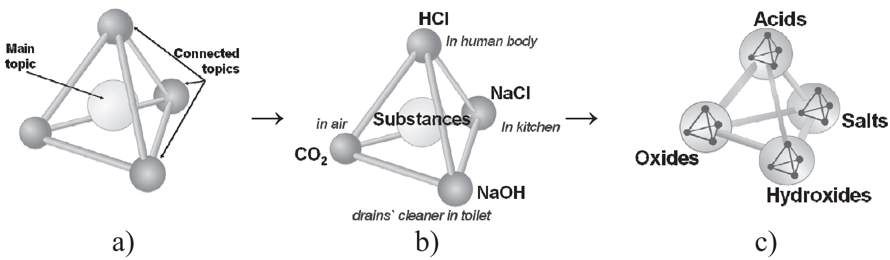

Figure 1. Visualisation of spatial mind model used for connection findings among substances:

a) spatial model – tetrahedron and interconnections in model;
b) connection finding on various substances;
c) summary of different substances in fractal approach.

The thematic system Substances is made by students and teachers after discussions. Finally there are selected most often occurred substances in students` daily practice for recognising substances around and done short overall summary on topic from general viewpoint (Fig. 1). It is recommended to use information technologies for the models` visualisation at the classroom, including colours in nodes of tetrahedron.

Teachers find out the teaching method as an alternative methodical solution in chemistry for enhancing chemical literacy. Students are actively engaged in learning process. Spatial mind model using gives a chance for students to build connective knowledge in systemic way joined forces with the interest, active learning and understanding in chemistry. Students start to think connectively, they do not concentrate only on factual remembering but start to learn through the comprehension. Most part of students acknowledged that studies by using new method become interesting for them. The spatial mind model evokes the increase of learning results.

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From Research To The Classroom

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Keywords High School education, experimental projects, laboratory research, inductive learning

Background. Within the new programs for High School education in Mexico (secondary level), a series of obligatory projects are established which comprehend from the first ones being very directed to the ones in the last unit, in which projects are more open and allow the student to have the decision making process and the election by themselves of methods and alternatives to follow.

One of the latter ones is a project that tries to relate art to chemistry. In this context, an experimental project similar to the one carried out in the research area was proposed during the guidance of a formal doctoral thesis (1, 2, 3, 4).

Objective. The academic objective which was considered is that the student follows the steps for formal research and which implies not only the presentation of a problem and election of a method but also a handling of all the involved variables.

On the basis of the previously indicated objective, the preservation of archaeological pieces by means of a process with natural gelatin was chosen and that has proven to be efficient in very old and deteriorated pieces.

Methods. The principle on which the process is based is in the use of gelatin in concentration of 1%, which is applied with a spray trying to cover all the pores of the chosen piece. Gelatin displays major durability and is free of undesirable bacteria and fungi by means of adding food preservatives (sodium sorbate and potassium benzoate), whose concentration is maximized when 1% of each are used, but presents a challenge for the students who initiate their experimentation using different concentrations for the preservatives (5). The experimental technique in which it was based originally used a sodium 22 labeled solution, not included in this type of student program.

The other factor of the experiment implies the addition of formaldehyde to prevent the decomposition of the gelatin by microbial effect. In this case, the addition of the formaldehyde at different times is experienced in the process of dissolution and application of the gelatin. The student also experiments here adding the formaldehyde (7) to the beginning, in the middle and at the end of the process and thus following a mental process similar to the one of the researcher; he then chooses in which of them the process becomes more efficient and prevents the premature denaturizing of the gelatin(6).

Results, conclusions and implications. The application of this project has allowed the student to systematize his experimental data and enables him to make decisions about the variables involved in the process; besides fomenting in them procedural as well as attitudinal competences.

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Obtaining And Identifying Inorganic Gases Using Microscale Techniques

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Keywords: Microscale, inorganic chemistry, laboratory, obtaining gases

Background and objective. Considering that one of the most important challenges in the development and teaching of Inorganic Chemistry requires a suitable design for a laboratory program which, of course, includes the safe and proper handling of gases, both in their production as well as in their properties' identification, a protocol was designed that allows obtaining and identifying five gases (ammonia, chlorine, sulfur dioxide, nitrogen dioxide and carbon dioxide). This protocol was implemented first in the National Olympiad of Chemistry held in Campeche, Cam. State in Mexico and served as an important element in the discrimination and selection of the 16 students who will participate in the International and Ibero-American Olympiad held last year in the UK and Cuba respectively. The application of the protocol was tested to 57 top high school students from the 32 states that comprise the United Mexican States (6 students from each state). In this paper, the obtained results are presented.

This same protocol was applied in two laboratory groups of students in a descriptive Inorganic Chemistry Course, within existing curricula. The subject is taught in the third semester for all undergraduate degrees offered in the Faculty of Chemistry. The analysis of the results will be presented.

Methods. The design of this experience implies the following:

1. Election to obtain the five gases: Ammonia, chlorine, sulfur dioxide, nitrogen dioxide and carbon dioxide.
2. Selection of the reagents to obtain the gases, prioritizing those in which the use of a solid and a liquid and where the reactions would be carried out at room temperature
3. Bibliographic research for the reactions in the identification of the gas.
4. Analysis of options that enabled to distinguish among them.
5. Selection of the 12 best options for identification involving different types of reactions (Acid-base, redox, precipitation and formation of complexes).
6. Preliminary tests to determine concentrations of the solutions selected.
7. Design of the preliminary protocol and validation thereof.
8. Experimental work to establish operating conditions
9. Changes to the protocol based on obtained experimental results.
10. Preparation of the equipment and reagents for the application to 60 exams with five different options.

Results. Students were presented with the task problem of obtaining and discriminating among five gases by using 12 different reagents and they were advised to use a disposable Petri dish with a hole in the center (to introduce the liquid reagent); drops of each of the reagents were placed nearby to enable them to identify the gas once generated in the closed system.

For the assessment of the performance test, a total of 100 points were allocated, divided as follows:

- 30 points to the filling out of the initial table (hypothesis)
- 30 points to the observations of the properties
- 10 points for the identification of the gas
- 20 points for the equations representing the reactions that allowed them to identify the gas (5 points each)
- 10 points for the equations formulated to obtain the different gases (2 points each).

In the case of students participating in the National Olympiad of Chemistry, the final evaluations were n the 17 to 85 point range out of 100 possible. The same protocol applied to 3er. Semester Chemistry college students had better results in average.

Conclusions and implications. From the standpoint of economics and according to ecological rules, the experiment was successful because the reagent consumption was minimum (4 ml. in total) and practically no waste was generated, which avoids gas generation into the atmosphere.

The preliminary results have allowed teachers to assess the main difficulties presented by students while addressing a practical problem and evaluating their lack of ability to collect and analyze the experimental data obtained.

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Application of Selective pedagogy at different levels of cognition in teaching- learning chemistry.

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Background Framework and purpose. Chemistry is one of the basic sciences a child learns from primary to tertiary level depending on his/her cognition and as the subject deals with abstract concepts one can not do by physical visualization ,it requires a lot of effort by the teacher to present the information by adopting a variety of pedagogical approach. Pedagogy finds an important place in the process of teaching- learning .Therefore more emphasis has been given in selecting variety of pedagogical approach to make learning more enjoyable long lasting. There always exists a link between pedagogy adopted in teaching –learning with that of cognitive development of the learners. The paper work insists on how teachers need to understand a subject enough to convey its essence to students with the goal to establish a sound knowledge base on which students will be able to build by exposing to different life experiences. Good teachers by adopting suitable pedagogical approach could translate information, good judgment, experience and wisdom into relevant knowledge that a student can understand, retain and pass to others. The present study emphasizes three different types of pedagogical approach based on their cognition levels viz: constructivism with the practice of activity based learning (ABL), for the age group 10 -13 years. Didactic approach with the practice of project based learning for the age group 14 -17 years. Evaluation approach with the practice of research orientation of the given content to develop higher order cognitive abilities such as evaluation and synthesis for the age group 18 and above. Teaching –learning Chemistry becomes more enjoyable by adopting consciously the recommended pedagogical approach depending on the cognition of the learners.

Introduction. According to the three different pedagogical approach based on the cognitive ability , activity based learning pedagogy used for the age group 10 to 13 years has the following significance . Semantic memory: Facts and lists from printed material are housed in the hippocampus. This information is the most difficult to remember and reclaim. Rote and drill activities (however, the brain will become bored if this is overdone) and more elaborative rehearsals, recitations, mnemonics, graphic organizers, inquiry problems, rhymes, discussions of a few paragraphs or passages at one time, outlines, mind-maps, and role plays are some ways for students to more easily retrieve data from this memory.

Episodic memory: This memory is also stored in the hippocampus and deals with factual memories related to location. Memory of learning can be triggered by remembering the physical setting in which the learning took place. Have students change seats regularly and change bulletin boards and other parts of the environment so that different locations trigger different learning episodes.

Procedural memory: The cerebellum houses muscle or bodily/kinesthetic memories. These include things like driving a car, riding a bike, and touch typing. Lessons should include movement that is frequently repeated in the guise of activities like role-plays and skits.

Automatic memory: This is the conditioned-response memory and is located in the cerebellum. Activities that will trigger this memory include decoding, using antonyms, making up songs to go with melodies, developing flash cards, and creating rhymes or rhythms.

Emotional memory: All learning has emotion tied to it and is processed in the amygdala. Tapping into and building on the students' experiences and thoughts is important.

Project based learning for the age group 14 -17 years is a component of an inquiry-based approach to learning. In this approach, students create knowledge and understanding through learning activities built around intellectual inquiry and a high degree of engagement with meaningful tasks. Within the context of this inquiry-based approach, projects take the role traditionally afforded to assessments such as tests and quizzes. Projects are designed to allow students with a variety of different learning styles to demonstrate their acquired knowledge.

Research oriented evaluation approach targeted for age group 18 and above is based on *Scientific-experimental models* which are probably the most historically dominant evaluation strategies. The objective is to prioritize on the desirability of impartiality, accuracy, objectivity and the validity of the information generated. Included under scientific-experimental models would be: the tradition of experimental and quasi-experimental designs; objectives-based research that comes from education; econometrically-oriented perspectives including cost-effectiveness and cost-benefit analysis; and the recent articulation of theory-driven evaluation. Through this method the students develop higher order thinking skills.

Methodology

The study recommends different types of pedagogical approach implemented for students of different age group ranging from 10 – 18 years. The first being the activity based learning (ABL). ABL pedagogy implemented for the age group 10 -13 years enhances active learning, in which students solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class. Activity-based learning, lends itself naturally and easily to cooperative learning. Group work is a common feature of ABL, with different children taking on the tasks which are appropriate to their individual levels. Therefore, a teacher should consciously adopt activity based teaching –learning approach to kindle the ability of learn by doing mind set among learners.

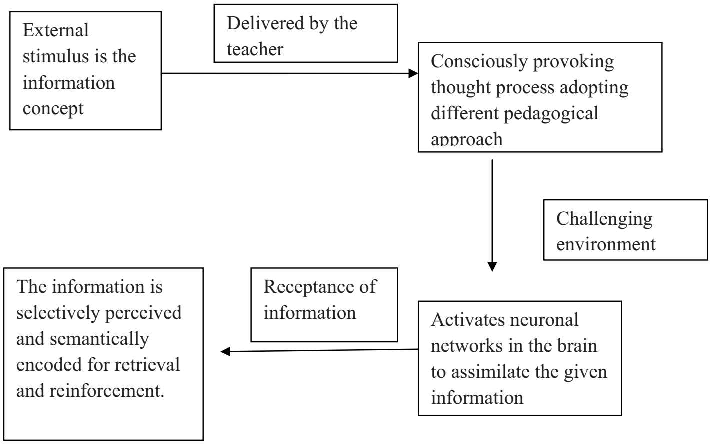
The second pedagogical approach is Project based learning (PBL) for the age group 14 -17 years. Project-based learning (PBL) provides complex tasks based on challenging questions or problems that involve the students' problem solving, decision making, investigative skills, and reflection that include teacher facilitation, but not direction. It allows students to work in groups or by themselves and enable them to come up with ideas and realistic solutions or presentations so that the students take a problem pertaining to a particular subject in the curriculum and apply it to a real life situation as they impart PBL approach. Thus PBL not helps students to develop self learning capacity but also improves their self-esteem promoting both cognitive and emotional factors of learning.

Research oriented evaluation approach targeted for age group 18 and above develops higher order cognitive, socio-cultural and affective aspects of learning. This method of teaching –learning provides ability to gather and interpret relevant scientific data and make judgments that include reflection on relevant scientific and ethical issues and improves the ability to communicate information, ideas, problems and solutions. It also enables the learners to develop skills that are necessary for them to undertake further study with sufficient degree of autonomy.

Results. The above mentioned three different methods are expected to bring results in such a manner that learning of chemistry becomes more enjoyable enabling the learners to get decent scores to pursue learning Chemistry as life long process.

Conclusions and Implications

Adopting consciously three different pedagogical approaches in the present paper depending on the cognition levels based on the age provokes understanding of the abstract concepts in the Chemistry subject as represented by a simple teaching- learning model focusing the role of a teacher in a typical teaching –learning environment projecting the possible educational implications.



The teacher plays a pivotal role to achieve the desirable learning outcomes depending on the levels of cognition of the learners.

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How to teach future teachers to teach resolving the tasks?

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Solving the tasks in chemistry, physics and mathematics is an integral part of teaching in these subjects and is associated with the belief that it is one of the most important element of checking the pupil's knowledge and skills.

Moreover, in all kinds of tests and examinations, these tasks are also included with major percentage of all tasks. This follows from the fact that in order to solve the task the student must use a variety of skills acquired in training. In Poland, in the *core curriculum of general education for primary and secondary schools* there is a statement that the most important aim of education is the comprehensive development of the pupil.

In the years 1970-1980 the twentieth century in Poland the problem of solving tasks by students was analyzed. Various functions of the tasks, the reasons of difficulties in resolving the tasks (Nędzyński, Mikulska), classification of the tasks (Matysik) and finally various methods of activating and encouraging pupils to do chemical calculations (Ardyn and Galska-Krajewska, Budniok , Langner. Szteinberg) were disscussed. Currently, the publications concerning this topic appear less frequently (Burewicz, Dębska, Maciejowska, Nodzyńska) but the problem of difficulties in resolving chemical tasks is still very important. Therefore it is significant that teachers should be prepared well to be able to properly teach the pupils how to do chemical calculations.

In order to teach solving chemical tasks it is not enough to know how the problem should be resolved. More important is the ability of analytical thinking and ability of dividing the problem into small steps.

The teacher should be able to explain the pupil what to do step by step. The number of steps vary however is can be a really a great number. Our previous research revealed that in order to write and balance chemical equation, which is usually the base for further steps in chemical calculation, pupil has to perform about 20-50 small operations, depending on the type of the equation. Unfortunately teachers do not realise with the problem and as a consequence they perform too many operations at a time and the pupil is not able to follow the teacher's thinking.

One of the methods developed in our research group is *solving the task over the phone*. One of the tasks the students should do in frames of the classes of chemical education is to tell other students how to solve the task without using any gestures and writing, but the voice only.

The rest of the group and the tutor assume the role of a pupil who does not know how to solve the task and verify whether the student's explanations are clear or not.

Initially explanation "by phone" makes a lot of trouble for students because

– he must solve the task
– he has to divide the task into very small steps and prepare the algorythm for pupil
– the student cannot simultaneously use another way of communication.
– he has to use appropriate words and he cannot make shortcuts.
– the student has to pay attention the information which usually uses automatically.

A major challenge is to explain over the phone how to use the information given in a graphic chart.

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After a few classes the future teachers can appropriately explain how to solve typical tasks. They use this ability during their school practice. When they solve the tasks with the pupils on the blackboard they remember all the information that is necessary to solve the task and they perform each operation on the board with a full comment. The task explained this way is easily absorbed by pupils.

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Microscale Chemistry Laboratory at Study Centers of The Open University of Japan

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Keywords: Microscale chemistry, Microscale chemistry laboratory, The Open University of Japan, Study center

Background. The Open University of Japan was founded 27 years ago, which is sole open university in Japan. Fifty study centers have been established in all prefectures throughout Japan. Each study center offers classroom lectures (schooling). For graduation, students must earn 124 credit units. There are two types of lectures: 1) Learning by television, radio and/or Internet. 2) Classroom lectures provided by study centers. Acquisition of more than 20 credit units from classroom lectures is compulsory for each student. Every year I have been giving classroom lectures of chemistry including chemical experiments at several study centers. However, there are several study centers which have no practice rooms for chemical experiments. In order to overcome this difficulty, I had introduced microscale chemistry laboratory. I had also pursued development of teaching materials suitable to carry out microscale chemistry laboratory.

Subjects of experiments. Experiments have been carried out on several topics, for example:
1) Chromatography with an SP-Sephadex ion exchanger using a 2 mL syringe as a column.
2) Preparation of various gases and the observation of their behavior.
3) Acid-base titration using a 1 mL microburet.
4) Electrolysis of aqueous solutions containing various electrolytes.
5) Reactions of various metal ions with NaOH and NH_3 solutions.

In this talk, I would like to introduce one of the teaching materials which we have developed: Microscale chromatography by use of SP-Sephadex cation exchanger.[1,2]

Methods. The micro-column is the outside part of 2 mL disposable plastic syringe and the reservoir of eluates is a test tube (Figure 1). SP-Sephadex is sulfonated cellulose. Cobalt(III) complexes are chosen as adsorber: $[Co(NH_3)_6]Cl_3$ (yellow), $[CoCl(NH_3)_5]Cl_2$ (red), $[CoCl_2(en)_2]Cl$ (green for *trans*-isomer; violet for *cis*-isomer. en = ethylenediamine), and K[Co(edta)] (reddish violet. edta = ethylenediaminetetraacetate^{4-}).

Results and Discussion. An aqueous solution containing the mixture of the complexes mentioned above is prepared and poured into the column. $[Co(edta)]^-$ does not show any affinity toward the cation exchanger, so that the reddish violet $[Co(edta)]^-$ anion can be removed by washing the column with water. The other three complex cations are held on the top of the column. The species can be easily separated with aqueous solutions of sodium chloride. SP-Sephadex is white material, so that the colored species can be seen very easily and clearly. Now, it is well known that chromatography is one of the most important analytical methods. However, traditional chromatographic experiments take tedious time and equipments are expensive. As the length of the column used in this experiment is very short, the experiment can be carried out in a very short time. The cost for the experiment is quite low.

Microscale chemistry laboratory was found to be very useful and convenient, since the experiments could be safely carried out even in an ordinary lecture room. I believe that the schooling is also very important to disseminate microscale chemistry laboratory which is not popular in Japan. In the talk, some experiments will be demonstrated.

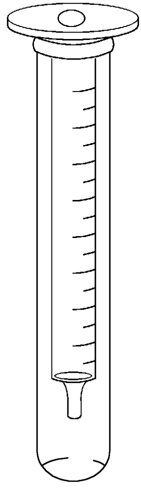

Figure 1. Micro-column

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Attract Students' Interest in Chemistry through Green Chemistry and Microscale Experiments

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Keywords: Green chemistry education, Green & Sustainable Chemistry, Microscale chemistry

Introduction. According to the investigation made by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) in 2004, chemistry is the most unpopular subject among high school students(1). TIMSS 2007 (2005-2008) also indicates that the index of Students' Positive Affect Toward Science is very low for Japanese students (2). Students seemed to find chemistry uninteresting, difficult to understand, and they think it is useless to study chemistry.

There are two main causes for the bad reputation of chemistry. One is the deteriorated image of chemistry. The other is the way by which chemistry is taught in some high schools where chemistry is taught without experiments, as experiments are often thought to be less effective for the preparation of the entrance examination to universities(3). To improve the bad image of chemistry, it is suggested to introduce the concept of green chemistry (GC). To make chemistry interesting, attractive experiments are essential in chemistry classrooms.

Green Chemistry Education

Green & Sustainable Chemistry (GSC) network, Japan has been launched in 2000. GSC is defined as "Chemical technologies to realize the human and environmental health, minimization of energy and resource consumption" (4). To promote GSC, education is essential. Some of our activities are described below.

1. Textbook on GSC: The education group of GSC Network published the book *Chemistry and Environment: Introduction to Green Chemistry* in 2002. The main issues in this book are: Chemistry is indispensable in understanding environmental problems; Chemists are working to improve the quality of air, water, *etc*. and to protect environment. Chemists are working to find new and innovative methods for making many useful and environmentally benign products. The book was revised in 2009 in which many new topics including the works that have received the GSC Awards. This textbook is widely adopted in universities and colleges.
2. Resources on GSC: In the journal *Chemistry and Education*, a monthly journal published by the Chemical Society of Japan, resources on GSC have been provided systematically since 2005 by the education group of GSC Network. Recently, the articles were compiled to a booklet, which have been distributed to teachers.
3. Activities of Tohoku Association of Chemical Education: The Tohoku Association of Chemical Education, organized by several college and high school teachers in and around Sendai, has been studying GSC and exchanging information on GSC technologies(5).

Development, Promotion and Dissemination of Microscale Chemistry (MC):

Microscale Chemistry is performed by using drastically reduced amounts of chemicals and miniature labware. The general advantages of MC are the reduction of environmental impacts (reduction of energy, chemicals, wastes), time saving and the improved laboratory safety (6,7). In MC, students can experience various reactions by themselves. We have developed many attractive MC experiments. Visual observations and actual experiences are very important aspects in introductory chemistry. MC can increase such opportunities and can contribute in nurturing students' interest toward chemistry. We propose to teach GSC through MC. It is effective in nurturing students' interest in chemistry, and in enhancing reliability of science and technology. We have been working to popularize MC in Japan to make chemistry classes more attractive and effective in deepening students' understanding.

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Activity of the Student during Evaluation of his Knowledge

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Keywords: Bologna System, Activity of the Student, Evaluation.

In the system of preparation of specialists – firemen and rescuers – large attention is paid to teaching bases of the special chemistry, i.e. chemistry of burning, which includes the bases of general, organic and physical chemistry.

Increase in efficiency of teaching process of the students of higher school constitutes an objective factor of a continuous scientific and technical progress of society. The necessity of perfection of the system of higher and special education, including Bologna system of education in the preparation of modern specialists results in new educational tendencies in the world, competitions among leading countries and their methods of specialist preparation, competitions among leading world Universities in their fight for a good specialist (manager, engineer, scientist) of the XXI century, and finally in hegemony in a fast developing world. Similar to all new systems in science including pedagogics, Bologna system of education has certain drawbacks and inaccuracies in some definitions, approaches, assessment of modules, and finally in evaluation of a general progress of the student during his studies.

One of the main drawbacks of the methods of evaluation is absence of consideration of student activity in the process of education.

To increase the efficiency of teaching of students it would be reasonable to use the ideas and research of cybernetics, which studies the systems, their features and laws of conduct. In our point of view, the teacher / student relation requires in the notions of cybernetics, in the educational system «Teacher – Student» a positive feedback which will allow to strengthen the interaction between the components of a given system.

To remove those drawbacks, while considering the activity of the student during education process, we suggest to form a general estimation for the module.

One can assume that a final assessment for the educational module (1,5–2 months of studies) must be equal to 50 grades. It includes the average assessment of the student on practical and laboratory courses, assessment of the module control test MCT and assessment of a general activity of the student during the lesson comprising the module. This last assessment for activity must take into account progress of the student (a number of positive grades) PG and number of lessons attended by the student ZS and general number of lessons of this module Z.

The final formula of total module estimation is as follows:

$$\text{mod} = \text{ave}_{\text{prac}} + \text{ave}_{\text{lab}} + \text{M CT} + (\text{PG} + \text{ZS})^{\text{PG}/(\text{Z}-1)}[\text{PG}/(\text{Z}-1)^{1/\text{ZS}}$$

Using of this formula for evaluation of diligence of the student during his studies, alongside with other stimuli, will contribute to increase in motivation and level of preparation. This method of progress evaluation can be applied for determination of a total module estimation during the study of other fundamental disciplines such as chemistry, physics, and mathematics.

History and Philosophy of Chemistry in Secondary Schools: Chemical Paper Tools (Chemical Formulae and Chemical Equations)

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Background. The 30 month, 8 country, EU History and Philosophy in Science Teaching (HIPST) project was established in February 2008. The UK part of the project has focused on three themes. The theme described in this paper is Chemical Formulae and Chemical Equations (Chemical Paper Tools). In the English Curriculum for Science (QCDA, 2009), learning about chemical formulae and equations is described in algorithmic terms ('… [pupils] represent common compounds by chemical formulae and use these formulae to form balanced symbol equations for reactions').

Under Cultural Understanding, the same National Curriculum requires pupils to 'recognise that modern science has its roots in many different societies and cultures'. The science education community's values are embedded, often implicitly, in its intended curricula. For example, the Science National Curriculum in England for 11 – 14 year olds (QCDA, 2009) states that: 'Pupils learn how knowledge and understanding in science are rooted in evidence.' The American Association for Advancement of Science (Project 2061) (AAAS, 1993, 2009) notes: 'The images that many people have of science and how it works are often distorted. The myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science. Hence, the study of science as a way of knowing needs to be made explicit in the curriculum.' Höttecke (2009) in his ESERA paper about HIPST acknowledged the importance of History and Philosophy of Science towards school teaching, and the dearth of research about and curriculum resources for HPS teaching in schools. Williams (2002) surveyed the history of science in textbooks in England in 1999, following the integration of science into the mainstream school science curriculum. He notes that, in the related history curriculum, pupils have to have: chronological understanding; knowledge and understanding of events, people and changes in the past; historical interpretation; historical enquiry; and organization and communication.

Methods. Furio *et al* (2002) have reviewed some of the literature over four decades regarding the topic and have concluded that 'a clear discrepancy exists between what assumed as correct by the scientific community and the thinking of educators'. They conclude that instructional strategies must attend to the issue of representation at sub-microscopic level to macroscopic features such as masses and volumes of materials. The work described here takes this recommendation seriously in creating a new approach based on historical and philosophical considerations. The lesson sequence has been constructed through joint activity between practising school teachers and the researcher and subject to national and international scrutiny. As yet unpublished work by a teacher researcher group based at Reading has provided scholarly evidence for the sequence construction.

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Results and implications

The teaching outline is:

	History	Philosophy	Pedagogy
1. Law of constant composition and atomic theory	Availability of sensitive and accurate balances in eighteenth century (e.g. Lavoisier)	Parallel developing of measurement and abstract concepts. Searching for errors rather than falsification	Historical newspaper simulations, plays and evidence from original papers
2. Chemical formulae	Variety of ways of expressing chemical formulae as symbolic representations of macroscopic features. Consolidation of conventions by human authority e.g. Gmelin, Berzelius	Formulae as a representational form. Interpretation of formulae in different formats to compare purposes of representation.	Historical newspaper simulations, evidence from original writings. Play about convention creation (Berzelius/ Gmelin)
3. Chemical equations	Need to express macroscopic observations at symbolic level	Equations as representational form, and equation interpretation	Historical equations in different formats (newspapers)
4. Reflection on submicro-scopic and macroscopic links	Restructuring historical knowledge through active writing by learners	Metacognitive explicit activity to capture doubts and reinforce learning.	Metacognitive group activity on role of representation and symbolism

Implications include tackling known learning difficulties explicitly and using innovative pedagogy (newspapers) to reinterpret historical dimensions.

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The contribution of international chemistry projects: a valuable experience for participants?

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Keywords: science education, international cooperation, EU funded projects

This paper focuses on three international projects in which the author participated. PALAVA (Oversby, 2005) was a transatlantic project involving three European countries (Slovenia, UK, and Finland) and the USA. It was funded by the USA National Science Foundation. CoSim and HIPST (History and Philosophy in Science Teaching, 2010) are two EU funded projects. CoSim linked colleagues in Poland, UK and Germany. HIPST links colleagues in 8 countries, from Israel, to Poland and coordinated by Germany.

I have been involved in three major international activities as described. The project reports for CoSim are in the public domain, and internal reports are available for the other two. These, and personal recollections, are the data sources that have been used to structure the framework provided below.

A summary of the projects is given in the table below:

Project	**PALAVA**	**CoSim**	**HIPST**
Project focus	Development and testing a method of assessing learning visualisation of chemical and physical processes in the gaseous phase	Creation of software for learner generated animations related to simple chemical processes	Provision resources for teaching History and Philosophy in Science Teaching.
Reason for project formation	Development of story boards as a method of investigating kinetic processes in chemistry.	Availability of sufficiently powerful PCs to design and run appropriate animated simulations at the particle level	Promotion of a humanistic approach to the history and philosophical background of chemical concepts to mitigate sterile chemistry teaching demotivating learners
Project outcomes	Evaluation of strengths and weaknesses of storyboarding for understanding chemical processes.	Evaluation of learner ability to design animated simulations at the particle level.	Resources, traditional and innovative for teaching History and Philosophy of Science in schools.

Project	PALAVA	CoSim	HIPST
Personal outcomes	Greater understanding of the challenges of representing dynamic processes in chemistry.	Greater understanding of the challenges of representing dynamic processes in chemistry.	Learning about History and Philosophy of Science, and creating new resources.
Aspects of collaboration	Personal links can bond colleagues together when face to face links are rare	Software design by collaboration can be challenging. Finding schools willing to be committed can be too hard.	Sometimes very different subject or cultural perspectives make it difficult to see valuable comparisons
Unexpected outcomes	Continuing bilateral links when the project ceased.	Planning for succession is required for sustainability	Very positive responses from some very thoughtful teachers

While there have been many positive aspects, some of the failures have arisen because of human problems, as the nature of the collaboration was insufficiently clarified at the start, and because there was too little in common between the participants. For the funders, the projects were successful in producing the promised outcomes. For the author, the projects were successful in providing professional development, in making enduring personal links, and in providing personal challenge in disciplinary and pedagogical knowledge. International links will continue to provide success at the disciplinary and personal levels, and will therefore continue to be funded.

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Computer Animated Models in Chemistry Teaching

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Keywords: didactics of chemistry, animated modelling of the micro-world

Background, framework, and purpose. Since the times of Jon Dalton, who was the first to suggest a set of standard graphic symbols for chemical elements and compounds to illustrate the structure of particular chemical compounds, chemists have been constantly trying to propose new models that would help pupils at all stages of education understand the structure of chemical compounds as well as processes of chemical reactions. Nowadays, numerous models that show the structure of atoms, particles or crystals of chemical compounds are used. Some of these models are "material" – pupils can touch them, while other are just pictures in textbooks or on the computer screen. These models, however, are very often inaccurate, contradictory to one another, and they lead to many misconceptions among pupils. During their chemical instruction at all levels, pupils come across different models of the micro-world structure. It sometimes happens that even within one textbook different types of pictures are used, which leads to a negative transfer. Due to this fact, in 2004 in a coherent concept of computer animated models that allow to present the micro-world was suggested by the Department of Chemistry of Pedagogical University of Cracow. This concept consists of the following research: *Koncepcja tworzenia modeli dynamicznych do stosowania w procesie kształtowania pojęć dotyczących struktury materii na poziomie mikroświata* [Paśko J.R. 2004], *Nowe podejście do modelowania reakcji kwasów z wodorotlenkami* [Paśko J.R., Komperda-Grochal M. 2004], *Koncepcja wizualizacji powstawania cząsteczek z atomów* [Paśko J.R., Nodzyńska M. 2004]. After 2004 this concept has been developed in: *Wizualizacja procesów chemicznych* [Paśko J.R. 2005], *Komputerowe modele dynamiczne w nauczaniu przedmiotów przyrodniczych* [Paśko J.R., Nodzyńska M., Cieśla P. 2007], *Jak uczyć o strukturze materii?* [Paśko J.R. 2008]. The models, created in accordance with this concept, are simple enough to be used at the first stages of education but also detailed enough to be used at more advanced stages of chemical instruction.

Methods. The main assumptions of computer animated models include: showing the spatial structure at the micro-level as well as the movement of particles, ions, and atoms in solids, liquids and, gases. In addition, these models maintain the proportions between the size of particular atoms and ions; compound particles and ions are presented in a way that preserves their real shapes. Moreover as atoms, ions and particles do not have clear-cut boundary, computer animated models show the structure of an electron cloud in a blurred manner, without boundaries. Furthermore, the models take into account the theory of Brownian motion; they point to the fact that atoms, ions, particles are colourless. Finally, they make it possible to repeat the stimulation of a reaction and point to the reaction's particular stages and to introduce some simplifications that are due to pupils' knowledge.

Results. Since 2004, the research whose aim is to check the influence of animation on the above-mentioned models on the pupils' comprehension of chemical reactions has been carried out. The research is conducted on different levels of education. Among pupils of primary school (aged 7 to 10) the following research have been carried: *Wykorzystanie modeli tworzonych komputerowo we wczesnym okresie edukacji chemicznej na poziomie nauczania początkowego* [Paśko I., Paśko J.R. 2004], *Wykorzystanie modeli w edukacji przyrodniczej* [Paśko I. 2006], oraz *Jak pokazać dziecku obraz mikroświata?* [Paśko I. 2009] . Among elder pupils of primary schools (aged 10-13) the following research have been carried: *Wpływ wieku uczniów oraz efekty zastosowania animacji komputerowej na kształtowanie wyobrażeń wśród uczniów klas szkoły podstawowej i Wyobrażenia o strukturze materii wśród uczniów klas szkoły podstawowej* *w świetle przeprowadzonych badań* [Chmielowska-Marmucka A, Paśko J.R. 2008, 2009] oraz *Zastosowanie modeli dynamicznych do nauczania o zmianach stanów skupienia* Tajduś J., Nodzyńska M. (2008). The level of animation comprehension among primary school and lower secondary school pupils was compared in: *Odbiór animacji procesów chemicznych przez uczniów V i VI klas szkoły podstawowej oraz I i II klas gimnazjum* [Paśko J.R., Woźniczka M. 2006]. In lower secondary school (pupils aged 13-16) the following research were conducted: *Wpływ wizualizacji procesów zachodzących w roztworach wodnych na stopień ich przyswojenia przez uczniów* [Nodzyńska M. 2004], *wpływ różnych technik wizualizacji procesów chemicznych na poziomie mikroświata na wyobrażenia uczniów dotyczące budowy substancji chemicznych* [Nodzyńska M., Paśko J.R. 2006], *The reception of various graphical presentations of chemical compounmolecule on the basic of research* [Baprowska A., Paśko J.R., 2008] and *Wpływ wieku uczniów oraz efekty zastosowania animacji komputerowej na kształtowanie wyobrażeń wśród uczniów gimnazjum* [Chmielowska-Marmucka A, Paśko J.R. 2008] i *Wpływ dynamicznych modeli komputerowych na wyobrażenia uczniów gimnazjum o wzorach strukturalnych tlenków* [Dulian B., Dulian G., Nodzyńska M. 2008]. From the funds of the International Visegrad Fund it was checked whether dynamic computer models are equally comprehensible to Polish, Czech, and Slovak pupils: *The influence of computer animated models on pupils' understanding of natural phenomena in the micro-world level, Metoda badań nad odbiorem dynamicznych modeli komputerowych przez uczniów, Modele struktury substancji w procesie nauczania chemii* [Bílek M., Nodzyńska M., Paśko J.R., Cieśla P., Paśko I. 2006]. The results of the research were published in two books: *Vliv dynamických počítačovych modelů na porozumění procesů z oblasti mikrosvěta u žáků zemí Visegrádského trojuhelníku, Wpływ komputerowych modeli dynamicznych na rozumienie procesów zachodzących na poziomie mikroświata przez uczniów krajów Trójkąta Wyszehradzkiego* [Nodzyńska M., Paśko J.R., Cieśla P., Paśko I. 2007]. The perception of animation among pupils is a frequent subject of many BS and MS theses and even of doctoral dissertations in our department.

Computer animated models are also used to correct assumptions concerning the structure of matter among chemistry teacher-trainees. It takes place when they are asked to create computer animated models, which is one of the requirements to pass the subject "didactics of chemistry." The aim of such a task is to help students imagine the process of a chemical reaction – the shape of particles, the proportion of their size etc. As such it is the final verification of the previously acquired knowledge and an attempt to a holistic perception of quantum chemistry, crystallography, and chemical kinetics. The research on the influence of the animations created by students on the comprehension of chemical reactions began in 2005: *Rola modelowania w procesie kształcenia przyszłych nauczycieli, Modelowanie dynamiczne - jako jedno z zadań zaliczeniowych na przedmiocie 'Dydaktyka Chemii', Rola programu Macromedia Flash w diagnozowaniu wyobrażeń studentów o strukturze materii* [Nodzyńska M., Paśko J.R. 2005] and later on continued in: *Od Presu do Flasha* [Nodzyńska M., Paśko J.R. 2007] *Program wizualizacyjny Macromedia Flash jako element kształcenia przyszłych nauczycieli* [Paśko J.R., Kopek W., 2008].

Conclusions and implication. Summing up, it may be said that animations shown to pupils from classes taking part in the experiment contributed to a better understanding of chemical reactions among pupils. Those pupils also learnt to describe chemical reactions using the terms of the micro-world.

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Publishing in Chemical Education Journals: *the Journal of Chemical Education* (JCE) and *Chemistry Education Research and Practice* (CERP) – 10th ECRICE Workshop

Norbert Pienta[1], Georgios Tsaparlis[2],

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Meet the Editors from the *Journal of Chemical Education* (JCE) and *Chemistry Education Research and Practice* (CERP) and. They will describe the journals and present information about publishing scholarly work.

General Topics

- Organization and components of each journal, including descriptions and editorial policies
- Strategies for success: common errors, following guidelines
- Special concerns for authors whose first language is not English: writing and editing as an author; copy-editing and triage from the perspective of the Journal
- Chemical education research papers: special needs and opportunities
- Serving as a reviewer in order to learn more about the process
- Questions and concerns from the participants

Journal of Chemical Education (JCE) Topics

JCE publishes articles, lab experiments, activities, columns, reports, and other content related to chemistry education in print and online in 12 issues per year. Individual or institutional subscriptions are available.

- A brief history including joint publication with American Chemical Society Journals and Paragon Plus (a new electronic system for authoring and reviewing)
- A new feature for international contributors (an international column that started in January 2010)

Chemistry Education Research and Practice (CERP) Topics

CERP is the journal for teachers, researchers and other practitioners in chemistry education. It is published free of charge, electronically, four times a year and covers: (i) research, and reviews of research in chemistry education; (ii) effective practice in the teaching of chemistry; (iii) in depth analyses of issues of direct relevance to chemistry education.

- CERP was the product of the 5th ECRICE (1999, Ioannina, Greece). The first five volumes (2000-2004) were published from the University of Ioannina, while since 2005 the journal has been published by the Royal Society of Chemistry (RSC).

KAPITAŁ LUDZKI
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Using Technology to Study Student Problem Solving

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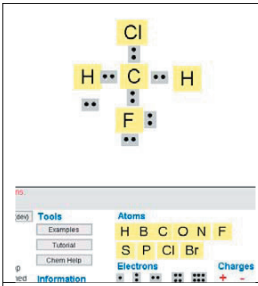
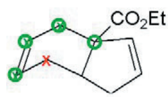
Keywords: student problem solving, Internet-based webware, assessment

Background, framework and purpose: Collecting information about student problem solving in introductory university courses typically involves observations, interviews or allowing students to describe the work as they solve it (Gabel & Bunce, 1994). Although these techniques provide valuable insight, considerable effort is required. We sought alternative methods in which more extensive information could be gathered about student strategies, pathways, and outcomes.

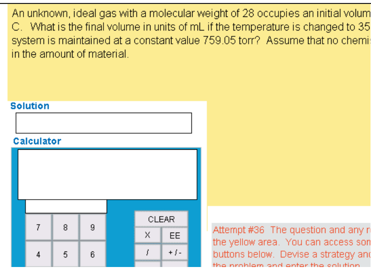
Methods: A series of web-based tools were developed using the Flash™ programming language. In each of these types of assessments, the student is presented with an individualized question that is generated algorithmically by the webware, has the tools available to solve the question and is told whether it was solved correctly, often with feedback. All of the steps of the process are captured in a database for later analysis. Thus, tools were created for (1) drawing Lewis structures (using a set of drag-and-drop atoms, bonds, electrons, and charges [Lewis tool, 2010]; (2) solving ideal gas and stoichiometry word problems; (3) drawing particulate nature of matter representations of atoms and molecules (using drag-and-drop spheres as atoms); (4) identifying portions of organic structures to identify functional groups or reactions; (5) drawing organic molecules using a common drawing interface.



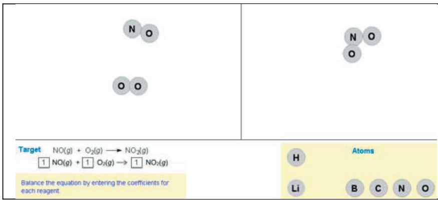
Portion of Lewis structure tool



Portion of organic representation tool



Portion of word problem



Portion of particulate nature of matter (spheres) tool.

Results: Because of the nature of the tools, students could access them from on campus or at home. Data were collected from large numbers and subjected to statistical analyses. Performance is often related to the course and level of the students. For example, students in a preparatory course, in a chemistry course for non-science majors, in the general or organic chemistry courses were asked to draw Lewis structures with different degrees of success and with different prevalence of the kinds of mistakes they made. The ideal gas word problem probed students' ability to convert between different units and number formats. Difficulties are considered based on theories related to cognitive load (Meerienboer and Sweller, 2005) and problem difficulty.

Conclusions and implications: Results and conclusions from each problem type will be presented and discussed. Implications for interventions will be discussed.

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Integrating Philosophy of Chemistry in higher Education

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There is consensus on the necessary inclusion of nature of science (NOS), the metascience in the curriculum, as is also consensus that the difficulty of its implementation in the classroom by teachers. Overcoming the distance of two cultures and bring the philosophy and science and gain skills and critical reflective of order are necessary for the dynamics of the knowledge society, innovation processes and to full citizenship. Studies indicate a lack of teaching materials and training disciplinary distance from humanist technical training among the main problems that prevent thinking about science as culture and thought process of introducing the training of science teachers. In peripheral countries like Brazil addition to other problems in the sociological. Chemistry in addition to problems of its own disciplinary field. School knowledge has been characterized by strong regulative discourse, little discussion of scientific and conceptual dimension and little influence of epistemological and sociological discourses. Research in Education focus on methodological aspects at the expense of the centrality of the content supported both by the teaching of science and education in general. However, the philosophy of chemistry has been constituted, even if belatedly, a disciplinary and interdisciplinary in recent years, with an agenda of issues and actors, and has been called to play an important role in teaching, learning and teacher training. However, even with a strong international community, has not won the school curriculum. In Brazil, the curricula analyzed and specific journal articles, including the new chemistry in school this theme is absent. So what are the epistemological and curricular dynamics underlying the production and reproduction of social and cultural knowledge that protect chemical interactions with the discourse of the humanities and what relations for the formation of school knowledge? These dynamics, poorly explained, should be primarily important for a clear characterization of school knowledge and improvements in education in explaining the philosophy and own a strong grammar. Thus, this work fits into a larger goal to criticize the Philosophy of Chemistry in the curriculum, in order to identify invariants forming the shape analysis of operation of a philosophy of teaching, immediately contributing to the community of educators Chemistry and the epistemology of the curriculum. Specifically, I present a case study of integration of philosophy of chemistry in the curriculum for initial training of teachers in a Brazilian university, identifying the limits and possibilities of this integration. Identify own limitations and internal epistemology of chemistry as naive realism and instrumentalism, the specificity of its language and diagrammatic thinking, using the concepts of Bernstein identify problem curriculum as the strong regulative discourse at the expense of instructional discourse and the strong presence of the hidden curriculum , the strong classification and strong framing that prevent a more flexible curriculum and the introduction of dynamic critical and reflective. As a suggestion and proposal, second, I seek from the fields of epistemology structuring for initial training - Correspondence and rationality, representation and language, and spoke method, contexts and values; Evolution and Judgement; Normativity and recursion - to build an agenda Philosophical problems of relevance of chemistry curriculum for initial training, problem still start at international level. These are articles draw from philosophers of chemistry, mainly from Hyle and the Foundations of Chemistry. In a third phase seeks to interrogate the 14 teachers who already teach the discipline philosophy of chemistry in the curriculum of higher education in some countries, mainly from Europe and USA, data will be collected through questionnaires and structured interviews and will be submitted to analysis content. A background analysis will also be made by the dynamics of the circulation of scientific knowledge on the perimeter and chemical center-periphery. Search is thus to build an agenda for analysis to refer to the dimensions ontological, epistemological and sociological to the teaching of chemistry necessary to think in chemistry beyond its factual dimension and its teaching than algorithmic

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Using an On-Line Graded Homework System, MasteringChemistry, to Enhance Student Metacognition and Self-Efficacy in a First-Year University General Chemistry Course

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Keywords: metacognition, self-efficacy, self-rating, MasteringChemistry

The role of metacognition and self-efficacy in science learning is the focus of recent studies at the secondary school (Aydin *et al,* 2009) and university levels (Cooper and Sandi-Urena, 2009; Taasoobshirazi and Glynn (2009; Uzuntiryaki and Aydin, 2008; Wiediger and Hutchinson (2002); and Rickey and Stacy, 2000). Of particular note is the work of Crippin *et al* (2009) and Kaberman and Dori (2009) involving the computerized learning environment and web-based problem solving.

Coutinho (2008) notes that there is a strong correlation among student metacognition, self-efficacy, and performance, and recommends "programs for students that enhance self-efficacy and strengthen their metacognitive strategies and skills".

This paper presents an attempt to improve student performance in a university-level general chemistry course by having students self-identify deficiencies in understanding of specific learning objectives in order to more effectively utilize available learning tools to more effectively achieve mastery of the learning objectives prior to taking a formative or summative learning examination.

The hypothesis was that student examination performance would be enhanced by engaging the students in formal self-assessment of their level of understanding of an extensive list of specific learning objectives, that their ability to self assess and their self-efficacy would gradually increase over the duration of the two-semester course, and that student examination performance would be directly related to student ability to accurately self assess. Hence, this study relates student metacognition and self-efficacy to examination performance. In this presentation metacognition is defined as the awareness of knowledge possessed and how learning is accomplished (Bransford *et al*, 2000), and self-efficacy is defined as confidence in the ability to demonstrate content and problem-solving mastery, which is more specific but consistent with the definition of Bandura (1997).

At the beginning of each semester, students rated themselves using a five-point Likert scale on their expected performance on an examination that tested understanding of all learning objectives. They then rated themselves on a subset of these learning objectives just prior to taking the exam that covered the subset of objectives. During the two semesters of the year-long course self-ratings were performed for ten exams, the last being the ACS standardized examination in General Chemistry. Students were also asked to rate their knowledge of the entire list of learning objectives at the end of each semester after taking the final exam.

Each exam question was related to a specific learning objective. Individual student performance on each question was rated on the same Likert scale used by the students to self rate themselves on the learning objective related to that exam question. Metacognition was measured as the absolute value of the difference between the student's self rating and the student's examination performance rating. Self-efficacy was measured by whether the differences between student self rating and exam performance rating was positive or negative.

The major learning tool in this course was MasteringChemistry, an on-line, graded homework program. Each course learning objective had a corresponding homework assignment comprised of a series of questions, each of which is rated by a universal population of students in terms of difficulty and average completion time, which could then be compared to the same ratings made by students in this study. Exam questions were derived from this set of questions, so correlations could be made between student performance on exams and effective student use of MasteringChemistry.

At the time of this abstract preparation only first-semester data were available. The data show that at the onset of the course, students exhibited poor recall of chemistry topics specified in a list of 100 course learning objectives, and there was no correlation between student ability to recall topics and student performance in the first semester course. Average student metacognition did not appear to improve markedly from the first to the fifth examination, but after completing the final examination, there was a strong correlation between individual student ability to assign a level of understanding of learning objectives with the student's examination mastery of the learning objectives. There was also a positive correlation between student self-efficacy and performance, and self-efficacy showed improvement over the course of the semester, in agreement with the findings of Coutinho (2008).

On course evaluations students overwhelmingly credited their use of MasteringChemistry and the metacognition exercise for their success in the course.

Future work will include analysis of second semester metacognition data and a comparison of standardized final exam performance of general chemistry students who participated in the metacognition self-evaluation exercise with students who did not. Learning objectives with poor average student metacognition on the standardized examination will be related to student performance on specific MasteringChemistry assignments, and findings will form the basis for altering classroom delivery of material related to those learning objectives and MasteringChemistry assignments.

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The States-Of-Matter Approach (SOMA) to introductory upper secondary chemistry: a textbook and its preliminary evaluation by teachers

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Keywords: upper-secondary school chemistry; chemistry for all; programme of studies; Greece; states-of-matter approach

Background, framework and purpose. Chemistry, as an upper-secondary school subject for all, should aim to supply students with chemical literacy and chemical culture, to cultivate higher-order cognitive skills, and to be a useful, interesting, and enjoyable subject.

A chemistry programme for all students in the tenth and the eleventh grade (ages 15-17) was proposed in Greece some years ago, and introduced chemistry through the separate study of the three states of matter [the *states-of-matter approach* (*SOMA*)] (Tsaparlis, 2000). There are three major units in the programme, namely: *air and the gaseous state - salt, salts, and the solid state – water, liquids, and the liquid state*. Following the proposal, a textbook was written that adopted SOMA.

The aim of this proposal is to present the book as well as the results of its preliminary evaluation by four experienced upper secondary Greek chemistry.

Methods

The states-of-matter approach (SOMA) to introductory chemistry – The textbook

With the first three major units, an original approach to chemistry is attempted through the three states of matter. The introduction of the gaseous state first was based on the following facts: (a) being the simplest, it is the best understood by scientists; (b) being macroscopically 'non-concrete' for most students (a misconception), it is the most suitable prelude to the study of the invisible submicrocosmos of atoms and molecules; (c) the elements and compounds which are, under normal conditions, in the gaseous state have small and simple molecules [we work with only few non-metals (H, O, N, halogens, and noble gases), and compounds (H_2O, O_3, NH_3, NO_x, CO, CO_2, gaseous hydrocarbons, H_2S, SO_2, HCl)]; (d) we start with the covalent bond (Johnstone, Morrison, & Reid, 1981; Johnstone, 2000); neither ions nor the ionic bond are necessary; in the case of the ideal gas, intermolecular forces are absent - but mention of real gases should be made; (e) the study of organic compounds is introduced early (Johnstone, Morrison, & Reid, 1981; Johnstone, 2000). In this way, some integration of inorganic and organic chemistry is achieved. For more information about SOMA, see Tsaparlis (2000).

A preliminary evaluation of the experimental material by experienced teachers

The textbook was subjected to a preliminary evaluation by a small number (four) of upper secondary Greek chemistry teachers teachers (plus a university chemistry professor). Three of the teachers were male and one female. One teacher had obtained a graduate diploma in science education (this teacher belonged to the research group of the senior author (GT).

When the teachers had completed studying the book, we took structured interviews with them, during which they were asked to answer a number of questions concerning their impression, comments, suggestion for improvements, etc. taking also into account the existing state textbooks for chemistry for general education of Greek tenth and eleventh grades. The interviews were tape-recorded with the teachers' consent.

Results

General questions – Positive opinions

- The teachers found the book complete, dealing with many matters, and its level was assumed to be advanced (difficult in some cases).
- SOMA was judged very original, having a logical flow of the material, and in general the evaluators liked it.
- All liked the integrated coverage of inorganic, organic, and physical chemistry.
- They found very good and complete the practical part of the book (dealing with applications and connections to life)
- They all liked the format/lay out of the book.

General questions – Negative opinions and reservations

- There were some reservations regarding SOMA. The approach was found good, but quite unusual.
- It contains a number of difficult concepts (e,g. Millikan's experiment, atomic emission spectra, ΔG, enthalpy, phase diagrammes, etc.).

  [*Authors' comment: Most of these are placed inside frames, and they are not essential – the teacher can skip them without damaging the flow of material. On the other hand, their presence provides for fuller coverage and global knowledge*.]
- All agreed that the level of the book is advanced, and that it will be difficult for the average student.
- Most thought that more organic chemistry would be necessary.

Further the teachers answered a number of questions on the relation of the book with chemical literacy and culture, and made suggestions for improvements. .

Conclusions and implications. We believe that *SOMA* combines the logic of chemistry with the psychology of learning (Johnstone, 2000). It could provide chemical literacy and chemical culture to all students, as well as make them appreciate chemistry as an interesting and enjoyable subject, and above all help them to realise its usefulness for their future career and life. We hope that *SOMA* has the potential to give school chemistry a new impetus and status.

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Chemistry Textbook Research in Brazil: An Overview

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Keywords: textbook, chemistry, Brazilian academic production.

Background, framework and purpose: Textbooks play a dominant role in chemistry teaching and in student learning. Most teachers rely quite heavily on the textbook, as perhaps the only source of information. In this sense, several educators have called for heightened scrutiny of curricula through formal textbook analyses. Chemistry textbooks have been analyzed in many parts of the world. For example, in Spain, fifty-eight Spanish high school chemistry textbooks from 1974 to 1998 were analyzed in relation to their treatment of metallic bonding (Posada, 1999). In Turkey, multiple thematically based and quantitative analysis procedures were utilized to explore the effectiveness of Turkish chemistry textbooks in terms of their reflection of reform. The themes gender equity, questioning level, science vocabulary load, and readability level provided the conceptual framework for the analyses (Kahveci, in press).

Clearly, more research is needed on chemistry textbook nationally. Therefore, the aim of this study is to discuss the chemistry textbook research in Brazil from the analysis of the database of theses and dissertations of Science Education graduate programs affiliated to the Brazilian Federal Agency for the Support and Evaluation of Graduate Education (CAPES).

Methods: A search of the database of theses and dissertations of Science Education graduate programs affiliated to CAPES covering the period from 2002 (earliest year available) to 2008 was conducted on the following key words: Textbooks, School Books, and Didactic Material. The search resulted in ten studies (master dissertations) produced on this topic. All of them were thoroughly read and classified into three categories: year of presentation, Brazilian geographic region of production, and thematic focus.

Results: The earliest dissertations identified in the present study were submitted in 2002 to the University of Săo Paulo (USP) and Federal Rural University of Pernambuco (UFRPE). Table 1 shows the distribution of the dissertations concluded in the period from 2002 to 2008. Most studies of chemistry textbooks focused on their contents. For example, how environmental subjects, chemical equilibrium and oxidation-reduction concepts are covered in high school textbooks. It can also be noted that two dissertations investigated the effectiveness of chemistry textbooks in terms of their reflection of the recent innovations and reforms in basic education curriculum in Brazil.

On the other hand, other important themes have been scarcely investigated. Only one dissertation determined the attention given to STS topic in high school chemistry textbooks. In the same way, only one dissertation investigated criteria used by high school teachers in selecting chemistry textbooks. The development of a tool designed to help high school teachers to analyze chemistry textbooks was also reported.

Table 1 – Distribution of dissertations on chemistry textbook in Brazil between 2002 to 2008 by thematic focus, institution of production, and publication period.

Thematic focus	Publication period (2004 – 2008) and institutions of production						
	2002 N=3; 30%	2003 N=1; 10%	2004 N=0; 0%	2005 N=2; 20%	2006 N=2; 20%	2007 N=1; 10%	2008 N=1; 10%
Teachers' criteria for textbook selection							USP
Contents in textbooks	USP UFRPE	USP		UFRN		USP	
Tool designed to help teachers to analyze textbooks					UnB		
STS topics					UEM		
Curricular Reform	USP			USP			

USP = University of São Paulo; UFRPE = Federal Rural University of Pernambuco; UFRN = Federal University of Rio Grande do Norte; UnB = University of Brasília; UEM= State University of Maringá.

Considering the Brazilian geographic regions, it is possible to observe that the Southeast region concentrates the highest number of theses and dissertations about chemistry textbooks accounting for 60% of the total. It is followed by the Northeast (20%), Central-West (10%), and South (10%) regions. This academic production analyzed was developed in graduate programs of five institutions (Table 1): USP in the Southeast region; UFRPE and UFRN in Northeast region; UnB in Central-West region; UEM in South region.

Conclusions and implications: The analysis of the database makes clear that the growth of the number of dissertations was small in the period 2002 – 2008, thus efforts for learning and training in chemical education area are necessary. Another challenge is that the number of graduate students is not well distributed into the country. This asymmetry was expected and happens in almost all areas of knowledge. It can be explained, among other factors, by the concentration of universities in the Southeast region of Brazil. The research showed that 50% of the academic production is related to chemistry content in textbooks. This is another aspect that demands attention, therefore a better distribution of competences in other themes is necessary.

It is worthwhile to emphasize that the search was based on the database of theses and dissertations of Science Education graduate programs. Theses and dissertations submitted to Education graduate programs were not considered in the present study. Thus, it is possible that other studies related to chemistry textbook have not been recovered.

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Literary Text as a Didactic Tool in Undergraduate Chemistry Teaching

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Keywords: writing, literary text, chemistry teaching.

Background, framework and purpose. Written communication in chemistry is fundamental to scholarship about the discourse and progress of science. Recently, in addition to innovative ideas for writing laboratory reports, several authors have described various approaches to introduce writing into their chemistry courses. A way to incorporate writing into the class is using scenario-based formulating questions (Galagher & Adams, 2002). By and large, the teachers ask more questions than the students do. Once again the point is to ask them to write their questions so that all students are involved. Formulating questions helps students better understand the material and assess the relevance of what they are studying to themselves and their world. In this paper, we investigate questions formulated by undergraduate chemistry students from the reading of the book *Uncle Tungsten: memories of a chemical boyhood* (Sacks, 2002). The data were analyzed by Discourse Analysis, in its French approach, according to Eni Orlandi, especially based on the concept of discourse typology (Orlandi, 2002). The author suggests that the discourse production occurs in the articulation of two processes: paraphrase and polysemy. Paraphrase allows the production of the same sense in various forms. Polysemy allows the use of different senses. Orlandi (2002) classified the discourses as: authoritarian (restrained polysemy), polemical (controlled polysemy), and ludic (open polysemy).

Methods. In this study, data collection was carried out in a Structural Chemistry course offered to freshman students in an undergraduate chemistry course in a Brazilian university. The 45 students enrolled in the course, in small groups, were asked to read Mendeleev's Garden chapter and write questions about it. The first source of data was student work samples (questions about Mendeleev's Garden chapter) collected during the activity. The students also completed a questionnaire on the effectiveness of the strategy.

The questions formulated by the students were categorized as follows:

- Mathematics – related to mathematical language. These questions tend to the establishment of an authoritarian discourse, since there is only one sense: do calculations and obtain numerical results;
- Definitions – requested the definition of expressions, words, and concepts. These questions characterize strongly the pedagogic discourse as authoritarian, in which polysemy is contained and there is no reversibility;
- Phenomena – related to facts of the natural world. These questions approach aspects of the nature of science embedded in the pedagogic discourse (authoritarian);
- Nature of science – related to the production of scientific knowledge. These questions indicate tendency to polemical discourse, since the referent is the production of science: scientific ideas, scientists' work etc.

Results. A total of 100 questions were formulated by the students. The frequency for each category of students' questions is shown in Figure 1.

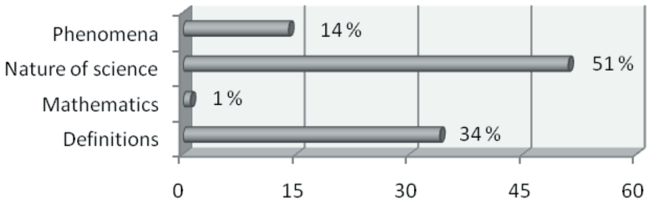

Figure 1. Frequency of each category of students' questions.

The only question related to mathematical language indicates students' curiosity about mathematical calculations involving the determination of the atomic weight of an element, i.e., mathematics as part of scientific activity. In the questions related to phenomena, the students' objectives were mainly understand the content and aspects of everyday life. This question type suggests that the reading made students attribute greater significance to the scientific concepts studied. Substantial percentage of questions requested definitions. These questions feature strongly the students' role in the school environment: learn definitions, especially those given by teachers. Questions related to the nature of science referred mainly to the hypotheses formulations, scientists' life, and scientific work. This category represents the majority of students' questions (51%). Such results can be justified by the characteristics of the studied chapter, which shows Mendeleev's academic career. Thus, the chapter may have favored the formulation of questions related to the production of scientific knowledge. These are non-trivial questions in undergraduate chemistry teaching, and they help students to eliminate misconceptions about it. The typology results demonstrated transitions from a pedagogic discourse, predominantly authoritarian, to a polemical discourse.

This didactic strategy was received nearly unanimous positive reviews from the students. The most common type of comment in the written evaluations of the course by the students indicates that they really like different classroom activities. The second most common type of comment reflects a favorable view of using literary texts in class. The students also report other contributions of this strategy to learning and to the goals of the course, such as integration of knowledge, critical and analytical reading, writing clearly, and pride of accomplishment.

The advantage of this type of strategy is that students have a chance to see a sample of the production of science. Most importantly, however, they realize that chemistry is present in their life.

Conclusions and implications. The results indicate the relevance of the proposal because it stimulated the development of skills relevant to the students and showed good receptivity from them. Hence, the literary texts act as mediators for non-traditional remarks by the students in undergraduate chemistry classes, suggesting the feasibility of this proposal at this level of education.

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Mastering the amount of substance: A revised learning cycle approach

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The amount of substance is an abstract concept and that is why it is not straightforward to explain it by analogies or models (Gabel 1999). Therefore, understanding and learning of the concept appears difficult for students (e.g. Claesgens & Stacy 2003; Furio, Azcona & Guisasola 2002). To understand the relationships of different concepts and using of concept of amount of substance require conceptual learning. Here, a teaching model has been developed based on a learning cycle aimed to support students to focus on conceptual learning. With the help of inductive reasoning, connections between different forms of information are supported and these connections are used to construct the concept.

Our research material was collected by a form, which prompted the students to draw a mind map of all concepts and phenomena connected with the amount of substance. Additionally, the questionnaire included two directive questions: (i) How would you define the concept of amount of substance and (ii) what do we need such a concept for? Students were asked to write all ideas on the paper around the word of amount of substance and connect them together as they see it fit. The research material was analysed by the method of content analysis (Krippendorf 2004).

This research was conducted between spring 2008 and spring 2009. Students who took part the research, were both from secondary school and upper secondary school. A total of 92 students participated in the research from different schools and summer science camps.

The developed teaching model was retested in August 2009 in one of the upper secondary school participated in the preliminary phase of research. The same questionnaire form was used as before. Answers were collected before teaching, immediately after teaching and three months after the teaching took place. Before teaching 16 students, immediately after teaching 14 students and three months after teaching 14 students answered the questionnaire.

Results. While developing the teaching model, it was found out that the students are willing to study the concept of amount of substance more as a mathematical instrument than as an explanatory concept. Concomitantly, a teaching model based on a learning cycle was chosen to improve conceptual learning. The teaching model was developed and screened during seven in-class lessons, where the most important themes discussed with the students were: 1. Investigating which way we could express amount and get to know to Avogadro`s number. 2. How to think about the size of atoms and molecules and to find out the concepts of atomic mass and molecule mass. 3. How to become acquainted with the definitions of the amount of substance defined by SI system. 4. How to generalize the concept of amount of substance to chemical reactions and to get to know the mathematical formulas.

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Table 1:Students definitions of amount of substance.

Grouping (immediately after teaching)	**Percentage value of answers**	Grouping (after 3 months)	Percentage value of answers
a) Tells amount of material	a)27 %	a) Tells amount of material.	a) 57 %
b) Defined to different concept	b) 18 %	b) Defined with the help of mathematical formula.	b) 7 %
c) Tells number of particle in some amount of material.	c) 9 %	c) Tells number of particle in some amount of material	c) 14 %
d) Define with the help of mathematical formula.	d) 46 %	d) No definitions	d) 21 %

Conclusion

In this research, it was found out that the teaching model helps the learning of concept of amount of substance. After teaching, most of the students still defined the concept as a mathematical formula; but there were answers (9 %), which were definitions that were targeted for (see Table 1). Also, it was found out that after three months, the percentage of students who still defined the concept as a mathematical formula was only 7 % of all students. Instead, the group who said that amount of substance tells numbers of particles in some amount of material was nearly as big as immediately after teaching.

Based on the research material and testing, the teaching model of the amount of substance could be stated to contain the following steps: 1. Get to know to the atomic scale and define the concepts of atomic mass and molecule mass with the help of laboratory work. 2. Define the Avogadro`s number and estimate the size of constant. 3. Define the mole mass with the help of laboratory work, Avogadro`s number and atomic mass. 4. Define the concept of amount of substance so that students connect the information, which includes the amount of substance, to concept map. 5. Compare different concept maps and discuss about maps in class. 6. Use concept in calculations.

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Retaining Weaker Students in Undergraduate Science Programmes

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Background, Framework and Purpose. Since the eighties, there has been an increasingly significant problem with students dropping out during their third level education. The Irish government's expansion policy on education has resulted in much higher numbers pursuing higher education than ever before, with over 60% of school leavers progressing to third level education in 2009 (Forfás Expert Group on Future Skills Needs, 2009). In addition, the current economic climate has led to an increase in the numbers of students choosing to stay in third level education.

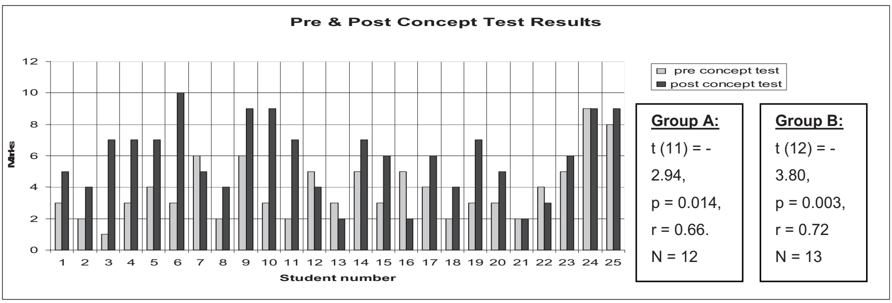
While the large numbers are seen as progressive and an improvement in the education system, it does lead to the problem of a very diverse group of students in higher education. (Childs & Sheehan 2009; Darmody & Fleming 2009) It is of vital importance with groups of wide ability that we ensure that the weaker students do not get lost or left behind. This pilot study is an attempt to increase retention amongst weaker students in undergraduate science programmes.

Method. A pilot intervention programme was designed for two groups of students, who have previously been identified as weak, in the first semester of the 2008-09 academic year. This programme lasted 9 weeks, consisting of tutorials in basic chemistry, linked to a chemistry module in Inorganic chemistry. This was an optional programme offered to the students, which meant we were only able to measure the performance of those who took both the pre- and post-tests. A pre- and post- diagnostic test of chemical concepts and misconceptions was designed and administered in the first and last tutorial session. The test also included an instrument measuring student attitudes and confidence towards science. The attitude/confidence tests used a Likert instrument. The pre- diagnostic concept tests were used to design the intervention programme in order to meet the students' specific needs. The students were taken in small class groups, rather than the larger lecture groups.

The same intervention programme was repeated in the first semester of the 2009-10 academic year for the equivalent second-year student groups.

Results.

Figure 1: Comparison of Pre- and Post-test results for groups 'A' and 'B'



The results based on the first intervention show, on average, a positive trend in both conceptual understanding and confidence levels. Figure 1 shows that 76% of students in both groups who did both tests improved in their post-diagnostic test performance, indicating that for the vast majority of the class the programme was beneficial. The majority of those who improved (72%) had good attendance records.

The performance of these two groups has been evaluated in the final examination for the Inorganic chemistry module, compared to the equivalent groups in the previous academic year, 2007-08. From this analysis we have seen an improvement in the groups overall performance. Students in group 'A' who participated in the intervention programme had higher grades ($M = 47.64$, $SE = 2.29$) than those who did not participant in the intervention programme ($M = 38.35$, $SE = 5.79$). This difference was not significant $t(23) = 1.50$; however it did represent a medium size effect ($r = 0.3$).Those in group 'B' who took part in the intervention programme had better grades ($M= 33.29$, $SE = 2.17$) than those who did not take part in the intervention programme ($M= 26.45$, $SE = 1.40$). This difference was considered to be significant, $t(22) = 2.64$. A medium -large size effect was also noticed ($r = 0.49$).

Due to circumstances outside of our control, only pre-diagnostic test results could be collected for the second intervention programme. This raises the problem of poor attendance and also the voluntary nature of the tutorials. From the pre-test results, these two groups of students are showing the same patterns of misconceptions as previous year's groups.

Conclusions and Implications. The results of the first intervention programme were positive. The examination results of students who undertook this programme were better than those in previous years. However, this was an optional programme and while the results are encouraging, poor attendance in both the main module and in the intervention programme clearly affect the results, as was the case with the second intervention programme. Many students who attended some of the nine week programme in the first intervention could not be assessed as they did not attend both pre- and post-test sessions. This programme successfully improved, not only chemical understanding, but also students' attitudes and confidence.

We intend to implement a longer intervention programme for the same two groups of students in their first year of study, as well as for first year students who have not previously studied chemistry in the 2010 semester. It is intended that the intervention programme will start earlier in the semester to help combat poor attendance as the students approach examination time. The new programme will also run for two semesters instead of one. The planned intervention tutorials will involve blended learning, including a combination of face-to-face teaching and learning, as well as online resources and also elements of formative assessment.

By using a variety of pedagogical techniques it is hoped that students from these groups will be equipped with the basic chemical understanding that they need for their undergraduate programmes of study, resulting in greater retention.

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Reflection on Nature of Science (NOS) Aspects by Teaching Scientific Inquiry. An explicit theoretical and practical reflective Approach to Enhance Prospective Teachers' Understanding of NOS.

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Rationale. Understanding the nature of science has been a central educational objective for over 100 years (Central Association of Science and Mathematics Teachers, 1907). Despite the fact that in the meantime many suggestions for improving and enhancing an understanding of NOS in the classroom and in science teacher education have been developed in many different countries, neither students nor teachers seem to have an 'adequate' conception of NOS (Abell & Lederman, 2007).

Consequently understanding NOS has become a central component of scientific literacy agreed internationally (American Association for the Advancement of Science, 1993; National Research Council, 1999; Schecker & Parchmann, 2007).

Despite the fact that many suggestions for improving an understanding of NOS have been developed in many countries (e.g. Khishife & Abd-El-Khalick, 2002), neither students nor teachers seem to have an adequate understanding of it. Quite contrary several misconceptions about science are held by many students, teachers and even scientists. Ten major myths are enumerated by McComas (1996).

Since teachers function as multiplicators of their own views, it seems to be necessary to foster their understanding of NOS. The present study describes necessities, possibilities, limits and perspectives of enhancing their understanding of NOS.

The study outlines methods, selected results, but also problems of a combined approach which includes an explicit theoretical instruction with a practical and reflective opportunity focusing on the following questions:

1. Can a seminar about epistemological, historical and sociological aspects of NOS contribute to a better understanding of NOS?
2. Can out-of-school-labs foster or enhance the reflection on aspects of NOS and on their relevance for science teaching?

Methodology. To assess the influences of a theoretical-explicit instruction followed by different practical-reflective learning opportunities in out-of-school learning settings quantitative as well as qualitative methods were used and evaluated. Influences of the different steps and practical learning opportunities as well as advantages and disadvantages were analysed.

The influence of the explicit introduction (seminar) on students' views on NOS was assessed by a questionnaire derived from "Views on Science and Education Questionnaire" (VOSE) (Chen, 2006) which is designed to measure participants' concept of NOS and corresponding teaching attitudes in a pre/post test control group design. The questionnaire was administered to both groups (intervention and control group). The questionnaire focuses on seven aspects of NOS. It consists of 15 questions and 72 items. The students were requested to mark their attitude on the Likert scale: from total agreement (2) to total disagreement (-2). Since most issues of NOS are multifaceted the score for each issue is an average score of several items. The averaged scores are then applied to statistical analysis (SPSS). Furthermore the questionnaire was used to create in-depth profiles of students' views by qualitatively judging the answers in the VOSE questionnaire of 9 selected students.

The reflective teaching part was evaluated by analyzing the answers to an open-ended questionnaire using qualitative methods. The questionnaire with targeted students was used to clarify their views on

1. The significance of NOS in science education
2. How to teach NOS
3. Problems of NOS instruction at school

Findings. According to the changes in views on NOS as assessed by the VOSE-questionnaire, some significant effects of the explicit instruction became obvious. But they neither reveal elaborated profiles of students' thinking nor about their beliefs of implementing NOS in science lessons. Therefore the quantitative analysis was complemented by a qualitative view.

The results of the open questionnaire reveal that:

- Students agree on the importance of NOS for science education but they also seem to recognize some organizational problems of implementation.

- Furthermore a mere theoretical instruction seems to be insufficient to promote students' understanding of NOS. Adequate practical opportunities seem to be necessary to make them more aware of the interrelatedness of the theories with scientific inquiry and science instruction in school and consequently to enhance their understanding of NOS.

Conclusions. Results of the study indicate a substantially progress of pre-service teachers` NOS-views in the course of the intervention. At the same time limits, of enhancing their views were identified. Analysis revealed several factors influencing and delimitating the possibilities of changing and enhancing students' views. These factors include: the abstract nature of the domain of scientific epistemological views, the complexity of incorporating it in practical learning settings, time constraints and participants' conceptions and the tenacity with which they hold on to their views. In addition, the study revealed that approaches to enhance scientific epistemological views can only function as a stimulus. The evaluation of the employed methods indicate their advantages and disadvantages as well as the necessity to use quantitative and qualitative methods to obtain a well-founded and meaningful assessment of students' understanding about NOS.

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More Than 20 Uses Of A Didactic Tool For The Teaching Of The Periodic Table And Its Properties

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Keywords: Microscale, didactic tool, periodic trends, chemical education

Background and objective. A didactic tool for teaching the properties of the elements in the periodic table has been developed and tested for some time with very positive results. Here, we present more than 20 ways to use this tool.

The periodic behavior of the elements and its utility in the prediction and extrapolation of properties through them is an indispensable tool in the education and the learning of basic concepts of chemistry. Therefore, a plastic model (a blister) in PETG of nutrition grade was designed. This blister[1] measures 29,5 cm in length per 18,6 cm wide, 1.5 cm height. Each blister has 118 cavities of one cm of diameter and with a depth of 0,5 cm, which are distributed according to the position of the elements in the present periodic table.

This didactic material has turned out to be very useful to visualize properties of the elements using economic material of different colors (sweet, chewing gum, marbles, small bullets, etc), or adapting test tubes each of 3 cm in length and 1 cm in diameter that can be introduced in the orifices of the blister.

Methods. We report more than 20 uses of the periodic blister to teach periodic properties as well as the position of the elements on the table, although these are not exhaustive and the application will depend on the creativity of the users. The following is a shortlist of them:

1) Acid-base character of oxides.
2) Write the name of each element on a bead and sort them on the table
3) Redox Trends
4) Physical state of the elements (liquid, solid, gas)
5) S, P, D, and F blocks
6) Element groups
7) Countries that have contributed to the discovery of the elements.
8) Century when elements have been discovered (XV, XVI, XVII, XVIII, XIX , XX and ancient times)
9) Metallic elements, non-metal and metalloids
10) Discovering scientists (max 5 elements by….)
11) Atomic radii
12) Abundance on Earth
13) Abundance in the universe
14) Abundance in the human body
15) Uses of the elements
16) Extraction methods
17) Atomic volume (beads of different sizes)
18) Common oxidative valences (-4,-3,-2-1-0,1,2,3,4)
19) Electronegativity
20) Valences (1 to 7)
21) Number of isotopes (0-4)
22) Solubility in salts
23) Natural elements and radioactive elements
24) Elements present on biological systems (macronutrients, micronutrients, trace elements, inert elements, biotoxins and radioactive elements)
25) Ionization potential

[1] Patent pending. Copyrights VAu 987-797.

Results, Conclusions And Implications. This didactic material allows the discussion of a great number of properties that vary periodically and also allows locating the position of the elements and learning nomenclature. The design allows experimental practice with simple reactions on microscale, lowering costs and diminishing risks. In addition, adapting test tubes is still possible for each user's versatile and adaptable necessities and resources.

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The Inorganic Chemistry Laboratory of the Chemistry Faculty Recovers the Chemical Wastes.

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Keywords: Chemical Laboratories, Waste Recycling, Chemical Waste Collection, Chemical Waste Recovery.

Background, framework and purpose. In all chemistry schools, the academic laboratories generate chemical wastes. Then, teachers must educate the students to management that wastes. The teacher mission is to bring up wholly the students by promoting ecologic culture and make them achieve a humanism based in the acquisition of values and behaviors, ethics and responsibilities with the conservation, preservation and environmental protection, and the health of human beings.

The students in the Inorganic Chemistry Laboratory at the National Autonomous University of Mexico are trained about the Recycle, Recover and Reuse process of the chemical wastes that they produce in laboratory experiments.

The purpose of this research is to train students in wastes separation, their collection in a container properly labeled, and the treatment and recovery of the reagents in the case of ions of the transition elements.

They will collect the wastes according on the specific metallic ion. They make the procedure for recover or recycle according the rules and regulations of the Chemistry Laboratory, Meijueiro and Rodriguez (2007) and the Mexican environmental regulations. NOM -052- SEMARNAT (1993).

Methods. In the Inorganic Chemistry Laboratory at the Chemistry Faculty of the UNAM Mexico; 600 students attend in a semester; they make eight or ten experiments by semester and they produce chemical wastes.

The teacher's reflections were that an activity that produces pollution needs attention, the treatment of the wastes generated during the realization of experiments in the university laboratories must be teached to chemistry students.

The students must know the national laws and regulations of ecological protection in our country like the "Normas Oficiales Mexicanas" (Mexican Official Standards): "NOM-052-SEMARNAT- 1993" that states the characteristics of dangerous wastes, and sets the limits when a waste is dangerous by its toxicity to the environment.

They must know The "NOM-053-SEMARNAT-1993" which states the procedure for carrying out the extraction test for determining the chemical compounds that make a waste hazardous. They must know the NOM-018-STPS-2000 that states the system for the identification and communication of hazards and risks for hazardous chemical substances in the work place.

They must be responsible to protect human health and the environment. Facultad de Química (2007).

The students separate the wastes according their dangerous characteristics: corrosively, reactivity, explosive level, toxicity, inflammability and patogenicity.

The chemical wastes are classified: Organic Solvents (with halogen and without halogen), Aqueous solutions (organic or inorganic), Acids and bases, Solids (inorganic or organic), Oils, Very reactive compounds, Very toxic compounds, Strong oxidants.

The students collect the chemical wastes in covered containers, properly labeled and they store them in a safe location in the laboratory; the students must treat periodically the wastes according to the specific chemical procedure. Burriel, et al (1994). The wastes do not treated in the laboratory will be send to the Environmental Management Unit (Unidad de Gestión Ambiental (UGA) at the same Chemistry Faculty. The UGA has regulations about the management of these chemical wastes. The laboratory periodically sends a list of the chemical wastes and solvents wastes that the UGA must collect like benzene, carbon tetrachloride, ether, or other chemicals such as ferrocene. The UGA then decides to make a treatment, storage, recover, or send them to the buried. National Research Council (1980)

Results. Treatment is an essential teaching tool. Students need to learn the importance of proper waste management, much of which is waste treatment. The best way to teach these responsibilities is to incorporate chemical waste treatment into the laboratory curriculum so that students will learn to fulfill their responsibilities from the start.

In the Inorganic Chemistry Laboratory, students have recovered the following reagents: $CuSO_4{\cdot}5H_2O$, CoO, Cr_2O_3, Ag, $PbCl_2$, MnO_2, $NiSO_4{\cdot}6H_2O$, these reagents can be reused in other experiments, after they recover the reagents the students become self-satisfied, and thus have great meaning for their curriculum.

The reflections of the students were:

We consider that waste management in teaching laboratories must be a part of our training; we need to management with the toxic properties of the chemical compounds that we use and know how to treat them and learn to recover, reuse and recycle them.

Conclusions. It is imperative that laboratory professionals from all disciplines are educated on pollution prevention concepts, on storage, treatment and disposal of chemical wastes during their academic training in order to make the pollution prevention become a standard in industry.

In our planet the environmental education is necessary and the teachers in that bring up chemistry students have a great responsibility, the water reuse and recycle is another ethic concept that the students must learn.

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México, Normas Oficiales Mexicanas

Educational Software for Evaluating Thermal Risk in Chemical Industry Using DSC Data

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Keywords: Educational Software, Adiabatic Conditions, Methyl, Nitrophenol, DSC, Kinetics, Thermal Risk, Time to Maximum Rate (TMR)

From educational point of view it is very important to show that the DSC data obtained in the experiments carried out in mg-scale can be successfully applied for the prediction of the thermal behaviour of the materials in ton-scale. Such scale-up is not commonly known and present study shows how it can be performed by AKTS-Software. In the first step of the elaboration of the DSC data the kinetic parameters of the investigated reaction are calculated. Kinetic parameters of the decomposition of hazardous chemicals are later applied for the estimation of their thermal behaviour under any temperature profile. Presented paper describes the application of the advanced kinetic approach for the determination of the thermal behaviour under adiabatic conditions occurring e.g. in batch reactors in case of cooling failure.

The kinetics of the decomposition of different samples (different manufacturers and batches) of 3-methyl-4-nitrophenol were investigated by conventional DSC in non-isothermal (few heating rates varying from 0.25 to 8.0 K/min) and isothermal (range of 200-260°C) modes. The kinetic parameters obtained with AKTS-Thermokinetics Software were applied for calculating reaction rate and progress under different heating rates and temperatures and verified by comparing simulated and experimental signals. After application of the heat balance to compare the amount of heat generated during reaction and its removal from the system, the knowledge of reaction rate at any temperature profiles allowed the determination of the temperature increase due to the self-heating in adiabatic and pseudo-adiabatic conditions. Applied advanced kinetic approach allowed simulation the course of the Heat-Wait-Search (HWS) mode of operation of adiabatic calorimeters. The thermal safety diagram depicting dependence of Time to Maximum Rate (TMR) on the initial temperature was calculated and compared with the results of HWS experiments carried out in the system with Φ-factor amounting to 3.2. Presented calculations clearly indicate that even very minor reaction progress reduces the TMR_{ad} of 24 hrs characteristic for a sample with initial reaction progress amounting to zero.

Described estimation method can be verified by just one HWS-ARC, or by one correctly chosen ISO-ARC run of reasonable duration by knowing in advance the dependence of the TMR on the initial temperature for any Φ-factor. Proposed procedure results in significant shortening of the measuring time compared to a safety hazard approach based on series of ARC experiments carried out at the beginning of a process safety evaluation.

Students' content knowledge about chemical reactions

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Keywords: chemistry, content knowledge, educational standards, test items

Background. Many countries introduced educational standards for science subjects to improve the quality of their school systems (Nentwig & Waddington, 2007). The evaluation of standards with written tests requires specific quality criteria, e.g. the content clarification (DeBoer, Herrmann-Abell & Gogos, 2007). In the United States several documents define topics which are compulsory (e.g. AAAS, 2001).

German educational standards define students' learning outcomes in chemistry for 10th grade (KMK, 2005) without a detailed description of compulsory topics. For an evaluation, the content of test items has to be defined by a content analysis of chemistry curricula. The results show that there are only few overlaps between the curricula of different states.

As a consequence, some items provide content information in the item stem (task type A) to guarantee test fairness for students from different states. However, it is unclear which influence the content information as well as reading comprehension have on item difficulty.

The present study focuses on the analysis of both influences by using a second task type (task type B) which does not include additional content information. This means that items and options of both task types are the same and that the only difference is the item stem.

Items are developed according to a normative structure model of competence for all science subjects (Walpuski, Kampa, Kauertz, & Wellnitz, 2008). This study validates this model and the item design used for the evaluation. The content-related focus lies on the fundamental concept "chemical reactions" in the area of competence "application of chemical content knowledge".

Methods. The content for the test items was validated by an evaluation of curricula with respect to technical terms under the headline "chemical reactions". Afterwards, the technical terms were used to develop the standard-based tasks. This process was standardized by a construction guideline for test items.

The model-fit of the developed test items is investigated with Rasch analysis (Boone & Scantlebury, 2006) assuming item difficulty to increase with increasing content complexity and with increasing level of cognitive processes demanded. Both aspects are taken into account for each item by the construction guideline.

Furthermore, the variables chemical content knowledge, last grade received in chemistry, cognitive skills, reading comprehension and last grade received in German were ascertained with paper-pencil-tests to validate and discriminate the results.

Results. About 1.300 students of 10th grade participated in the assessment. Due to the Multi-Matrix-Design, each of the 160 test items was done by at least 170 students. Most characteristic values of a Rasch analysis (weighted mean square values and t-values) fit the usual criteria of quality (Wilson, 2005). Therefore, from an empirical perspective only few items have to be deleted for further analysis.

The analysis of item difficulty focuses on the adapted dimension „content complexity" that Kauertz (2008) identified as difficulty causing. First, the two task types were considered separately. The item difficulty of task type A increases over all five levels of complexity. For task type B it increases too, but differences between the levels are smaller. Afterwards, the differences of the mean values were regarded between the task types on every level of complexity. The differences between the task types decrease with increasing complexity.

Further analyses of item data were performed to guarantee their quality. For the person data the influence of the ascertained companion variables on the achievement in the test was measured. The results show that the application of content knowledge correlates strongly with content knowledge and cognitive skills. The correlation with reading comprehension is on a high level as well but lesser.

Conclusions. First, this study contributes to the validation of the assumed competence model, especially with regard to difficulty causing item characteristics. Obviously, it is possible to predict the item difficulty of task type A by its content complexity and the cognitive processes. The comparison with task type B shows that the difference between the item difficulties decreases with increasing complexity. Therefore, content knowledge is necessary to solve items but not sufficient. Students also need cognitive skills. This indicates that the items are useful for a competence test which measures students' competence in view of the application of content knowledge.

Furthermore, the results give an overview of the content knowledge German students have at the end of 10th grade in view of chemical reactions.

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Student Ratio Use and Understanding of Molarity Concepts Within Solutions Chemistry

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Numbers are an important component of chemistry and can represent different things in different contexts. For example, the number "2" could represent the charge on an ion or it could represent a stoichiometric coefficient in a balanced equation. Since number is both important and not possible to interpret directly, studying how students understand number in specific chemical contexts is necessary. The context of this project, solutions, is remarkable as a source of insight because solutions add the important additional factor of mixture, where different amounts of materials are present. The concept of molarity was chosen for study because students encounter molarity through dilution and concentration problems. Molarity is specifically of interest because it is not just a number, but a ratio between two different constructs: moles and volume. This research intends to answer three research questions: 1) What are students' interpretations of molarity in solutions chemistry? 2) Are there patterns in how students use ratio in their solving strategies for molarity problems? and 3) Do students' understandings of ratio vary from domain specific tasks to structurally isomorphic tasks? The various understandings that students hold regarding ratio and molarity and how they use ratios while solving molarity problems is best studied through a basic interpretive qualitative study with a grounded theory analysis.

Ratios are prevalent in chemistry and students may have different understandings and uses of ratio for each possibility. Ratio is an essential component to the teaching of chemistry and students are often tested on their algorithmic skills. However, as studies suggest, students can perform algorithmically and have no understanding of the concept being tested (Beal & Prescott 1994; Nakhleh, 1993; Nakhleh & Mitchell, 1993). Student performance without understanding suggests that a study focused on students' understandings of ratio with respect to molarity would be worthwhile.

Data will be collected from incoming university students who have taken a chemistry placement exam that will enable stratified sampling. Student understandings of molarity and use of ratio will be collected through specific tasks and diagnostics. Students will first take a diagnostic involving domain specific questions relating to molarity and general questions regarding proportions and ratio. To elicit student understandings of molarity, students will be presented with two tasks where each of the constructs of molarity are varied to explore the dimensionality of their responses. In Task 1, students are presented with four bottles with the same volume but different concentrations of CaCl2. In Task 2, students are presented with three bottles all with the same molarity but with differing volumes. The next two tasks are structurally isomorphic to the molarity tasks and involve concentration of color and heights of blocks of wood. These tasks explore whether students' understandings of ratio vary from tasks that are structurally similar to those in the field of chemistry. Task 3 involves five blocks of wood, each of the same height but with varying proportions of red and white paint. Task 4 involves 5 blocks of wood that are all the same shade of pink but at varied heights. Finally, students will work through several molarity problems through a think-aloud to find their problem solving strategies and how they use ratio in the context of molarity.

The motivation for this study arises from the importance of ratio, molarity, and number in chemistry, including its impact on teaching and assessment standards. In addition, number has arisen as an important and confounding concept in interviews with students about solution phenomena in general. For example, in a pilot study one student thought that 0.05 M is 5% less moles than 0.10 M while others think that three bottles of different volume that are labeled with a concentration of 0.05 M means that all three bottles have the same amount of moles of solute with more space between the molecules as the volume increases. These interpretations could be explained by ratio use if we knew their solving strategies.

More data needs to be collected with the incoming students in the Spring 2010. Implications of this study include outcomes in research, instruction and standards. An understanding of how students understand molarity will be useful for instruction and standards assessment. For example, teachers can see the different ways in which students understand molarity and can teach accordingly. Another example is that the various ways in how students understand molarity may not be truly assessed through the algorithmic standards that we currently have. This could lead to new standards that are more conceptual and aimed at how students truly understand molarity and its ratio. It is important to know if students hold a different view of molarity when the volume is varied. Current instruction and assessment assumes a static understanding of molarity no matter the varied volume. There may be different strategies that students use to solve molarity problems; some are successful and some are not. If certain strategies are indicative of certain ratio abilities, teachers could use it as a diagnostic to find the level of their students and understand the misconceptions that their students hold. If students are unable to explain domain specific task but are able to explain structurally isomorphic tasks, this could lead to improvements in instruction, standards assessment and research. For example, teachers will know that they need to connect concentration to structurally isomorphic tasks to help students understand molarity. It would also point to a change in standards if students hold different understandings for different situations. New standards would be necessary to help identify these misconceptions. This could also affect current research interviews.

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Mixed-methods study of the impact of cooperative, problem based laboratory instruction on metacognition use and chemistry problem solving skills

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Keywords: Laboratory instruction, metacognition, assessment, general chemistry, cooperative learning

Despite the considerable amount of research on metacognition and its impact on our understanding of learning, there seems to be no clear consensus regarding its definition and its relationship to other concepts like self-regulation (Thomas, Anderson, & Nashon, 2008; Schunk, 2008). For research purposes, we subscribe to the definition of metacognition as "knowledge and regulation of one's own cognitive system" (Brown, 1987, p. 66). The theoretical framework derived from this conceptualization describes two major components: knowledge of cognition (declarative, procedural, and conditional knowledge) and regulation of cognition (Schraw, Crippen, & Hartley, 2006). Our research interest focuses on regulation of cognition which comprises the repertoire of planning, monitoring, and evaluating activities or actions in which an individual engages while performing a task. The influence and relevance of metacognition in learning and problem solving has been substantially demonstrated (Georghiades, 2004). Understandably, there has been an increasing interest in metacognition assessment and its development through instruction (Davidowitz & Rollnick, 2003; Georghiades, 2004). Nonetheless, the lack of simple, rapid, and automated assessment tools has slowed its study. In addressing this issue, a multi-methods assessment of metacognitive skillfulness in college chemistry problem solving has been reported (Cooper, Sandi-Urena, & Stevens, 2008). This assessment utilizes a traditional prospective self-report, the Metacognitive Activities Inventory, MCAI, (Cooper & Sandi-Urena, 2009) followed by a concurrent, computer-based instrument, IMMEX (Stevens, Johnson, & Soller, 2005). IMMEX is capable of recording and analyzing a large number of performances in a short period of time, thereby allowing the rapid classification of students according to their metacognition use level (low, intermediate, and high).

The present study is an assessment of the impact of college chemistry cooperative problem based laboratory instruction on students' development and self report of metacognition use, and on ill-structured problem solving strategy and ability. A mixed-methods sequential explanatory design was utilized for this study. In the quantitative phase metacognition use was evaluated using the multi-methods described above. MCAI paired sample t-tests showed a significant increase in awareness of metacognition in students who experienced the laboratory learning environment (treatment group). In addition, IMMEX findings indicated that participation in the learning environment was significantly associated with use of more metacognitive problem solving strategies. A chi square test showed that a significantly higher proportion of these students were classified as 'high' metacognition users. Item Response Theory (IRT) modeling was utilized to calculate participants' ability to solve IMMEX ill-structured problems. Mean ability comparison of conditions showed that the treatment group significantly outperformed the control group. These results were consistent for three independent samples totaling over 1500 participants. A phenomenological approach was utilized for the qualitative component of the study. Eleven student semi-structured interviews were used as main source of qualitative data; open-coding, analysis, and interpretation were conducted by a team of three researchers. The outcome space obtained strongly supports and sheds light into explaining the quantitative findings: the instruction used created a learning environment in which the development and use of metacognitive skills was essential to functioning and completing the tasks assigned. Metacognitive prompting and an intense social interaction emerged as fundamental factors. This work's contributions are twofold: first, it exemplifies the use of reliable and validated methods to assess metacognition use in chemistry; second, it contributes sound and significant evidence addressing one of the most discussed and persistent questions in science education: what is the role of science laboratory instruction? This mixed-methods study puts forth research showing "simple relationships between experiences in the laboratory and student learning" (Hofstein & Mamlok-Naaman, 2007).

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Learning from teaching: GTA development of scientific skills through general chemistry laboratory instruction

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Keywords: teaching assistants, epistemological development, metacognitive development, chemistry laboratory, phenomenology

The idea that appropriately designed laboratory instruction can play a significant role in students' achievement of scientific literacy seems to be prevalent among chemistry educators (Hofstein & Mamlok-Naaman, 2007). Consistent with this premise, related education research has focused on the implementation of different instructional approaches, and students' gains and perceptions (Hofstein, & Lunetta, 2004). Interest in teaching assistants has been mostly limited to training, and to their perceived expectations (Bond-Robinson & Bernard Rodriques, 2006; French & Russell, 2002). Little attention has been paid to the benefits that *teaching* may have for science graduate teaching assistants, GTAs. Even though being a GTA may be presented as a way of gaining valuable teaching experience, more often than not these positions are primarily considered a secure source of financial support, and graduate students and research advisers alike often perceive it as *time away from the research lab*.

In 2002 French and Russell posed an intriguing question: "can teaching inquiry-based labs complement other activities through which GTAs learn to conduct research?" (p. 1037). Based on the premise that people learn more effectively when they teach, these authors maintained that facilitating development of inquiry skills would in turn favor GTAs' own research skills. They demonstrated that GTAs' perception was that their involvement in an inquiry based biology course had contributed to their ability to do research. In the scarce chemistry-related literature, most of the GTA gains seem to fall within the dimensions proposed by Seymour (2005): content knowledge and understanding, teaching (teaching skills, effective communication, and enjoyment), and appreciation of personal and career paths. Typically, these reports have not resulted from a thorough analysis of the learning environment but from survey type instruments. As part of a larger research program, this study investigates the effect that general chemistry laboratory instructional environments have on GTAs' research skills.

Metacognition—the ability to reflect about one's own cognitive activity and its outcomes (Schraw, Crippen, & Hartley, 2006)—plays a relevant role in learning, problem solving and research; personal epistemology—individual's assumptions about the origin, nature, limits, and certainty of knowledge (Baxter Magolda, 2004)—is strongly tied to identity development and expectations and ways of learning. Given the centrality of these two constructs in developing scientific skills and identity, we focused on GTA's epistemological and metacognitive developments in relation to their role in the academic laboratory. Large-enrollment general chemistry programs at two research universities were chosen for this purpose. One of the programs uses inquiry through a well established cooperative project-based approach (Institution A); the other is based on traditional verification-type experiences (Institution B). The methodological framework chosen was phenomenology (Patton, 2002) since it allowed us to explore the essence and meaning of the teaching assistant experience as lived by the participants. This approach shed light about the processes that might impact GTAs metacognitive and epistemological developments. The research team investigated the two programs separately and at different times. Participants were first-year chemistry GTAs: 14 at Institution A and 15 at Institution B. Data collection used a semi-structured interview protocol that prompted GTAs to describe their own experiences as students, their perception of their students' experiences, their own experiences as GTAs, and their thoughts about learning and teaching in the academic laboratory. Interviews were conducted at the end of GTAs' first semester assignment, lasted approximately one hour, were audio taped, transcribed and analyzed separately by institution. Open coding analysis, followed by emergence of themes that were then collapsed into dimensions produced an outcome space for each academic program. The outcome space obtained for Institution A offers a rich description of how the cooperative project-based context promotes GTAs' metacognitive and epistemological development and sheds understanding about the motivation driving GTAs' intellectual engagement. Data analysis for Institution B is underway; findings from the two institutions will be contrasted as part of this presentation. Evidence will be discussed that suggests that appropriate teaching experiences may contribute to better prepare graduate students for their journey in becoming scientists and to embark on successful research. We believe that a better understanding of potential GTA benefits in learning environments may place innovative instruction in a new light of appreciation.

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Use of In-situ Techniques for Monitoring Electrochromism in Laboratory Settings.

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This experiment was developed to put current technology to use in order to develop the existing lab experiment content. Relatively few laboratory experiments address the application of in-situ instrumental techniques in experimental settings. It is this scarcity that induced us to introduce two examples of the more recent in-situ experimental methodology, namely, *ın- sıtu* spectroelectrochemical and *ın- sıtu* electrocolorimetric methods. These applications will help teach students (*i*) electrochromism methodology, (*ii*) thin film preparation techniques of electrochromic materials, (*iii*) application of *in-situ* spectroelectrochemical and *in-situ* electrocolorimetric techniques to monitor electrochromism, (*iv*) designing of an electrochromic display device, (*v*) demonstrating an electrochemical writing (e.g. "j c e " letters) with an electrochromic display device, and (*vi*) usage of an *in-situ* electrocolorimetric technique for determining the color parameters of electrochromic materials.

Keywords: Upper-Division Undergraduate; Laboratory Instruction; Electrochemistry; Spectroscopy; Instrumental Methods; Chemical Education Research

Introduction. With its main focus on the changes of simultaneous transmission/absorption spectrum during the electrochemical perturbations of a system, spectroelectrochemistry is widely used in science labs as an in-situ technique. Despite its wide use, relatively few articles deal with practical examples of how to teach and apply in-situ spectroelectrochemistry methods in labs (Heineman 1983; Plieth, Wilson, Gutierrez, 1998). The number of publications on how to teach the application of spectroelectrochemistry for optical and electrochemical characterization of different electrochromic materials is limited, too (Lawrence, Stenger, 2001;Hepel 2008; Forslund 1997). The literature reveals no examples of practical teaching principles and applications of *in-situ* electrocolorimetry techniques. Therefore, we have described the principles and applications of *in-situ* electrocolorimetry combined with *in-situ* spectroelectrochemistry in this experimental procedure that characterizes electrochromism of the methyl viologen (MV), a material extensively investigated for digital displays and smart windows applications.

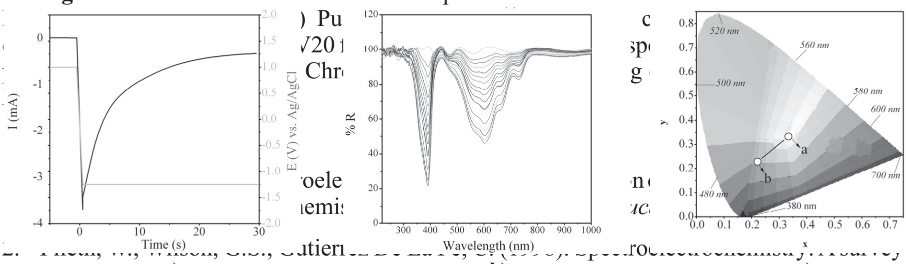
Materials and Instrumentation. Electrochemical coating, *in-situ* spectroelectrochemistry and *in-situ* electrocolorimetry measurements were performed with three-electrode cells using a potentiostat-galvanostat combined with a spectrophotometer. During the electrode modification process, ITO electrode was coated with nafion cation exchange membrane and then MV was incorporated into Nafion electrochemically. Two ITO slides (2.5-7.5 cm) were used for electrochromic display devices (ECD). One of them was coated with MV with the same procedure described above. The other one was coated with MV as the letters "J C E". A thin layer spectroelectrochemical cell (TLSEC) is used for in-situ spectroelectrochemical and in-situ electrocolorimetric measurements. TLSEC is placed into the cell holder of the spectrophotometer. Three-electrode system (Ag/AgCl reference electrode, Pt wire counter electrode and ITO working electrode) is placed into the TLSEC and connected to the potentiostat.

Results and discussion. By bridging the gap between the 'artificial' lab environment and instrumental applications ın the real world, this experiment presents a new opportunity for faculty who wish to induce student enthusiasm in research fields in science, technology and engineering.

In situ spectroelectrochemistry is the best way of examining the changes in optical properties of material coated on the working electrode upon voltage applied. Therefore, in this experimental study, students learned how to monitor the spectroelectrochemical properties of a desired system such as potential, current, % reflectance (%R) and color changes (coordinate of the colors) during bleaching and coloring of MV film (Figure 1). Finally in this experimental study, a model ECD was designed to write "J C E" letter electrochemically. ECD was built by arranging two ITO glasses coated with electrochromic MV films (one was coated as "J C E" letters and used as cathode) facing each other and separated by a gel electrolyte.

Students working in a chemistry laboratory will gain valuable hands-on experience with the use of these in-situ spectroelectrochemical and in-situ electrocolorimetric experiments accompanied by simultaneous recording of voltammetric, spectroscopic and colorimetric characteristics of a desired system. The design of the experiment revs up student interest in solving spectroscopic and electrochemical problems by developing their perspectives through these new in-situ instrumental techniques.

Figure 1. *In-situ* electrocolorimetric responses of MV20 film recorded in 0.20 M LiCl …) Pu … V20 f … Chr … oele … emis …



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Instructional Quality of Lab Work

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Keywords: Experiments, Chemistry Education, Video-study, Instructional Quality

Purposes. In research on quality in education, many different characteristics influencing the learning process of individuals have been identified (e.g. Brophy & Good, 1986; Tobin & Fraser, 2003; Helmke, 2007), but most characteristics of quality in education are not for a subject-specific instruction. Helmke (2002) and Ditton (2000) state that looking at general quality of education exclusively is outdated, so they call for specific characteristics of quality in specific subjects. With regard to this, the aim of the study is to identify those experiment-specific characteristics which enhance interest and have a positive effect on achievement in chemistry education. This will be achieved by observational research (video-analysis) based on a category system and paper-pencil-tests.

Methods. The project is divided into two phases. In the school year 2008/2009 (first phase), 18 lessons in chemistry education were videotaped. The topic was 'Alcohols' in grade 10 of secondary schools (middle track). Teachers (N=16) were instructed to demonstrate a typical chemistry lesson under the condition that at least one experiment should be conducted. These 18 classes are the first control-group. One year later (second phase), at least 10 of the 16 teachers1 are asked to participate in an intervention in which the characteristics of quality in phases of experiments will be given. This will be realised by a short teacher training with a feedback based on the videos from the first phase of the project. The direct control-group2 will be formed by parallel classes (without intervention) taught by the same teachers, which will be videotaped previous to the intervention-group.

In order to analyse the videos, especially the experimental phases, a high- and low-inferent category system was constructed and evaluated. This category system detects characteristics of education, which could be determinants with an effect for education-goals and characteristics of students. It bases on the systemic model of quality in education (Reusser & Pauli, 2003), the offer and use model (Helmke, 2007) and results of the general quality of education research (e.g. Biggs, 1979; Harvey & Green, 1993; Smith, 1985). All lessons will be analysed with this high- and low-inferent category system. To be able to go beyond a mere description of chemistry instruction, video-analysis should be completed by using further criteria like interest, motivation, intelligence or capacity (Seidel & Prenzel 2006). Thus, the cognitive ability test (Heller & Perleth, 2000), an achievement test (pre-post), a test on scientific procedures (Klos et al., 2008) and a questionnaire about interest and motivation (pre-post) are used.

Results. To evaluate the category system, available video data were reanalysed in a pilot study. The surface structure of the lessons (low-inferent) was analysed by time sampling (10 second steps) with the program videograph®. The inter-rater reliability of this pilot study was between $.55 < \kappa < 1.0$. The deep structure of the lessons was rated by a rating-questionnaire with a four-point Likert Scale (strongly agree – strongly disagree). The reliability of the high inferent category system was evaluated by the Intraclass Coefficient (ICC). All the inter-rater reliabilities are highly significant ($p \leq 0.001$).

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[1] Assuming that about ⅓ of the teachers will drop out for various reasons (e.g. not teaching a 10th grade class any longer)

[2] Enabling control if there are time-based variances or changes in a school (e.g. a new book, new chemistry rooms)

It could be observed that the planning of the experiments averages 16 % of the teaching time, the procedure 58 % and the analysis 19 %. Thus, 92 % of the teaching time is used for experimentation. This is not surprising because of the condition that the teachers had to conduct at least one experiment. Mostly, the procedure of the experiments is organised in group work (94 %). In certain cases, the students have to work at different stations (2 %) or have to conduct a demonstration-experiment (4 %). During the group work, the students spend more time to conduct the same experiment (92 %) compared to conducting different experiments. Furthermore, it could be observed that experiments are mostly used at the beginning of the lessons (61 %). Conducting an experiment to test a hypothesis is seen in 27% of the videos. The third function of an experiment, which could be observed, is confirming a hypothesis (12 %). First results of the second phase can be presented at the conference.

Conclusions

The results of the inter-rater reliability of the low-inferent ratings are between $.55 \leq \kappa \leq 1.0$, so the closeness of agreement of the category system (surface structure) is satisfying up to very good (Wirtz & Caspar, 2002). The worst results of κ are the categories "contents of communication" and "portion of communication". The cause for these (only satisfying) results is that the rating is time-based and not event-based. As a result we will rate these categories by events (change of speaking) to increase the reliability. Also the closeness of agreement of the high-inferent ratings could be shown: all the inter-rater reliabilities are highly significant ($p \leq 0.001$).

Results of this study may offer practical instructions for experimental phases in chemistry education to improve the learning process of the students. Additionally, a capacious category system with high- and low-inference ratings can be used for self-evaluation or within a teacher training in chemistry education.

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KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

Identifying Student's Misconceptions About Indicators: A Study of Turkish University Students

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Keywords: Pre service chemistry teachers, indicators, misconceptions

In recent years, the studies in science education have focused on searching what kind of difficulties students meet while learning scientific concepts and what misconceptions they have (Novak, 1993; Zoller, 1990). Misconceptions are the conceptions constructed by students which are not scientifically accepted. There are several types of misconceptions. Conceptual misunderstandings develop when students are taught scientific information in a way that does not challenge them to confront paradoxes and conflicts resulting from their own preconceived notions and nonscientific beliefs. Vernacular misconceptions arise from the different usage of words in everyday life and in scientific contexts. Factual misconceptions are falsities often learned at an early age that remain unchallenged into adulthood. The printed material and textbooks can also be sources of misconceptions within or outside of the classroom (Nakipoğlu and Bülbül Tekin, 2006). Primary reasons of the misconceptions can be listed as student' insufficient background, insufficient motivation and interest, teacher's insufficient domain knowledge, and text books deficient statements (Chi, 1992).

There are some research focused on teaching acid-base subject. For example, Drechsler and Schmidt (2005) aimed to determine how text books and teachers handle the different models to explain acid-base reactions. Demircioğlu and his friends (2005) tried to explain the effects of newly developed teaching material on students' achievement and misconceptions in acid-base subject. In another study, Morgil and her friends (2005) compared the effects of traditional and computer-assisted teaching methods on students' understandings of acid-base subject. These studies have displayed that students' have difficulties while learning this subject. In the literature, few studies searched directly for indicators (Cesar et al., 2001; Kooser et al., 2001; Flowers, 1997). In our study, it has been focused on the indicators used in many fields for several reasons fields and the misconceptions determined related to the indicators have been discussed. The study was conducted with 158 university students who participated in general chemistry and analytic chemistry courses. Students were posed 6 questions related to indicator topic to determine their misconceptions related to the subject. Four of these questions were open-ended, one of them was yes- no choice question and one of them was of two choice question.

Students' misconceptions and knowledge deficiencies related to indicator topic were examined through their responces to the questions. When students are mentioned about indicators, they perceive directly acid-base indicators and although they know other indicators. They define all indicators as acid-base indicators. Because acid-base indicators are the most common indicator types in courses. This is a serious misconception. Since these students will be chemistry teachers in the future, these misconceptions should be determined and removed. So "indicators do not consist only acid-base indicators" should be emphasized by teachers in courses and in text books. The other determined result is that most of the students think that indicator reactions proceed with the same mechanism. The reason of this thought is that they perceive indicators as acid-base indicators. The other determination is that students think that events realized at the end point are physical. In this point there is a serious complexity. Because expressions such as "the end point is a point where physical changes are observed" and "indicators cause to changes in the end point" take part in some definitions. These expressions are right but the false is that the change in indicators is physical. Whereas observed event in the end point is a pysical change but realized event is chemical.

The study have displayed that students have serious misconceptions about indicator topic, they perceive indicators only as acid-base indicators and think titration event only as acid-base titration. The determination of student' misconceptions and knowledge deficiencies about indicator topic is so important since this provide that on which points should be focused while students are learning titration and indicator topics in analytic chemistry course. Before teaching the topic, the determination of students' possible misconceptions and knowledge deficiencies is important for teaching the topic without defect. There are several ways to identify misconceptions. First, a teacher should use a formative assessment to see where the student is, in terms of the concept being introduced. Another way to identify misconceptions is through brainstorming. The teacher can facilitate a discussion on a concept being introduced, creating a web of the students ideas. A third way to uncover misconceptions is to create a safe environment where students are free to discuss their ideas, and will not be ridiculed by others if the information they have constructed is not correct. While teaching titration topic, firstly general definition of indicators should be done and main lines of topic should be exhibited with a schema. It is emphasized that indicators are not used matters for only acid-base titrations. Titration types and indicators used in every titration types and the characteristics of these indicators should be explained in this schema. In that way general view of topic is provided. So it is explained to students that titrations do not consist of only acid-base titrations and indicators are not used for only acid-base titrations.

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Comparision Of Three Different Learning Methods In Environmental Education

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Environmental Education (EE) is a learning process that aims to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO, 1975, p.3). However, research have shown that students, from primary to undergraduate level, had limited environmental knowledge (Liarakou, Gavrilakis, & Flouri 2009; Pe'er, Goldman, & Yavetz 2007; Summers, Kruger, & Childs 2000; Tuncer, Ertepinar, Tekkaya, & Sungur 2005). This case has shown the necessity to use new instructional approaches to teach environmental knowledge. Therefore in this study, jigsaw cooperative learning and project based learning were used as alternative instructional approaches, and it was aimed to investigate the effects of them on university students' environmental knowledge attitudes towards environment in comparison with regular teacher-centred instruction.

To enhance the aim, pre- and post-testing control group design was used. Totally 133 university students from three classes, who were attending environmental education lesson, were participated in this study. Two classes were randomly selected as experimental (N_{E-1}=31 N_{E-2}= 52) and one of them as control groups (N=50). While environmental education lesson was accomplished via jigsaw cooperative learning in the experimental group-1 and project based learning in the experimental group-2, teacher-centred instruction was used in control group. It was aimed students in all groups to enhance the same learning objectives during one semester (four month) under the guidance of same instructor.

31 students in the experimental group-1 initially meet in their home groups, which were randomly stratified by the instructor, and then each member in the groups were assigned a portion of the subject of environmental issues to learn as an 'expert' (Slavin, 1991). The home groups then broke apart, like pieces of a jigsaw puzzle, and students moved into jigsaw groups, which consist of members from the other home groups who had been assigned the same portion of the material. During this jigsaw process, students studied on *water pollution, soil pollution, air pollution*, *radioactive pollution* and *environmental organisation.* Students then returned to their home groups, where they taught their subjects to the rest of their group. In the experimental group-2, project based learning was used (Barak & Dori 2005; Juhl, Yearsley & Silva 1997). 52 students randomly stratified in ten cooperative groups, and then they identified their projects about environmental issues related to *global warming, thinning ozone layer, recycling, plastic bags, radioactive pollution, heavy metals*, *solid waste*, *water pollution, chemical waste,* and *artificial fertilizer.* After each group completed their own project, they presented their studies by using some materials such as power point, models, posters etc. In the control group, 50 students were taught the same subjects according to regular teacher-centred approach.

To determine students' environmental knowledge, '*Environmental Knowledge Test'* (EKT) with 20 items, and to measure their attitudes towards environment, 4-point likert type '*Attitudes towards Environment Scale'* (AES) with 36 items were constructed by the researcher. For the validity, the EKT and AES were reviewed by 4 and 6 science educators respectively, and then piloted with participation of 159 university students to ensure the reliabilities. The reliability coefficient (KR-20) of the EKT was found to be 0.79, and Cronbach's alpha reliability coefficient of the AES was found to be 0.83. The assessment tools were applied on all the groups before and after the instructions. For the statistical analysis, one way ANOVA was used to compare the means of groups. ANOVA results indicated that there was no significance difference between mean scores of the students in each group with respect to students' prior environmental knowledge ($F_{(2-130)}$=1.49; p>0.05), and prior attitudes towards environment ($F_{(2-130)}$=0.44; p>0.05). In order to investigate the effects of instructions on students' environmental knowledge and attitudes towards environment, one way ANOVA was run after instruction. The results of EKT showed that there was a significant mean difference between scores of students ($F_{(2-130)}$=104,68; p<0.05). Scheffe test indicated that these differences were between all the groups (p<0.05). These results underlined that students trained by jigsaw cooperative learning instruction had significantly higher scores on EKT (M_{E-1}=17.64) than students in the project based learning classes (M_{E-2}=16.15), and both of these experimental group students' mean scores were significantly higher than teacher-centred instruction (M_C=10.18). The ANOVA results of AES also showed the significant differences between groups ($F_{(2-130)}$=57.46; p<0.05). According to the Scheffe test, it was found that experimental group students' attitudes towards environment significantly higher (M_{E-1}=106.26, M_{E-2}=100.08; p<0.05) than control group students' attitudes (M_C=77.44; p>0.05).

Based on the results, it can be concluded that jigsaw cooperative learning and project-based learning caused significantly better acquisition of the environmental knowledge and positively increasing of attitudes towards environment in comparison with teacher-centred instruction as mentioned by the other researchers (Dori & Tal 2000, Juhl, et al. 1997; Lord 1999).

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ITS Chemistry!

The development, implementation and evaluation of an intervention programme aimed at developing thinking skills and understanding in Chemistry

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Keywords: second level chemical education, chemical misconceptions, particulate nature of matter, the mole concept, cognitive development.

Introduction: It is well documented that Chemistry is among one of the most difficult and conceptually challenging subjects on the school curriculum. Many factors contribute to the complex nature of this subject and much work has been carried out in attempting to make the content of this subject more accessible for those studying it. Chemistry by its nature is abstract and requires formal operational thought. It is a subject that contains many higher order chemical and mathematical concepts. Thus anyone not having reached this level of cognitive development will have difficult with the study of Chemistry. One must wonder how many of our pupils have reached this stage of cognitive development. Chiappetta (1976) concluded after studying a number of investigations '*that most adolescents and young adults have not attained the formal operational stage of cognitive development*'. In Ireland, it has been found that approximately 17.7% of Leaving Certificate Chemistry pupils have reached the formal operational stage of cognitive development (Childs and Sheehan, 2009a). Another aspect that explains why pupils find particular topics in Chemistry difficult is the area of chemical misconceptions. The misconceptions pupils' possess about topics in Chemistry have a major effect on the learning and understanding of new information in Chemistry. Misconceptions held by the learner prevent further learning and understanding of many Chemistry topics. Ausubel (1978) stated that if he '*had to reduce all of educational psychology to just one principle, he would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly'*. Information stored in the long term memory, if incorrect, results in major difficulties for the Chemistry pupil in learning new material Misconceptions exist as a result of the manner in which the person learns. Many intervention programmes have been developed which have aimed to enhance pupils thinking skills. Over the past number of years the programmes which have attracted most attention and indeed have been successful in this aim are as follows: The Instrumental Enrichment Approach (I.E), Philosophy for Children (P4C), Cognitive Acceleration (CA) and the Infusion Approach. The Cognitive Acceleration through Science Education (CASE) programme is widely recognised and accredited with causing large cognitive development gains for participants. The materials of the CASE programme, aptly named *'Thinking Science',* introduced and developed formal operational thinking patterns over a period of two years with a large cohort of children in the UK. There are however a number of problems with running the '*Thinking Science'* lessons in the Irish classroom. First off '*Thinking Science'* activities are separate to the curriculum. Running the programme would take from the time allocated for the completion of an already over crowded Science/Chemistry syllabus. Secondly *'Thinking Science'* lessons require a class of 70 minutes every two weeks A 70 minute slot every two weeks in a school laboratory will be difficult for all schools to achieve.

Methodology. Working within the tight constrains of the Irish Chemistry syllabus the '*ITS Chemistry'* programme was developed. '*ITS* Chemistry' stands for Increasing Thinking Skills in Chemistry. It was heavily influence by the CASE philosophies but integrated these strategies and methodologies into the current Leaving Certificate Chemistry syllabus. The programme aimed to develop thinking skills, address misconceptions and alleviate difficulties pupils are having with a number of topics on the Chemistry syllabus. ITS Chemistry is an intervention programme aimed at increasing understanding in Chemistry through developing cognitive ability and addressing misconceptions. This intervention programme was developed for pupils who had just completed their Junior Certificate and who had chosen to study Chemistry for their Leaving Certificate examination. It is intended that this programme be implemented in the first 12 weeks of the pupils' study of Chemistry. Previous investigations (Childs and Sheehan, 2009b) have shown that the Mole and calculations involving the Mole are perceived as being difficult. The Particulate Nature of Matter was also identified as an aspect of Chemistry in which pupils possessed a large number of misconceptions. As a result the Mole and the Particulate Nature of Matter were selected as the content for this intervention programme. Lessons were developed using the CASE methodology. Each topic area was divided into sub-topics and lessons that included the five pillars of the CASE methodology were drawn up. The lessons also took account of common misconceptions in the Particulate Nature of Matter and the Mole concept. The teachers that agreed to take part in the implementation of this programme underwent training at the start of the school term. Training involved a look at the history of this project, and a look at the structure of the intervention programme and how it fits in with the established Leaving Certificate Chemistry syllabus. The philosophy and the methodology of the project were explained to teachers. These Chemistry teachers and one of the authors (MS) then implemented the ITS Chemistry programme. At the very beginning of this intervention programme the cognitive development of pupils was assessed using Science Reasoning Task Three. They then completed the 12 week programme and afterwards completed a post-test. The post-test took the form of another Science Reasoning Task and a misconceptions test and these scores were compared with the pre-test scores. Cognitive development and types and numbers of misconceptions were compared with a control group which did not participate in the intervention programme, but covered the same material in the tradition way. The teachers' views were collected through a teacher's diary and a short questionnaire at the end of the project. The research questions to be answered by this investigation are as follows:

1. Can cognitive acceleration be achieved through infusing a successful cognitive acceleration technique into the normal Irish Chemistry syllabus?
2. Can general Chemistry misconceptions be addressed at the very beginning of the Leaving Certificate Chemistry course and as a result alleviate difficulties pupils have with different Chemistry topics, in particular the Particulate Nature of Matter and the Mole?
3. Can the cognitive ability of 16 – 17 year old pupils be positively affected by altering the methodologies involved in the teaching of Chemistry?
4. Does this research-based teaching strategy increase peoples understanding of the Particulate Nature of Matter and the Mole?

Results and Conclusion. Results from this intervention programme are at an early stage of analysis. A full report on the results and findings of this investigation will be available for the conference.

Initial results indicate that both teachers and pupils have found this approach interesting and beneficial. Should this intervention programme prove successful in developing the thinking skills and Chemical understanding of Irish second level Chemistry pupils it has major implications for how the subject is taught in the future. It is hoped to disseminate the revised materials for wider use in Irish schools from 2010-2011 onwards.

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Basic quantum chemistry concepts on the Ausubel continuum of rote and meaningful learning: a concept-map analysis of a qualitative study with beginning chemistry college students

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Keywords: lower secondary chemistry; constructivist teaching and learning; meaningful learning; atoms and molecules

Background, framework and purpose. We report the procedure and results of the second part of a broader study on the ideas of second-year college chemistry students on basic quantum chemistry concepts (Schrödinger equation, atomic and molecular orbitals, the hydrogen atom versus many-electron atoms, hybridization). In the first part (Stefani & Tsaparlis, 2009), a qualitative research was developed, following the conventions of phenomenography (Marton, 1981; Marton. & Booth, 1997). Four categories, *A*, *B*, *C*, and *D* were identified, which cover all the shades of variation of the notion of model combined with level of explanations. The shades of variations that these phenomenographic categories revealed were judged to be compatible with Ausubel's continuum of rote and meaningful learning. Rote learning (categories A and B) is consistent with a concrete and nad've notion of models as exact replicas of scientific entities, as well as of low level explanations, that include verbal reproductions of terms or simple propositions of the subject matter and textbooks. Meaningful learning (categories C and D) is characterized by a notion of models as convenient scientific constructs for the purpose of the study of physical world, as well as of a high level of personal and idiosyncratic explanations.

In the second part of this research project, we constructed concept maps for each student, and consequently we implemented quantification of the maps (Pendley, Bretz, & Novak, 1994 Willson & Williams, 1994). Our aim was to check whether the quantification of the concept maps leads to similar results concerning the Ausubel continuum.

Methods. Nineteen second-year college chemistry students (ten female and nine male) from the Department of Chemistry of a Greek university (mean age ~19.5) were the subjects of the study**.** They had been exposed to instruction of the basics of quantum chemistry integrated in various subjects as general/inorganic and organic chemistry. Semi-structured individualized interviews where taken and the transcribed material of each interview was separated into topics or thematic units as follows: atomic orbitals (AOs) (definition, pictorial representation, types); the Schrödinger equation (equation classification/systems of application); the hydrogen atom versus the helium atom (exact solution versus zero-order approximation); the oxygen atom (zero-order approximation); molecular orbitals (MOs); hybrid orbitals.

Concept Map Construction and Quantification

The two authors independently generated concept maps from the transcripts. Inter-rater reliability was calculated by counting the number of similar nodes and links, and gave a value of 0.97.

Following the construction and validation of the concept maps, we identified the common elements as well as the elements of differentiation of knowledge constructs that were depicted in the maps. The method of Francisco l et al. (2002) was adopted. The following formula was used for calculating the total mark Q assigned to the concept map: $Q = x - y - 2z$, where: x = number of correct links; y = number of false links; z = number of misconceptions.

Results. From the results, it is concluded that the distribution in the Ausubel continuum means that a low total mark *Q* corresponds to low level phenomenographic category. The two methods end in compatible results, indicating that the two criteria stated initially (e.g. level of models and levels of explanations), along with those stated in the quantification of the concept maps, the number of correct links, which illustrates the wealth of the knowledge structure, as well as the number of misconceptions, and false links, which illustrates the distortion of the knowledge structure, may stand together as characteristics of the knowledge structures.

Conclusions and implications. The message deriving from our analysis is that students need to learn science by integrating concepts in their knowledge structure, making the correct links between them, and avoiding or reconstructing misconceptions. In the same way, students need to learn how to make high level personal explanations and how to use models the way scientists do and not as just replicas of reality.

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Homework assignments and motivation in chemistry education

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Keywords: homework, motivation, chemistry education

Homework behaviour and motivation. The almost proverbial battle over homework still seems a prominent battle fought by students, parents and teachers (Cooper, 2007). Students tend not to do their homework, probably considering homework a waste of time. Getting students to make an effort doing their homework may contribute to winning the homework battle in parts. As there is minor evidence for a correlation between time spent on assignments and achievement, homework effort apparently is a crucial factor for achievement (Schnyder, Niggli, Cathomas, Trautwein, & Lüdtke, 2006). Hence, there is reason to assume that aspects of homework motivation such as value and expectancy beliefs might have a positive effect on homework effort (Trautwein & Köller, 2003).

Most studies on homework are concerned with homework in general and less emphasis is put on domain-specific aspects and behaviour, albeit supposed to differ depending on the subject. Homework behaviour has not been subject to a study investigating domain-specific effects in chemistry education, yet. However, Trautwein and Lüdtke (2007) have conducted a study focussing on differences in homework effort with respect to different school subjects using scales deriving from a previously developed homework model (Trautwein, Lüdtke, Schnyder, & Niggli, 2006) indicating motivation to be affected by the learning environment.

The purpose of the study proposed is to investigate to what extent homework assignments in chemistry education embedded into different learning environments may positively influence students' motivation with regard to value beliefs and expectancy beliefs. Presumably, assignments perceived as being difficult have a negative effect on expectancy beliefs and probably value beliefs are influenced by the arrangement of the learning environments.

Method

Design

Consequently, a variety of homework assignments are created and the respective learning environment is manipulated by (1) a variation of context (domain specific, non-domain specific 1, non-domain specific 2), (2) the treatment of experiment (paper-pencil, hands-on), and (3) level of task demands (low, medium, high). The resulting assignments are rated by a sample of 500 tenth grade students. Every student has to evaluate a set of eighteen assignments differing in context, treatment of experiments and level of task demand.

(1) Each rating set contains assignments dealing with a problem to be solved embedded into two rather non-domain specific contexts and assignments regarding the problem to be solved from a domain-specific point of view. The contexts are generated by stories.

(2) To solve the hands-on-experiment assignments an experiment has to be carried out, while the paper-pencil variation contains a representation of probable observation. In both cases, the respective observations have to be interpreted and the results are to be evaluated taking the problem to be solved into account.

(3) The level of task demands is determined by the complexity of tasks.

Instruments

Students are asked to self-report on their attitudes towards homework by adopting the questionnaires developed and successfully used by Trautwein et al. (2006; 2007) in order to get an overall picture of students' attitudes towards homework with regard to different subjects (English, mathematics, physics and chemistry). Beforehand, most of the items have been adapted in order to assess the situation specific attitude towards homework. To score the respective items, a 4-point Likert-type scale is used ranging from total disagreement (1) to total agreement (4).

Results. A ranking of homework assignments is intended to be presented in a poster presentation along with sample assignments and consequences for further studies. On the whole, the results of the study are intended to permit to describe the qualities of assignments in chemistry education and thus a comparison to assignments in other domains.

Expected implications. Light is to be shed on the interdependencies of the qualities of assignments with homework motivation and the effects of perceived homework quality on the learning progress are to be validated. In due course, a categorisation of assignments with regard to features relevant for motivation should be possible.

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The "Sublimation" of Iodine – A Misconception

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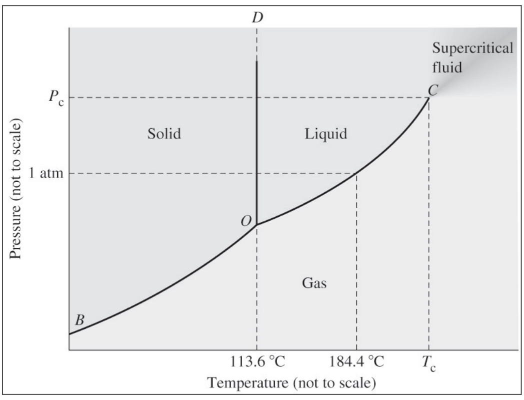
Keywords: misconception, iodine, sublimation, chemistry teaching

Misconceptions can be extremely persistent and hard to change, creating obstacles to correct further learning. Preconceptions, resulting from previous learning experience, play a significant role (both positive and negative) in the understanding and the quality of the concepts learned by the students. Many students (and, unfortunately, some teachers) believe that their concepts are correct because the proposed explanations, corresponding to their understanding of certain phenomena, make sense. Consequently, if students face new information that, unlike their alternative conceptions, does not fit their explanations, they may ignore it or reject it because it seems wrong to them. Thus, it is of great importance to identify, confront and correct different misconceptions students are having.

The most effective chemistry tool is an experiment or a demonstration. Using them it is possible, more or less easily, to test the correctness (or falseness) of the explanation of a phenomenon. Demonstrations/experiments are inextricable component of chemistry teaching, and, if properly preformed (better by students than by their teachers), lead to the development of an active and creative thinking.

Among the numerous examples of misconceptions, one of the widely spread ones is that about the sublimation of iodine. In many textbooks [1–4] and by many teachers it is claimed that iodine is a typical example of a substance that sublimates. Such statements are found in almost every textbook in Macedonia and therefore is carried over the students. The notable exception is the book written by one of the authors of the present communication and his collaborators [5].

In order to test the prevalence of this statement and to improve the formulation of the concept of sublimation, a poll was preformed on 280 high-school students from the first year. The results of the poll are presented and further discussed in the present communication. The arguments against the erroneous conception incorporate the design of a relatively simple experiment.



It is well-known that iodine produces fumes (iodine vapor) upon heating. Violet fumes can be noticed even at room temperature due to the high vapor pressure of the substance in question. However, it is possible to obtain liquid iodine at atmospheric pressure using appropriate apparatus and controlling the temperature just above the melting point of iodine (114 şC). Additional evidence in support of existence of liquid iodine at atmospheric pressure is obtained by the phase diagram (see above) of this substance [6] from which it can be clearly seen that iodine first **melts** and then **vaporizes** and that if the heating is carried out in a way as to avoid abrupt rise of the temperature, the **sublimation** does not take place.

The authors hope that they will be able to ameliorate the situation in Macedonia and that the present communication may play a positive role even in regions outside Macedonia.

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Molecules Are Not Substances, Substances Are Not Molecules

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Keywords: substance, molecule, misconception, chemistry teaching

The **substance** and **molecule** concepts are (or should be) clearly defined. Whereas the definition of a *molecule* is found in [1], a definition for *substance* is missing but it could be deduced from the definitions of related terms (such as *substance content*, *substance flow rate* or *substance fraction*). In [1] a molecule is defined as "an electrically neutral entity consisting of more than one atom ($n > 1$)" and, consequently, one is dealing with an **entity** that can not posses any *macroscopic property*. The molecules do **not** have colour, do not have a refractive index, do **not** have a substance fraction, do **not** …. On the other hand, all these (and many, many more) properties could be attributed to *substances* – collections of almost **unimaginably many** entities.

These simple concepts are easy to grasp and it would be expected that they are, both mentally and in writing, clearly distinguished.

Alas, such is *not* the case. In many (too many!) texts – textbooks, scientific articles and others – statements such as "nitric oxide is a signaling molecule…" (e.g. [2]), "copper(II) sulfate crystallizes with five water molecules", "butadiene with one bromine molecule gives…" etc. are very often encountered. It is, of course, assumed that the authors of such statements are well aware that the mentioned substances (nitric oxide, copper sulfate, butadiene and so on) are neither molecules nor can they react with one or two or three molecules to give a product that is again a substance composed of a practically unimaginable number of entities (molecules, ions). The authors *are* probably aware but this is not that certain for the students or the general readers.

Thus, the implicit notion that substances *are* molecules gives rise to a wide-spread (and widely spreading) misconception. While translating into Macedonian a famous university textbook on physical chemistry [3], two of the present authors had a very hard time to both keep the translation faithful to the original and point out to the future readers the falseness of such statements in the work of extremely renowned authors and the extremely renowned publisher.

To check whether even professors are or are not immune to unconsciously assuming the correctness of the misconception in question, an impromptu and absolutely unofficial test was made with a dozen of professors who were asked "with how many molecules the anhydrous copper(II) sulfate gives blue vitriol?". Note that both "anhydrous copper(II) sulfate" and "blue vitriol" are *substances* and are not even composed of molecules (with the exception of the water molecules in the structure of $CuSO_4{\cdot}5H_2O$).

With a single exception, the answers were of the type "of course, with five molecules"!

If such was the case with the chemistry professors, one can only imagine what a pervert conception the high-school or university students are apt to have. It is, thus, the firm belief of the present authors that utmost care should be taken to specify not the name of the substance but its *quantity* (on a molecular or a macroscopic level) and if a reaction is meant, then given should be the values of the stoichiometric coefficients in the reaction equation such as it is written. The stoichiometric coefficients are, of course, equal to the transformed quantities of reactants and/or products for a unit change of the extent of the given reaction (the coefficients for the reactants in the reaction equation being taken as negative).

While the suggestion about the unquestionable need to distinguish molecules from substances and vice versa should have a general applicability, it is absolutely essential that it should particularly apply to chemistry teachers and textbook authors.

A study is under way in which the principal author of this communication is testing high-school students whether they are able to recognize (in a multiple-choice test) the statements of the above-mentioned type as misconceptions. It is feared that the results will not be very encouraging.

Even less probable seems to be the situation in which in no textbook or scholarly article, one or two molecules would “react” with a substance, or molecules would “posses” macroscopic properties. It is the faint believe of the authors that the present communication would ameliorate the general (in many cases, rather deplorable) practice concerning the unconsciously assumed “equivalence” of molecules and substances.

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KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

Development of Interests in Science – a Longitudinal Study with Primary School Children

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Keywords: interest in science, science in out-of-school-courses, science education in primary schools

Background, framework, purpose. The importance of the natural sciences for general education is undisputed (OECD 1999). The German curricula for day nurseries and for science lessons in grades 5 and 6 both already include the foundations needed for later scientific education in view of scientific literacy. However, it seems that "basic scientific education in primary schools … is still difficult territory for some" (Marquardt-Mau, 2001, p. 85).

Hence we decided in 2004 to develop an extracurricular educational programme called "KieWi & Co.- Kinder entdecken Wissenschaft" (Children discover Science) with the aim of arousing and furthering children's interests in science and to improve their scientific competence in view of current scientific literacy. By developing, testing and evaluating educational programmes as part of the KieWi & Co. courses, we try to provide suggestions and recommendations for science education in primary schools.

The theoretical basis of our course design is the pedagogical interest theory and the Self determination theorie of motivation. According to the interest theory, interest-triggered actions are self-intentional actions, which can take the form of short-term "interest" for a particular object (situational interest) or a long-term preoccupation with something (individual interest); leading to a relatively strong personality trait (Renninger 1998). Furthermore, because selecting areas of interest is a result of value judgments, the former become meaningful for the self-concept of a person (Hannover 1998). To induce long-term interest-led actions from children, educational environments should be designed as follows: If it is possible to give the learner the opportunity to satisfy his inherent psychological need for relatedness, autonomy and competence then interest-triggered actions become more likely (Ryan & Deci 2000).

Methods. The intention of increasing children´s interests in science alone rendered one-day or other short term projects impossible because both the development of competencies and of areas of interest to form relatively stable personality traits requires active and repeated efforts on the part of the learner.

In this way the participating 8 to 12 year olds take part in weekly courses which follow a systematic pattern and are designed for the long-term. In a period of up to two years they get to know the scientific basics and ways of working by investigating age-appropriate problems in small groups. (Some of our course modules can be found at http://www.parsel.eu.)

A longitudinal study (including a control group) was the only way to find out how strong and how lasting the resulting effects are. Therefore 114 children in eight different KieWi-groups fill out a questionnaire at the beginning of the KieWi course (t0), after each half year of participating in the course (t1…t4) and half a year later (t5; follow up) and 268 children from different schools (control group) were asked too. Variables in this questionnaire according to the theoretical background are: self-concept (5 Items), motivational learning climate (12 items), attitudes (11 items), interests in contents (10 items) and methods (11 items).

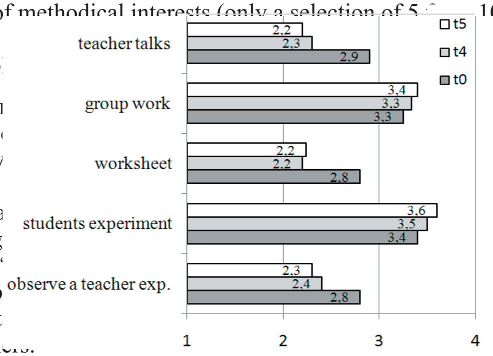
Results. As could be expected, the children who participate in our course regard their ability to successfully work with scientific data positively. After two years (t4) of participation, an

significant increase of the children's confidence can be observed (self-concept [scale of 5 items, Cronbach´s α=.76] t0 M=3,3; t1 M=3,2; t2 M=3,3; t3 M=3,3; t4 M=3,4; t5 M=3,5).

When asked for their methodical preferences in science education, distinct changes in the KieWi children's preference could be observed (Fig. 1).

Activities that allow for more self-determination (working in groups, experimenting independently) are preferred. Activities such as watching the teacher experiment or answering small questions were disliked.

Fig. 1: Changes of methodical interests (only a selection of 5 ... 10 items are shown) from beginning (t0) ... (t5). How do you like the fo... very good (4)



Conclusions a... o positively influence the scientific interests ... in dealing with scientific data in specific way... The other children (control group) in primary ... the natural sciences and science education a... pabilities. On the basis of the positive finding... st course sequences of the KieWi courses in "... in what way the concept of the KieWi & Co... ools. To find an answer to this question we st... nd established a monthly workshop for teachers.

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Evaluation of the "Application of Chemistry Content Knowledge" in the Framework of the German National Educational Standards

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Background. The German National Educational Standards as a consequence of the poor PISA results of German students describe four areas of competence for the scientific subjects *biology, chemistry* and *physics*, which are *content knowledge*, *acquirement of knowledge*, *communication* and *evaluation & judgement*. This paper focuses on *content knowledge*, especially in chemistry. During the process of test development the area was renamed as "*application of content knowledge*", as the chemistry content taught at different schools from different types of school located in 16 different federal states is totally heterogeneous caused by nearly 50 different curricula.

Tests for all areas of competence are currently being developed and proved in the German project ESNaS (Evaluation der Standards in den Naturwissenschaften für die Sekundarstufe I – Evaluation of the National Educational Standards for Natural Sciences at the Lower Secondary Level) by teachers and researchers (Kauertz et al. submitted). The items will be used in a nationwide pilot study in 2009/10 and in a nationwide assessment in 2012.

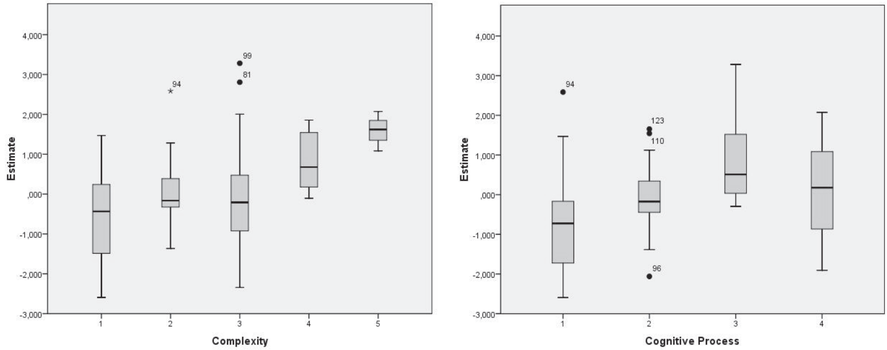
Following the standards the area of competence application of content knowledge is subdivided into four subareas, called basic concepts, which are matter-particle-relations, structure-property-relations, chemical reaction, energetic considerations regarding chemical transformations. As energetic aspects are important for all other three basic concepts and as the test items might hardly be differentiated especially from those concerning the basic concept chemical reaction it is not tried to separate them from the others. So test items are developed with regard to the first three basic concepts.

Methods. Competence models (Schecker & Parchmann, 2007) are used to guide the development of test items for large scale assessments in order to vary the item difficulty in a controlled manner. These models use several dimensions of which one dimension usually describes the content of the tasks. In this project a model of competence is adopted, which originally was developed to describe physics content knowledge (Kauertz & Fischer, 2006). So the dimension *application of chemistry knowledge* is combined with two further dimensions expected to influence item difficulty which are called *cognitive processes* needed to answer the item and *complexity of the task*. The cognitive processes with increasing demands are reproduction, selection, organisation and integration, the complexity increases in the way one fact, two facts, one relation, two relations and a basic concept. As a consequence, a two-dimensional matrix could be described (Walpuski et al., 2009).

150 items were developed by teachers according to this model of competence. Then the items were evaluated by at least two science educators and one psychometrical expert and proposals for improvement were made. On these suggestions the items were revised. The layout was harmonized and finally one linguistic expert controlled the items. In the pilot-study the items are distributed in a multi-matrix design and Rasch analysis will be used for evaluation.

Results. During these days the pilot study is running, therefore results cannot be presented in this paper but will be presented at the conference. Nevertheless there are preliminary data from a pre-pilot study which show that there is influence of the two dimensions, *complexity and cognitive processes* on item difficulty (figures 1a and b).

Fig. 1a and b: Item difficulty depending on complexity (a) and cognitive processes (b)



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Mapping Students' Thinking Patterns In Learning Organic Chemistry

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Keywords: organic chemistry, organizing themes, knowledge structure, structure-reactivity

Background, framework and purpose. What would we expect students to know after their one year university level organic chemistry studies? Most organic chemistry textbooks introduce their material as being constructed on the structure-reactivity principle. Demonstrations using structure-reactivity relationships have also been devised (for example, Newsome (2003)). If so, then structure-reactivity relationships should also be reflected in examination results, which in turn should lead to a development of conceptual understanding or a logic structure. The structure-reactivity principle would be a powerful tool for the students to "take with them from the course". Another principle, that runs through the material is that of molecular motion, which makes it possible to predict phase changes, kinetics and equilibria. This is the object of our current study.

Students' thinking patterns or their cognitive organization of the material has been established using the *knowledge space theory* (KST) developed by mathematical psychologists, principally Falmagne and Doignon (1999) and applied as an internet-based teaching/ learning tool in mathematics and general chemistry (ALEKS). An overview of its application in chemistry is given by Taagepera and Arasasingham (2010). It has been shown that effective comprehension and thinking require a coherent understanding of the organizing principle (Bransford, Brown, Cocking (1999)). This also assumes that the student is able to make connections between factual knowledge and the organizing principle. The students' ability to make connections has been assessed with concept mapping and contrasted with unconnected factual information using algorithmic approaches by Francisco, Nakleh, Nurrenbern, Miller (2002) and others. Helping students make connections has been emphasized by Wieman (2006) as an important part of making science education more scientific.

We have looked at how the structure-reactivity organizing principle is reflected in our students' thinking patterns by looking at correlations of electron density distribution patterns and our students' ability to predict physical as well as chemical properties (Taagepera and Noori, 2000). From electron density distributions, students should be able to predict the bond polarities and the expected intermolecular forces, which in turn lead to predictions of specific physical properties. For instance, if a student makes a prediction of physical properties which contradicts the electron density analysis, then that student most likely does not have a fundamental understanding of the necessary underlying principles. Another study probed the students' understanding of stereochemistry as part of the structure-reactivity approach (Taagepera, Arasasingham, King, Potter, Martorell, Ford, Wu, Kearney, 2010).

Methods. Our studies were done in organic chemistry lecture classes (~300 students) over the past 10 years in a large U.S. university. The students were mostly biology majors who generally do not go on to take any further courses in organic chemistry. Students were usually tested before (pretest) and after (posttest) studying the material to see whether they could construct their own knowledge, based on basic principles. We used a simple analysis of percentage of correct responses on pre- and posttests as well as establishing the connectivity of these responses by using KST. Each student was placed into a *response state* based on the questions which were answered correctly. The response states were gathered and optimized to define the students' *knowledge structure* and their *critical learning pathway*, which reflect the cognitive organization of students' knowledge. Misconceptions were also documented.

The tests were constructed so as to connect back to the basic principles. They were given either separately or as a part of an examination. The tests were mostly open ended, often asking students to also explain or justify their answers.

Results. Although the percent of correct answers increased from pre- to posttests, the logic structure did not develop initially for any of the three overarching themes: electron distribution, stereochemistry or molecular motion. In the electron distribution study, the teaching approach was modified as a result of these studies. After every lecture was begun with: "Where are the electrons?", some improvement was noted in the knowledge structure (Taagepera et al., 2000)

The organizing principle for stereochemistry was taken to be a plane of symmetry, which is introduced in most organic chemistry textbooks. However, the students have a difficult time determining planes of symmetry of even simple molecules, since the overarching theme of symmetry is not developed systematically in the textbooks nor do they have previous experience with looking for planes of symmetry. Molecular motion is a complex issue, which has required the definition of a number of knowledge structures. Several preliminary results are available: (1) if students cannot visualize the underlying molecular level, they will have trouble justifying their answers of macroscopic phenomena, such as sublimation and equilibria; and (2) vapor pressure is a difficult concept for the students. It is usually not incorporated into the analysis of intermolecular forces and phase changes.

Conclusion and implications. The logic structures in organic chemistry are not transparent enough for most students to develop conceptual understanding in the one-year organic chemistry course. Without a logic structure the students will have a difficult time applying their knowledge, extending their thinking or remembering the material because they have never fundamentally understood "why things are the way they are". Our teaching has changed as a result of these studies. We do not presume what students know before we start teaching, we give a pretest; we keep pointing out the connections between new material and the basic principles or overarching themes.

It is hard to escape the conclusion that some rethinking needs to be done as to what students really need to know after one year of organic chemistry. More time needs to be freed up for making the connections between overarching themes implying that we need to make decisions on what content to leave out. KST serves as a useful tool here, since isolated factual information which is not related to the overarching theme could be left out.

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correlations, molecular motion

How students use their knowledge on collision theory to design, perform and explain experiments about the rate of reaction in an inquiry based task.

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Keywords: Inquiry guided tasks, design of experiments, chemistry laboratory, secondary school

Background and framework. To improve the scientific literacy (PISA, 2006), learners must have opportunities to practice selected skills. Laboratory activities, if their design is accurate, can be a useful tool for this purpose. Mastering Procedures as designing experiments and controlling variables are essential in the scientific research and so, as part of the scientific literacy.

The benefits of using inquiry centred tasks in secondary school chemistry as a way to improve significant learning have been widely demonstrated (Hofstein & Lunetta, 1982, 2004), particularly with the use of sensors and MBL technology (Tortosa, Pintó & Saez 2008). More concretely it is stated that when properly developed, inquiry-centered laboratories have the potential to enhance students' meaningful learning (Minster & Krauss, 2005). Although many researches have been conducted on chemistry inquiry guided tasks (Aksela, 2005), we found not so much research studies analyzing how secondary school students perform when designing chemistry experiments.

Purpose. We understand that learning of a concept has occurred if there is the possibility to apply the knowledge to new situations. The objective of our work is to evaluate to which extent secondary school students are able to apply the collision theory to a concrete context in order to design and to perform an experiment.

Methods. The research was conducted with 43 chemistry students (16-17 years) belonging to three secondary schools in Catalonia (Spain) attending a four hour chemistry workshop in an inquiry-guided learning-cycle, at the university.

Students had to solve a contextualized problem in which the understanding of the chemical concept "*rate or reaction*" was crucial to solve the task. The workshop was designed as a leaning cycle, starting with activities to make explicit students' previous ideas. Students from different schools had been differently taught about collision theory. Pupils were asked to design and to perform an experiment in order to increase the rate of carbon dioxide production obtained by the reaction of calcium carbonate and hydrochloric acid. The first author of this paper was the teacher that monitor the session where students, working in small groups, receive support.

More specifically pupils were guided with the following questions:

- Which factor do you choose to investigate its effect on the rate of reaction?
- Design the experiment you would perform to test your ideas, and explain it briefly.
- Which are other variables that can affect the rate of reaction?
- What will you do to avoid the influence of them in your experiment?

Results. We have collected and analyzed students' explanations in their worksheets. We found (Table 1):

School		A n = 23	B n = 11	C n=9	Total (n =43)
Variable chosen	Temperature	4	5	3	12
	Concentration	6	2	4	12
	Surface contact	13	4	2	19
Mention other correct variables		23	11	9	43
Mention incorrect variable (pressure)		20	0	3	23
Correct explanation of control of variables		19	8	4	31
Incorrect explanation of control of variables		3	0	3	6
No explanation of control of variables		1	3	2	6

Table 1. Variables chosen and control of variables performed by students of each school

a) Students choose rightly the variables to test if they influence in the increase of the rate of reaction: the increase of temperature, the increase of concentration of hydrochloric acid and the increase of surface of contact (calcium carbonate in smaller pieces)

b) The frequency in the selection of each variable is similar in each group

c) All students were able to mention other variables that could affect their experiment

d) More than half of students considered wrongly that changes in pressure would affect the rate of the reaction studied.

e) Approximately half of the students' explanations relate correctly the control of variables to the collision theory. The other half of students do not.

Conclusions and implications. Students were able identify correctly the main factors that affect the rate of reaction. However, half of them mention the pressure as a variable that we know does not affect the number of effective collisions in the studied reaction. We interpret this fact saying that students could apply the collision theory in general terms but they have a weakness in their relating macroscopic and microscopic properties of matter.

The lack of explanation about the variables chosen for half of the students tell us the partial understanding collision theory, the lack of confidence on their knowledge or the difficulty to express the role of each variable in the rate of the reaction.

We interpret our results as a basis for next works on this topic.

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Using word association method to study students' knowledge structure related to air pollution

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Background, framework and purpose. Word association test is one of the various techniques (*eg* concept mapping, knowledge space theory, concept profile analysis *etc*) used to gain insights into students' knowledge structure (White & Gunstone, 1992). In the word association test usually students were asked to write down within limited time as many response words as they could think of in association with each stimulus (primer or starter) word. Based on the idea that the associated words obtained from different stimulus words form a string, researchers (or teachers) may calculate the relatedness coefficient between the stimulus words and – in case of examining group of students – the frequency coefficient between the response words and the stimulus words. With these coefficients one may draw a graph about the stimulus and response words (concepts) modelling students' cognitive structure as a map of concepts. Word association tests have been used for a variety of purposes in chemical education studies, too (*eg* Chachapuz & Maskill, 1987; Gussarsky & Grodetsky, 1988; Cardellini & Bahar, 2000; Cardellini, 2008; Nakiboglu, 2008).

In this survey we used word association test to study Hungarian students' knowledge structure related to air pollution. We were mostly interested in using word association test for exploring students' typical misconceptions in this area.

Methods. In our test students (40 7th graders and 40 8th graders from a primary school; 29 9th graders and 28 10th graders from a secondary grammar school) were asked to write down within one minute as many response words as they could think of in association with seven stimulus words related to air pollution. These stimulus words were: acid rain, carbon dioxide, sulphur dioxide, nitrogen oxides, ozone, ozone hole, greenhouse effect. They were written on different pages of a booklet. Students had one minute to write down their association words under these stimulus words in a column, and after one minute they had to turn a page to the next stimulus word. Using the procedure reported by Cardellini (2008), we calculated the index of the overlaps between the stimulus words, the relatedness coefficient according to Garskof & Houston (1963). We drew the cognitive maps for the different students' groups at different cut-off points for the relatedness coefficients (between the stimulus words) and the frequency coefficients (between the stimulus and response words).

Results and conclusions. The interconnection network of the stimulus words at cut-off point of 0.1 shows very strong connection between 'ozone' and 'ozone hole' in grades 7-10. However the connection between 'carbon dioxide' and 'greenhouse effect' appears only from 9th grade, while the connection between 'nitrogen oxides' and 'acid rain', and the concepts 'sulphur dioxide' and 'acid rain' appears from 8th and 9th grades, respectively. It is noted that there was a relatively strong connection between 'ozone hole' and 'greenhouse effect' in the map of 9th graders.

The interconnection networks between the stimulus and response words show that the students' knowledge structures are becoming more and more organized by increasing chemical instructions.

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Acknowledgment

This work was supported by the Hungarian Scientific Research Fund (OTKA T-049379).

Students' knowledge structure in chemistry (Applications of knowledge space theory)

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Keywords: knowledge structure, knowledge space theory

Background, framework and purpose. In studying and modelling the cognitive organisation of knowledge we often use graphs and networks. Concept maps can be used for exploring the knowledge structure of individuals. Word association test is a technique used to gain insights into knowledge structure of both individuals and a group of students. Knowledge space theory as a multidimensional model can be applied for studying the cognitive organisation of knowledge characteristic of a group of students.

Knowledge space theory (KST) was developed by Doignon & Falmagne (1999) in the last couple of decades. Basic concepts of this theory are: knowledge space, knowledge state, knowledge structure, surmise relation and critical learning pathway. *Knowledge space* defines the knowledge needed to understand a certain subject. In math or science this is defined by a set of problems, which a student needs to be able to solve. Problems involve a hierarchical ordering. According to the *surmise relation* if a student is capable of solving a given problem at higher level of the hierarchy, we can surmise that – in ideal conditions – this student can also solve other problems, which are at lower level of the hierarchy. In real situations the disturbing effect of the lucky-guess and the careless-error has to be taken into consideration. Each student is defined by a *knowledge state*, which is the summation of the problems, which the student has solved correctly. A representation of knowledge states for any group of students is called *knowledge structure*. The knowledge structure has to be well graded (*eg* each knowledge state must have a predecessor state and a successor state except of the null state [0] and the final state with correct answers to all questions [Q]). There are several pathways through the knowledge structure between the null state [0] and the final state [Q]. The most common pathway is called *critical learning pathway*, which is the most probably order in learning concepts.

The application of KST to chemical concepts have previously demonstrated by Taagepera *et al* (1997, 2000, 2002), Arasasingham *et al* (2004, 2005), Tóth *et al* (2006, 2007a, 2007b, 2007c, 2007d, 2008, 2009a, 2009b), and Vaarik *et al* (2008).

In this paper we summarise our research on using KST for mapping knowledge structure characteristic of a group of students focusing on the questions: How can we (1) find the most probable hierarchical connectivity of concepts; (2) determine the critical concept (the concept that most of the students are ready to learn); and (3) extend the formalism of KST to any hierarchically organised input data?

Methods. For KST analysis responses have to be scored in a binary fashion (right = 1; wrong = 0). Theoretically we can have 2^n possible response states (where n: the number of the items), from the null state [0] where none of the problems were answered correctly to the final state [Q] where all the problems were solved. A set of response states gives the response structure. Starting from this response structure, one can recognise a subset of response states (so called knowledge structure) fitted to the original response structure at least at the $p = 0.05$ level of significance. Based on the knowledge structure we can determine the most probable hierarchy of the items (represented by the so-called Hasse diagram) by a systematic trial-and-error process to minimise the χ^2 values. For the calculations, a Visual Basic computer program (Potter, n.d.) was used. Details of the KST analysis were published earlier (Tóth, 2007c).

Results and conclusions

(1) Based on the probable hierarchies of the items (Hasse diagrams) we showed that (i) rote learning gave separated and non-mobilizable knowledge (Tóth, 2007c); and (ii) students typically used problem-solving strategies as algorithms instead of the conceptual understanding (Tóth & Sebestyén, 2009b).

(2) Comparing the actual respond structure with the hypothetical knowledge structure derived from the expert hierarchy of the items we could determine the critical concept that most of the students are ready to learn (Tóth et al, 2007b, 2007c). Identification of critical concept gives possibility to optimise the teaching process.

(3) We successfully combined KST with phenomenography (Marton, 1981) to study students' thinking patterns in describing an atom and an ion (Tóth et al, 2007a, 2007d). Results showed a typical shape of the process of conceptual change. The initial model for representation of students' knowledge structure is a simple one but during the instruction this model becomes more complex and finally crystallises the new model.

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Acknowledgment

This work was supported by the Hungarian Scientific Research Fund (OTKA T-049379).

The Development Of Chemistry Teachers' Competencies Related To Planning Of Teaching/Learning Process

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Keywords: chemistry teachers' competencies, the planning of teaching/learning process

Introduction. Efficient teaching means that the majority of students construct knowledge and develop skills, defined by a curriculum aims and outcomes, during the planned period. Good planning increases the efficiency of the teaching/learning process. When making a plan it is essential that the teacher has a clear idea of what he/she wants to achieve, that he/she provides adequate contents, and carefully selects the adequate methods of work. In recent decades constructivist classroom teaching practices are recommended in many of the national science education reforms (Haney & McArthur, 2001).

The important set of teachers' competencies is associated with planning of teaching and learning process. These competencies reflect four stages of successful planning: (a) pre-conditions, (b) writing plann, (c) implementing plan in the classroom, and (d) revising plan for future use (Davis & Zaret, 1984). High quality planning is crucial for high quality teaching and higher student learning outcomes (Vogt & Rogalla, 2009).

In the planning phase, it is necessary to determine the modes of monitoring the learning process. This means that, for all planned tasks and activities, the teacher must have in mind what should be taken as the indicators of learning (Trivić & Tomašević, 2008). It is also necessary that the teacher plans ahead how he/she will check whether the desired learning results are achieved by the students.

Our work with teachers in various in-service training courses revealed the fact that, most commonly, no consideration of the relations between the goals, students' activities, activity indicators, learning outcomes, attainment indicators and evaluation of the results precedes their creation of the teaching process.

This paper offers the tasks and activities for pre-service chemistry teachers' education, which might help future chemistry teachers to develop competencies related to planning teaching/learning situations and to estimate, in the planning phase, whether a teaching situation will enable their students to construct necessary knowledge and skills. It is not our aim to reduce the space for the teacher's creativity, but to provide him/her with a way to assess the quality and efficiency of his/her own lesson plan. The suggested tasks and activities are aimed at helping the teacher when he/she has to decide how to organize a lesson, for the same goals can be achieved in various ways, with different students' activities. The teaching methods that involve students in an active way in the learning process increase their positive attitude towards science (Zarotiadou & Tsaparlis, 2000). Different methods of learning require different amounts of time for knowledge construction, and often, different resources (e.g. substance quantities, lab equipment, etc).

Description of the practice. Our approach to assessing the efficiency of a plan and the realization of a lesson is based on the following principles:

- Each student should constructs those basic skills and knowledge of chemistry which will enable him/her:
  - to understand the properties of the substances with which he/she is in contact in real environment in order to be able to handle them properly,
  - to understand nature from the aspect of substances that build it, as well as to become aware of the effects of various substances on the environment and the need for its protection,

- to understand information obtainable from popular scientific literature and other widely available sources, as well as to be able to discuss such information successfully with others.

- Learning chemistry is an active process in which the student should be able to construe new knowledge and skills on the basis of his/her existing knowledge and experience.
- The selected contents and learning methods should reflect the specificities and identity of chemistry as science (specific terminology, nature of factual knowledge, concepts and theoretic models, as well as typical methodology).

The procedure for assessing the efficiency of a plan includes the following steps:
1. determining a list of teaching/learning aims,
2. considering the teaching/learning situations and activities which should lead to reaching the aims, i.e. the outcomes,
3. considering the conditions necessary for the realization of the teaching tasks according to the defined aims (necessary equipment, adequate space, needed time),
4. considering indicators of learning (students' behaviour),
5. considering attainment indicators and the modes for the evaluation of the students'

Conclusion and implications. The suggested procedure for assessing the efficiency of a plan for the realization of the teaching/learning process can both guide the teacher during planning and realization and help him/her to make connections between goals, activities and the conditions that ensure qualitative teaching/learning attainments.

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A model of understanding scientific concepts with applications to the teaching and learning of chemical concepts

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Keywords: model of understanding, functional and structural analysis, secondary school, chemical education, content analysis

At the dawn of the XXIth century, it becomes essential that the young people undergo a scientific basic training, either with a view to participate in a society more and more dominated by sciences and technologies or to follow studies in a scientific or technical domain. And yet as principal responsible for the acquisition of a scientific basic training, the high school attains these purposes only partly since several young people leave the school without getting their high school diploma and others choose not to follow study in scientific or technical domains (Kovacs, 1998). In this respect, difficulties that encounter the pupils in the learning of sciences seem associated with deficiencies in their understanding of basic concepts which continue even after completing several courses in these domains (Kjćrnsli, Angell and Dregs, 2002). To discover the reasons of the deficiencies of the pupils in the understanding of concepts in sciences, we studied what reveal different researches on their difficulties in various scientific activities: acquisition of concepts, resolution of problems, practical work in the science laboratory and reflection on the nature of science (Perkins and Simons, 1988). Even if these research currents shed some light on the various ways students learn science, the diversity of these points of view have favoured the multiplication of directives and of results, often contradictory, applied to science education (Brown et Hammer, 2008).

To solve the paradoxes linked with these contradictions, it is necessary to overcome the opposition between science education approaches in order to show the possibility of their coexistence, even their complementary aspects. In this respect, the research on understanding of scientific concepts can only benefit from an integration of methods and results coming from these various perspectives (Appleton, 1997; Zimmerman, 2000). As a result, the objective of this theoretical research is to work out a diagram of the understanding of scientific concepts which accomplishes such integration. To take into account the complex character of the phenomenon of understanding scientific concepts, we adopted a systemic approach where variables are interconnected in the form of an organized whole, represented by a diagram (Luffiego, Batista, Ramos, and Soto, 1994; Brown & Hammer, 2008). To work out the diagram of the understanding of science concepts, we made the analysis and synthesis, in an iterative way, of the literature in this domain (Mucchielli, 2006; Trudel, 2005). The main steps of this approach are: 1) the identification of the texts to be analyzed concerning the understanding of concepts in sciences; 2) the segmentation of the texts in units of analysis; 3) the location and coding of units of analysis; 3) the structuring of results in a diagram of scientific conceptual understanding; 5) the validation of this diagram. The validation of the resulting diagram is based on the clarification of paradoxes identified in the texts following these principles (Simons, 1999): 1) to search dimensions or progresses in variables rather than dichotomies; 2) to consider oppositions under a new perspective allowing to view them as complementary aspects; 3) in the case of a dilemma (i.e. a choice between opposed views), to consider how one choice can reinforce the other one; 4) to construct a scaffold allowing to replace one of the terms of an opposition with the other one; 5) to determine the conditions under which a given variable was studied.

Based on the results of this analysis and synthesis, the model of understanding of scientific concepts, is constituted by the main dimensions of understanding and their reciprocal relations (Trudel, Parent and Météoui, in press). In this respect, our model of understanding accomplishes the integration of the different aspects of understanding of scientific concepts with the aid of two conceptual tools:

- A conceptual network of understanding, of structural nature, which shows the different paths of learning when the pupil progresses in his understanding.
- A schema of the approach to understanding, of functional nature, which describes the organization of the different factors that influence understanding.

Concerning the impact the model could have in the teaching and learning of chemistry in the secondary school, the use of the model of understanding of concepts in sciences would allow the teacher to anticipate the various paths taken by his pupils in their progress toward the understanding of chemical concepts, to anticipate their difficulties, and to conceive educational strategies adapted to their level of understanding. We will illustrate the use of our model to enhance pupils' understanding of chemical reactions. We conclude by specifying the limits of our research and we draw perspectives for new researches in education and learning of chemical concepts.

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An introductory chemistry course for lower-secondary school (grade 7th or 8th) – Teaching the concept of molecule using constructivist and meaningful-learning methodology

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Keywords: lower secondary chemistry; constructivist teaching and learning; meaningful learning; atoms and molecules

Background, framework and purpose. The science education literature shows that students encounter difficulties when attempting to understand chemical concepts such as that of molecule, and thus make the connection between the macro and the submicro levels of chemistry (see, for example, Piaget & Inhelder, 1974; Dow, Auld & Wilson, 1978; Novick & Nussbaum, 1978, 1981; Brook, Briggs, & Driver, 1984, Tsaparlis, 1997; Bunce & Gabel, 2002).

Here we report on the use of a new textbook written in Greek for an introductory lower-secondary chemistry course (for the seventh or the eighth grade) that aims at the application of the theory and practice of science education, and in particular the encouragement of constructivist-active learning and of conceptual/meaningful learning. The book is made of eight units that contain twenty-four lessons. The six units are: matter and soil, water; chemical reactions, air, molecules, atoms. Note the delayed introduction of the concepts of atom and molecule (see also Georgiadou & Tsaparlis, 2000; Johnstone, 2000; Toomet, DePierro, and Garafalo, 2001). The textbook has been subjected to a preliminary evaluation by four experienced Greek science teachers (submitted for publication).

The purpose of this paper is to report on the experimental teaching to 8th-grade Greek students of the three lessons on the concept of molecule.

Methods. Four public lower secondary Greek schools participated in the study. One of the schools (School 1) was ‘experimental’, attracting higher ability students. In each school an experienced science teacher taught the lessons. Three teachers had a chemistry degree, and one teacher had a degree in geology.

The teachers first taught the relevant topics from the standard state chemistry textbook, according to their usual approach. Following that, a pre-test consisting of a number of questions were given to the students. The lessons on the molecule concept were then taught to the same classes from the experimental textbook by the same teachers: *(i) The concept of molecule in solids and liquids, (ii) Ever-moving molecules, (iii)* The concept of molecule in gases. After this teaching intervention, the same test was given to the students as a post-test.

To check reliability of the marking scheme, ten answered sheets were marked by two markers, and the correlation between the markers was found high: Pearson $r = 0.990$; Spearman $\rho = 0.976$.

The study was carried out for two consecutive years (2006-07 and 2007-08), but in the second year only the pre-test was administered to the three of the four schools. Note also that during the second year there was a change in the state textbook used by the students.

Results. For 2006-07, the experimental school (School 1) increased its performance from **50.5** (maximum 100) in the pre-test to **67.5** in post-test.. For school 2, the average marks were **37.8** and **48.9**, and for School 3 **29.6** and **51.6** respectively. Finally, School 4 achieved in post-test **50.4**, similar to schools 2 and 3 (School 4 did not answer the pre-test). The statistical student t-test (after checking for normality of the distribution with the Kolmogorov-Smirnov test), showed that the differences between pre- and post-test are significant for each school separately at the 1% significance level.

For 2007-08, the average performance of the students in pre-test were **47.1** for School 1, **34.0** for School 2, and **37.2** for School 3. We observe that (with the exception of School 3), these performances were not very different from those in the previous years (recall that there was a change of the state textbook).

Conclusions and implications. It appears that the constructivist and conceptual approach to the concept of molecule, as it is given in the experimental textbook, improves considerably students' performance. In reality, students seem that are aided to overcome learning difficulties related to the concept of molecule, that is, when attempting to make the transition from the macro to the submicro level of chemistry. Finally, it is notable that a new chemistry standard state school textbook was used in the second school year, but no serious change in achievement was noted in comparison with the previous textbook.

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Bonding concepts / Types of chemical bonds: In search of an optimum (?) teaching order - workshop

Georgios Tsaparlis

The distinction between intramolecular and intermolecular bonds [“true bonds” versus “forces”(?)], and the particular types of chemical bonds (ionic, covalent, metallic, hydrogen bond, Van der Waals forces, London dispersion forces), will be the focus of this workshop. The fundamental question for the workshop is whether it matters the teaching order in which these bonding concepts are presented. The organizer will present teaching order(s) that appear in a number of textbooks. Participants will discuss these orders, and propose modifications or their own preferred orders. A discussion will follow, and a teaching order based on the “States-Of-Matter Approach” (SOMA) to introductory upper secondary chemistry will be presented and discussed. This approach introduces chemistry through the separate study of the three states of matter: air and gases; salt, salts, and solids; water and liquids.

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The Influence of Language on Chemistry Achievement

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Keywords: school language, domain-specific language, chemistry achievement

Theoretical Background. The results of international large scale assessment studies (TIMSS, PISA) show that students in Germany have problems concerning subject-specific text comprehension. Looking at the results of PISA 2000, it becomes evident that in the German sample (n = 5000) around 10% did not even reach level I in reading comprehension (scale values 335–407; OECD-average: 6%) and still 12.7% remained at level I (Artelt et al., 2002, Schümer & Baumert, 2001). This means that these students exhibit, at best, superficial understanding even of simple texts. Thus; these low-achievers were identified as a risk group. Remarkably enough, most of these students (47.1%) as well as most of their parents are born in Germany and their everyday language is German. This means that the size of this risk group cannot be explained by just referring to the number of students with immigrant backgrounds. The results concerning reading literacy in PISA 2003 and 2006 indicated changes for the better but these increases are not statistically significant (Drechsel & Artelt, 2007). In PISA 2000, the 'immigrant group' was considered separately and it was found that the students performed significantly worse when test language was different from the one primarily used in their everyday lives (Ramm et al., 2004).

Merzyn (1998) pointed out that teaching is largely dependent on competent linguistic performance. The situation becomes even worse as students have to learn a domain-specific language in chemistry classes, too. The learning of a subject and its language are inextricably linked. Classes can address these issues on two different levels, the oral language level and the written language level. Thus, it is very important for students to be able to competently use subject language when learning subject content.

Above all, language skills are not only relevant for students with immigration background but also for German students (Baur & Spettmann, 2008). Therefore, it stands to be reasoned that competent use of German language is essential for students to follow and understand lessons in German schools (Hopf, 2005; Ramm et. al., 2004).

Methods. For these reasons, the present project's focus is on the linguistic aspects of science education. The aim is to determine the effects that competent use of the domain-specific language has on learning chemistry. Therefore, students who have been specifically supported in learning the domain-specific language in chemistry will be compared in their learning achievement with students who have worked with a more pointed emphasis on the chemistry content.

The study aims at the these goals;

– Investigation of the influence of the competent use of school language on the learning of domain- specific language in chemistry

– Analysis of the effect of a training in domain-specific language in chemistry in improving chemistry achievement?

The study is conducted with a pre/post-test design. The total sample will consist of 400 grade-7-students from higher secondary schools (German *Gymnasium*) and comprehensive schools (German *Gesamtschule*). In order to measure the language level in the school language (L_s) the C-Test (Baur & Spettmann, 2008) is administered. In addition, the pre-test will collect data with regard to the following control variables: cognitive abilities, interest and a questionnaire on social background. Based on these data, two groups of 100 students each are formed. Group A consists of those students who show high in school language (L_s (+)) and perform low in chemistry-specific language (L_c (-)); group B consists of those students with low levels in both languages. In addition, both groups are composed of 50% German- and 50% Turkish-speaking students (see Figure 1). So, the following 2x2 design results;

	Training with emphasis on chemical language	Training with emphasis on chemical content
Group A: L_s (+) & L_c (-)	50% German students 50 % Turkish students	50% German students 50 % Turkish students
Group B: L_s (-) & L_c (-)	50% German students 50 % Turkish students	50% German students 50 % Turkish students

Figure 1: Overview of the groups

Results. The pilot study will be conducted in spring 2010. First results will be presented on the poster.

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PowerPoint presentation in general chemistry teaching

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Keywords: chemical education, secondary schools, PowerPoint presentation, questionnaire investigation, effectiveness of teaching

Introduction. The concept of teaching chemistry, which currently prevails in the secondary and primary schools of most European countries, strongly prefers the teaching of general chemistry as the starting discipline. Other parts of the chemistry curriculum should build on this part. The goal of teaching general chemistry should be to make the students familiar with the general laws which apply in all chemical disciplines. The subject matter of general chemistry describes phenomena which are usually not directly accessible to observation. The great difficulty of the curriculum is partially caused by its dependence one the already advanced knowledge and skills in mathematics and physics. We have identified the problems of high theoretical difficulty of general chemistry, the unpopularity of the curriculum for pupils and a small illustration and visual attractiveness of the curriculum as the problems to solve.

One of the possible ways of solving problems in the teaching of general chemistry could be to increase the clarity of the curriculum using ICT. With respect to intensive onset of the use of PowerPoint presentations in teaching, first at the universities and then at secondary and primary schools, we decided to try to process the curriculum in the form of presentations. We assumed that we could find a way to take advantage of this didactic device. We also assumed that we can identify the potential negative impacts of PowerPoint presentations in the educational process and verify the impact of the presentations on the effectiveness of teaching. In terms of pupils our further research focused on the influence of presentation utilized in teaching on the students' attention and level of understanding of the subject matter. From the perspective of teachers, we have focused on the time-consuming preparation of lessons accompanied by PowerPoint presentations, on the dynamic teaching and on the status of teachers in the classroom. In terms of presentation we were mainly interested in the efficient use of graphic elements and the elimination of negatively affecting attention and understanding of subject matter.

Methodology. When making presentations, we started primarily with the principle of the maximum use of graphic and visual elements such as images, diagrams, photos, animations, graphs and tables. Furthermore, we have attempted to comply with the principles relating to color and fonts. Another basis for making presentations was detailed research literature. We have used the research that is directly involved in verification efficiency and impact of presentations at educational process [1, 2, 3, 4], but also from works devoted to the impact of graphics on the process of learning and understanding [4, 5]. This work suggests, among other things, that color text draws attention, but black text is easier to comprehend, that words written in small font draw more attention than words written in big font, etc.

In the next phase, the teachers were asked to take part in the seminar where these presentations were introduced and the teachers' questions about the work with presentations in their lessons were answered. The teachers of secondary schools were given 10 PowerPoint presentations of general chemistry curriculum; each of them was designed for one 45-minute lesson. For each presentation there was a short text devoted to the content and objectives of the presentations and also to the tasks that are an integral part of the presentations.

Reactions of teachers were available by questionnaires. These were focused on the questions of graphics of the submitted presentations, on the system of submitted tasks, and on the assessment of effectiveness of teaching supplemented with presentations. In the questionnaire the teachers also expressed their opinions on the effectiveness of work with pre-prepared presentation. Moreover the questionnaire contained one question related to the technical equipment of schools to enable us to relate the acquired information to the technical equipment available in the classrooms where the investigation was carried out.

Results and conclusion. The results we obtained were the source of some interesting information. All teachers stated that their schools possess the technical equipment necessary to introduce computer presentations in their classroom teaching. The answers to the questions whether classroom teaching supplemented with presentations increases the interest of students in the curriculum, increases attentiveness and contributes to better comprehension of the curriculum are more complex. The results of questionnaire closed items and also the results of teachers' reactions in open items show that a considerable part of the teachers think that the interest and attentiveness of students have been increasing. However it is necessary to mention that at the same time especially these teachers often refer to a positive influence of presentations in relation to the alternation in students' activity. From this it can be concluded that higher interest can often be influenced by "novelty" effect, which means that a longer-time application of this tool can lead to a decrease of students' interest. The results of questionnaire open items bring about another interesting fact. Different teachers give completely contradictory opinions on e.g. contacts between the teacher and the student. From this it can be concluded that not only does the perception of teaching by different teachers vary, but also most likely the whole teaching with presentations performed by different teachers differs. This finding corresponds to similar results of research conducted at universities [6].

In the last phase of research the effectiveness of teaching, supplemented by presentations with the help of didactic tests, should be assessed. These tests will be assigned in groups of pupils whose teachers with presentations, we provided them with, have long been working and in control groups. The results will be compared to detecting the changes of effectiveness of teaching.

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KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

The Assessment Of Inquiry Approaches On Developing Understanding Of Chemical Concepts In Estonian Lower Secondary Schools

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Keywords: Inquiry-based approaches, conceptual development, assessment

Background, framework and purpose. Our traditional educational system has worked in a way that discourages the natural process of inquiry. Students ask fewer questions as they move through the grade levels. In traditional schools, students learn not to ask too many questions, instead they listen and repeat the expected answers. Inquiry refers to seeking information by questioning. The process begins, as in normal life, by using all of our senses for gathering information (Exline, 2004).

Many countries have come to the conclusion that science teaching needs deep renewal in order to benefit students (Rocard et al., 2007). Inquiry-based projects have been developed in the United States (*Science and Technology for Children (STC), Insights*), in the European Union (*Pollen*, *Sinus-Transfer*), and supported recently in Estonia under the *INNOVE* project.

We have based our approach on The American National Academy of Sciences' National Science Resources Center's curricula, (STC) and Science and Technology Concepts for Middle Schools (STC/MS). The curricula are organized by science strands, which help students develop an understanding of scientific concepts over a period of 8 years. These strands include physical science, earth science, life science, and technology. The hierarchical ordering of these strands allows for the determination of the development of conceptual understanding using the *knowledge space theory (KST)* developed by Doignon and Falmagne (1999) and others, which shows the students´ cognitive organization of knowledge.

The purpose of our current research is that of an exploratory study in preparation for the possible adoption of an inquiry-based curriculum in Estonia. Numerous studies on inquiry-based teaching in Estonia are available, for example Kask (2009) and Kask and Rannikmäe (2006). Programs based on the inquiry-based projects adopted by various countries have been used in Estonia, but their effectiveness has not been assessed. The goals of the study are to (1) assess the effect of inquiry-based teaching, using the new materials, on the development of conceptual understanding; (2) test and develop the necessary materials; and (3) propose teacher inservice programs. We are at the beginning of a 4-year study with some preliminary results.

KST studies have been used by us previously to assess the development of cognitive structures necessary for conceptual understanding (Taagepera et al., 2005; Vaarik et al., 2008) . The general observation is that although the knowledge base increases between pre- and posttests in traditional teaching, the organization of the new knowledge is still weak. It is of major interest to determine whether inquiry-based methods using the new materials are more effective in developing conceptual understanding than the traditional ones.

Methods. This study will be carried out with students in grades 7 through 9 (ages 12 - 15). Classes receiving inquiry-based teaching will be compared to control groups or classes receiving traditional teaching. The concepts include the ones in the Estonian National Curriculum for which materials can be easily adapted or developed: *measurement, solids and liquids, changes in physical properties, chemical reactions, nutritional chemistry, and properties of matter - comparison of physical and chemical changes.*

The initial test on *measurement* consisted of 9 questions which contained a hierarchical order or logic structure as determined by chemistry teachers and professors. The first 2 questions involved basic requirements for measuring, the next 5 involved factors affecting measurement accuracy and the final 2 questions addressed the evaluation of the accuracy of the measurement.

The initial results were obtained with a 7th grade class, which received the inquiry-based program, and an 8th grade class where the traditional approach was used.

Three methods of analysis were used: the percent of correct answers on pre- and posttests for a particular multiple-choice question (with and without explanations) to measure the knowledge gained, the use of *knowledge space theory* (KST) to determine the cognitive structure of the knowledge gained and the analysis of misconceptions.

Results. Preliminary results indicate that for the *measurement* concept, students who received the inquiry-based approach in the 7th grade performed better in the percent correct answer analysis than students in 8th grade with the traditional approach. This was true with just the correct answers, and even more so when explanations or justifications were included. The explanations for various questions were expressed in more detail and there were fewer misconceptions. It has been observed previously that students give correct answers without necessarily being able to justify why the answer was correct (Vaarik, 2008). The question arises as to whether we are getting false positive results if the students cannot justify the correct answers.

The KST analysis provided a *knowledge structure* as well as a *critical learning pathway* that were better organized for the 7th graders than for the 8th graders. The critical learning pathway started with the basic requirements for measuring, but the measurement evaluation questions preceded the questions which tested for the effect of various factors. The critical learning pathway for the 8th graders was all scrambled. Further studies will indicate whether the test also needs to undergo some changes.

Conclusion and implications. The results of our study will help measure the effectiveness of inquiry-based learning on developing conceptual understanding using materials similar to the ones developed for inquiry-based projects in other countries. Preliminary results indicate that not only are the project materials more student friendly, they also teach the underlying science better. The conditions for optimizing the learning need to be developed by modifying the materials where necessary and training teachers to use these materials.

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Effective practice of Interactive Electronic Whiteboard in Chemistry Teacher Education

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Keywords: interactive whiteboard, teacher education, pre-service training

Implementation of the Bologna process at Croatian universities required the implementation of adapted study programmes and a new approach to education and learning. The newest technical and computational accesories like interactive whiteboards (IWB) are supposed to be applied together with appropriate didactic methods.

In the first part of our research we investigated the pedagogical experience of chemistry teachers who are using IWBs in classroom. In a period of last four years almost every public school in Republic of Croatia was supplied with at least one IWB. Unfortunately no educational courses have been offered and chemistry teachers are using the IWBs as common boards or just ignore them. Relevant results obtained by semi-structured interviews with teachers(1) and questionnaires will be presented on poster.

The second part of our research concerns with development of didactic methods appropriate for IWB. The power of interactivity of IWB was presented to different groups of chemistry students in pre-service teacher training for the last tree years. We assumed that our students were effective and experienced computer users. Consequently, specific requirements of IWB software were quickly mastered. Through the course of Methods in teaching chemistry for both chemistry and biology majors, appropriate didactic methods using animations and virtual laboratory experiments(2) were investigated with active students participation. Groups of students adapted different didactic methods and applied them to their course mates. The IWB was used at tree stages: (i) supported didactic: where IWB was used just as a visual support with little interactivity, (ii) interactive: with limited use of the potential of the IWB to stimulate students' responses and demonstrate some concepts, and (iii) enhanced interactive: integrating concept and cognitive development in a way that the interactive capacity of the technology was exploited. Pilot students responded briskly, quickly accepting interactive device what will be presented on poster. The results can be partially compared to findings reported for high schools in other countries(3).

The achieved results are analysed by interviewing and polling(1) and compared to common didactic methods. We have also used the method of participant observation(1) in order to obtain more qualitative data. We found that the knowledge achieved through simulation on an IWB can be compared to the knowledge achieved through laboratory work, and it is even more efficient than the knowledge showed after classical lessons using common didactic methods. Following a general idea that chemistry lectures have to be based on experiments, such experiments can be shown in real laboratory or almost equally efficiently in simulated laboratory using IWB. Simulating experiments on IWB is even advisable for dangerous, expensive, and/or long lasting experiments.

In-service training how to use the full potential of IWB should be organized for chemistry teachers, as it was reported for other countries (4) .Chemistry students in pre-service training readily applied their chemistry knowledge using IWB testing different didactic methods. This research gives a measurable contribution to the quality of university education of chemistry teachers, and consequently to the quality of in-service teaching. The achieved results contribute to the Quality Assurance in Higher Education, one of the main goals of the Bologna process.

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The Criteria for Evaluating the Quality of the Documents in Pedagogical Research Settings

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Keywords: quantitative research, qualitative research, document analysis, textbook analysis

In the field of the humanities and social sciences, two paradigms of scientific research were developed in the past. Regarding their attributes, they are called quantitative and qualitative. This paper focuses on qualitative research in which the researcher has been directly involved and has himself been examining the research phenomenon in the studied environment. The qualitative research regarding its ontological, epistemological and methodological aspect is not a consistent phenomenon; namely, it combines different kinds of research, e.g. a case study, life history, action research and others. Bogdan and Biklen (2003) use the term »qualitative research« as the superordinate concept, joining different research approaches with certain common characteristics as well. With the expression »qualitative research« the research is denoted consisting of the basic empirical material, collected in the research process, which is verbally described or narrated. Furthermore, the collected material is worked on and analyzed in words without numerical operations (Mesec 1998). Other authors (e.g. Denzin and Lincoln 2000, Creswell 1998) similarly define qualitative research. According to Creswell (1998) for example, the qualitative research is the research process designed according to a clear methodological tradition of research, whereby researchers build up a complex, holistic framework by analyzing narratives and observations, conducting the research work in the habitat.

The aim of qualitative study is to gather data in the form of rich content–based descriptions of people, events, and situations by using different, especially non–structural, techniques, to discover the stakeholders' views and similar, and to analyse the gathered data verbally, and finally to interpret the findings in a form of a concept or grounded theory which is contextually dependent. At analyzing the gathered data statistical procedures are also not used, but predominantly the qualitative analysis, the essence of which is searching for codes in the analyzed materials (Bryman 2004). The main part of the qualitative analysis of the material is formed by the coding process namely, i.e. interpreting the analyzed text and attributing the meaning (of key words, notions, codes) to its individual parts (Charmaz 2006; Bryman 2004), respectively. Qualitative analysis of the material starts with defining the coding units, followed by the appropriate phenomena records according to our judgement and analyzing the characteristics of these phenomena, and ends with the development of the grounded theory (Glaser and Strauss 1967). The grounded theory is read out as a narrative about the phenomenon, which was the subject of the study. It is characteristic for the theory to be constructed from the collected data and to develop in the course of the entire research process. The grounded theory is contextually bound, i.e. it is not a general theory (the findings cannot be generalized without additional definitions), but the theory of a narrower scope, valid only in certain environments and certain conditions, respectively.

The paper will include the analysis of the data gathering techniques and instruments which are used in the qualitative research, especially the text analyse, which is the basis for the in-depth chemistry textbook analysis. A special emphasis will be placed on the criteria which serve the purpose of finding out the quality of documents (e.g. chemistry textbooks and notebooks, teachers' individual teaching material (for example activity sheets, laboratory instructions, etc), students' individual classroom notes, etc). The criteria which are used for evaluating the quality of the documents from the chemistry education research perspective, will be presented. The criteria are divided into three groups: (1) the group of positivistic criteria consists of those criteria which have been directly taken from quantitative research; (2) the group of post-positivistic criteria which are those criteria whose authors claim that qualitative empirical research presents a different form of scientific research than quantitative one; the proponents of such a view require that a set of different methodological approaches must be established; and (3) the group of criteria that consists of authors who when defining the quality of scientific findings of the qualitative research base their decisions on post-modern and post-structural approach.

In the paper some specific examples from the chemistry textbook analysis will be presented to illustrate the qualitative research approaches in document analysis.

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Introduction of Scientific Inquiry in the Teaching-Learning Process of Chemistry in Secondary Schools of Latvia

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Keywords: scientific inquiry, planning and projecting.

Results of various international studies show that in the countries of the European Union students' interest in science has decreased during the past twenty years [1]. To improve this situation it is necessary to change the approach to teaching and learning science in a way that makes the student a more active participant of the study process [3].

Educational reform in Latvia is implemented systemically with the financial support from the European Union for the projects "Curriculum Development and In-service Training of Teachers in Science, Mathematics and Technology" (2005-2008) and "Science and Mathematics" (2008-2011). Among the criteria that have been proposed as priorities for the reform implementation is active student involvement in scientific inquiry (Fig. 1). By the term "scientific inquiry" we understand the cognitive path, the general process in which a person is seeking information or building comprehension [2].

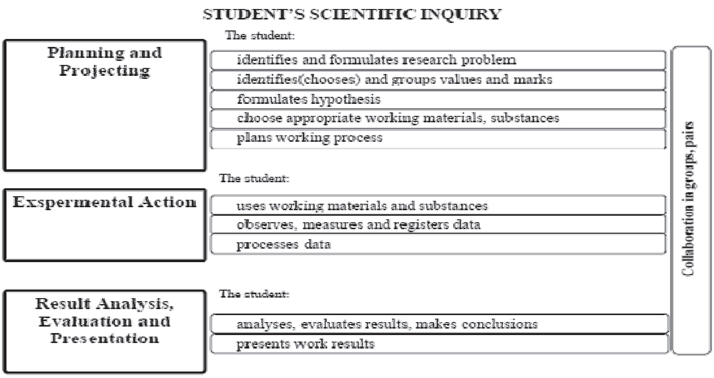

Figure 1. Scientific Inquiry

A coherent system has been devised within the project for gradual development of scientific inquiry skills in science subjects (chemistry, biology, physics) in grades 10 to 12 at upper secondary level. Laws and regulations provide for the development of these skills also at lower secondary level, however their development in practice is not purposeful due to the lack of support materials for teachers. At the beginning of the project 36 % of 613 students representing 12 pilot schools noted that they had very few opportunities to perform laboratory work or scientific inquiry.

Further we will discuss one of the study issues, namely, the success of upper secondary school students in projecting and planning of scientific inquiry in chemistry. Methods used during the study were diagnostics of students, teacher and student surveys, and lesson observation. Data processing software Microsoft Office Excel and SPSS were used for processing and analysing the research quantitative data. The obtained qualitative data were processed by using the software OSR NVIVO 7.

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According to the modernized curriculum, descriptions (41) of laboratory works and scientific inquiries were prepared and piloted in schools. During the study it was established that the use of the devised materials and successful instruction given by a teacher ensure gradual improvement of the scientific inquiry skills of the students from grade 10 to 12, and the results of diagnostic tasks prove it (total number of students 613): for example, 30 % of grade 10 students have acquired skills of formulating hypothesis; in grade 11 this figure is 46 %, in grade 12 – 74 %. More than 70 % of grade 12 students have fully acquired projecting and planning skills. 25 % of teachers (50 teachers were surveyed during the closing stage of the project) maintain that in comparison with grade 10 a real progress is observed in students' scientific inquiry and projecting skills. At the same time teachers indicate that part of students still find it difficult to formulate hypothesis 49 %, identify values – 11 %.

However, the project experts established that in more than 30 % from the observed chemistry lessons (61 lessons) teachers had difficulties in organising scientific inquiry in the classroom.

Protocols of 23 scientific laboratory works performed by 169 students were analysed. It was established that in grade 10 students are learning to identify the research problem, formulate the hypothesis and group values (however, the formulated hypotheses are often short of substantiation), but in grade 12 students do that without assistance within the scientific inquiry work. It was also established that teachers frequently make mistakes when they correct students' works. In the conclusion of the study 85 % of students (total number - 613 gave positive assessment to the scientific inquiry in study process and noted that their scientific inquiry skills improved.

Results of the study proved the following: 1) grade 10 students have relatively significant difficulties regarding scientific inquiry skills (including the projecting and planning skills), but grade 12 students are able to perform the scientific inquiry steps without assistance; 2) students became more interested in scientific inquiry; 3) teachers need support as they experience difficulties in organising the scientific inquiry work in the teaching-learning process.

In order to make conclusions about scientific inquiry skills acquisition in Latvian schools (in grades 10 to 12) it is necessary to carry out a more comprehensive study. To this effect, the monitoring system of scientific inquiry skills acquisition is being devised. The curriculum in chemistry for grades 7 to 9 is being improved and piloted and descriptions of scientific laboratory works are devised for grades 7 to 9 and grades 1 to 6 with an aim to bridge the gap between the curriculum of natural sciences in grades 1 to 6 and the curriculum in the upper secondary school, thus ensuring succession in the development of students' scientific inquiry skills. The work is currently continued to raise the professional capacity of teachers regarding issues of organising scientific inquiry for students.

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Evaluation of Scientific Inquiry Standards

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Keywords: Educational standards, assessment, scientific inquiry, competencies

Background. Resulting from findings of international large-scale assessments such as TIMSS and PISA the Assembly of German Ministers of Education agreed on National Educational Standards as normative guidelines for secondary schools. The standards define four areas of competence for the scientific subjects *biology, chemistry* and *physics*, which are *content knowledge*, *acquirement of knowledge*, *communication* and *evaluation & judgement*. This paper focuses on the area of competence *acquirement of knowledge* only.

Tests for all areas of competence are currently being developed and proved in the German project ESNaS (Evaluation der Standards in den Naturwissenschaften für die Sekundarstufe I – Evaluation of the National Educational Standards for Natural Sciences at the Lower Secondary Level) by teachers and researchers. The items will be empirically tested in a nationwide pilot study in 2009/10 and used in a nationwide assessment in 2012. The aim of this presentation is to explain the construction of test items of a *a priori* defined difficulty instead of *post hoc* analysis using a new model of competence. The validity of the model will be evaluated in a pilot study, results will be presented at the conference.

The area of competence *acquirement of knowledge* can be subdivided into different subareas, which are *methods of scientific investigations* (scientific inquiry), *development of scientific models and theories* and *nature of science* as far as they are testable in paper-pencil-tests. The emphasis of this presentation lies on the different aspects of scientific inquiry (questions, hypotheses, design and data) which are assessed by paper-pencil-tests.

For large-scale assessments, competence is demanded to be operationalised in competence models (Schecker & Parchmann, 2007). In most cases competence models use several dimensions of which one dimension usually describes the content of the tasks. A certain competence therefore combines a specified content with other dimensions, which, for example, describe the difficulty. As a result, competence describes more than just having knowledge in a domain.

Methods. In order to construct items of a defined difficulty, a model of competence, which originally was developed to describe physics content knowledge (Kauertz & Fischer, 2006), has been adapted for describing competences in science in general. Two difficulty generating aspects *complexity of the task* and necessary *cognitive processes* are combined with aspects of a model of inquiry competence (Mayer, Grube & Möller, 2008) using experiences from the development of a similar test for chemistry education (Klos et al, 2007). This third dimension describes the content of the tasks. Therefore, the content-related aspects of *acquirement of knowledge* can be described as shown in table 1.

acquirement of knowledge		
methods of scientific investigations	development of scientific models and theories	nature of science
- Questions - Hypotheses - Design - Data	- Functionality - Application - Limits	- Characteristics of scientific knowledge - Development of scientific knowledge

Table 1: Area of competence *acquirement of knowledge*

Teachers of all German states developed 140 items according to the model of competence. The items were cross-checked by at least two science educators and one psychometrical as well as one linguistic expert before they were approved for the pilot-study. In the pilot-study the items are distributed in a multi-matrix design. Rasch analysis is used to check the model fit and difficulty of the items. Data on intelligence, interest, content validity and reading comprehension are raised for validity purposes.

Results. Due to the fact that the pilot-study is currently running, results cannot be presented in this paper but will be available and presented at the conference. Preliminary data from pre-pilot studies show that the two assumed difficulty-generating aspects (complexity & cognitive processes) are appropriate for this purpose.

Conclusions and Implications. The data from the pilot-study will enable us to arrange test booklets of defined difficulty to assess the competences of the students in the area of competence *acquirement of knowledge*. Data from the additional test and questionnaires will enable us to check for convergent and discriminant validity.

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The teaching of safety: the importance of a global approach of both technical and human aspects

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Keywords: safety, education, teaching, technical, human

The teaching of safety is a very complex topic, since it is directly related not only to technical aspects, but also to human ones. Each of these aspects is related to many orthogonal variables. Variables can be considered as to be orthogonal to each other as long as the variations of one of them have no influence on another of them. Thus the complete set of orthogonal relevant variables for safety aspects will generate a space the dimension of which equals the minimum number of linearly independent variables required to describe it.

Most often the teaching of chemical safety is just limited to physical and chemical aspects, since conventional science can easily deal with them as a consequence of their belonging to a space in which all variables are measurable. However, taking into account subjective variables cannot be excluded from teaching, since the roots of safety are fundamentally subjective. Subjective neither means "erroneous", nor "not scientific". It just means: "the measuring units of which do not only depend on objective measurable magnitudes". Thus, the teaching of safety can be developed at very different levels of complexity.

The easiest one is to reduce safety to its chemical and physical aspects. In this frame, one however must define some basic notions such as danger, risk or accident. Energy and time appear as to be the main variables to consider in the assessment of the runaway occurrence probability [1]. In this frame, it is important to discuss the nature of different kinds of energy. The most important for chemists are the chemical, the mechanical, the electrical, the thermal energy and in nanochemistry, the surface energy. It is also important to draw the attention onto the fact that any of them can play the role of any other in its effects which possibly can lead to a loss of control situation. As far as chemistry is the science of the transformation of matter, chemical safety connects the fields of matter, space and time. Therein, three magnitudes are essential to be mastered: the amount of available energy expressed in terms of Joules for all types of energy, the potentials which are described in terms of the ratio of an amount of energy to the size of a location where it can be stored, and the power which is proportional to the energy to be released in a given time, which is often directly linked with the undesired destructive effects the control of which is the goal of safety.

All these studies will lead to an assessment of the criticality of the process one intends to run, and provide information for the efficient development of countermeasures against any ***non*** acceptable evolution from the nominal working conditions.

A second level of teaching safety consists in dealing with safety assessment with regard to all ***not*** chemical factors possibly leading to dangerous situations. The dangers can arise from the reacting mixture, from the operating devices, from human behavior, from acute or chronic toxic effects, from environmental pollution or degradation. Many tools [2] are available for this purpose: techniques such as what if, hazop, chetah, causal tree, malfunction tree, check list, source-medium-target, etc … as risk assessment methods can be used and their mutual crosslinking will result in rather reliable answers concerning the localization of all potential risks induced by running a process.

Besides these techniques just devoted to the pure technical aspects, some more human aspects must be taken into account, and more especially all ergonomic aspects at the workplace, the long term possible effects on health, the transfer of information, the correct understanding of the process by the workers …

Further, the aspects in relation with laws and regulation, but also all restrictions concerning the use and the release towards the environment of toxic or hazardous products must be integrated in safety teaching at this level.

The third and certainly the most difficult level to cope with consists in integrating subjective and paradigm dependent factors [3]: our mind is fundamentally linearly oriented as a consequence of the simplicity of the logics arising from such a paradigm. In a measurable monovariable environment, our conventional logic keeps a sense. The notions of right and false are exclusive of each other, and it is easy to classify the sequence, the magnitude or the relation of cause to effect in such an environment. But as soon as two or more linearly independent variables must be considered simultaneously, very common and useful notions such as right or false, good or bad etc…, loose completely their sense, because they depend on vector orientations which are depending on the observer's position or choice. Therefore, a same system can lead to apparently completely opposite conclusions, although all of them are perfectly right but analyzed from different points of view. Therein are the origins of critically contradictory conclusions arising from different points of view such as the technical one, the safety oriented one, the financial oriented one, the human oriented one etc… However, since finally, a decision must be taken, one chooses most often a gentleman's agreement which can be respected as long as an unexpected accident does not bring almost everyone to the same point of view, from which it becomes easy to judge (and more especially for lawyers) what was right or not, who is guilty or not, what must be done or not …, although these decisions are never better than the previous ones and could be discussed the same manner from another point of view. Finally, one must come to the conclusion that in the multivariate space of safety, some variables belong to the non measurable set of subjective magnitudes, since they cannot, like objective magnitudes, be reduced to a bijective correlation with a geodesic trajectory of a physical magnitude in the space-time universe.

Therefore, safety must be taught as an area in which many ***contradictions can coexist***, which ***does not mean*** that some assumptions must be false as a logical consequence of such contradictions. As an example, in a room, an arrow can be considered as right or left turned depending on the side from which it is looked at. A similar contradiction can be found in the easy acceptance of the natural lethal frequency rate (given as the number of lethal accidents occurred over a period of 10^6 hours) which is about 1.5 for human life, and the nearly total rejection of any accident occurring in industries, where the frequency rate can be much lower and does not only concern lethal accidents, but includes all accidental events, and even minor ones provided they result in a temporary interruption of the working capabilities of the injured people. An accidental death in industrial environment is considered as completely intolerable, although by just considering the mathematical aspect of the frequency rate as defined, the conclusion would be that many industries are safer than common life (which is an almost true conclusion).

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Pre-Service Chemistry Teachers` Use Of Active Learning Methods

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Background, framework and purpose. During the practical pedagogical training students have to use the knowledge gained through number of theoretical and pedagogical subjects in the framework of their tertiary education. The active learning methods are also included as topics in some of them, as the research evidence from classroom practice points to their important role in the learning process. Active learning methods are by some authors termed as student–centred learning strategies. Harden and Crosby (Harden et al., 2000) describe the relationship between teacher–centred and student–centred learning strategies as following: teacher-centred learning – when the focus on the teacher transmitting knowledge is from the expert to the novice, and student-centred learning when focusing on the students' learning - what /students/ do to achieve this, rather than what the /teacher/ does. In the presented research we aimed to investigate the acquaintance of prospective chemistry teachers – students of the third and fourth year at the Faculty of Education at the University of Ljubljana – with methods of active learning and their ability to use them efficiently during their practical pedagogical training, when they are in the role of a teacher.

The following research questions were posed: (1) what proportion of time of the lessons do prospective teachers devotes to the use of active learning methods? (2) Which active learning methods and with which purpose do prospective teachers use in their teaching and to which extend?

The article considers how it is possible to improve the teaching and learning in primary schools by encouraging prospective chemistry teachers – students during their practical pedagogical training (PPT) - to adopt student-centred forms of teaching and to urge them not to use only the knowledge gained through a number of theoretical and pedagogical subjects, but rather to aspire them to introduce different forms of active learning, or to go even further – to promote those methods of active learning which facilitate the learning of chemistry with understanding.

Methods. The data was collected by the use of classroom observations and students` reflective diaries.

Classroom observations

During PPT, the 3rd and 4th year students taught in many chemistry lessons at a particular primary school. Peer-students wrote classroom observations about the teaching conducted by their peers during all lessons of PPT. The observations for each of the lessons had to include: the timeline, description of all teachers` and pupils` activities and behaviour. Students wrote observations with computer-notebooks during lessons and handed them in on the same day through the faculty server.

Besides peer-students, also a teacher-mentor was present during all PPT lessons, and university teachers (authors of the article) accompanied students at primary schools for at least two lessons per student. During lessons attended, university teachers wrote classroom observations the same way as was expected from students.

Students` reflective essays

In the week after PPT, students were asked to sum up their thoughts about their experiences in a reflective essay. It was required that in their writing students should also address the following (by filling out the prepared table): (1) articulate which active learning methods they have used during PPT based on their lesson plans, (2) explain for which purposes they applied particular active learning methods and how they felt about their successfulness in achieving the goals.

Results. The results, processed by the use of qualitative methods of data analysis suggest that students recognize many advantages of the use of the methods of active learning in chemistry classroom, but due to their limited experience, they are so far not able to use them as efficiently as they would like to.

The classroom observations revealed that all groups of (prospective) chemistry teachers devote significant **proportions of chemistry lessons** to pupils' active involvement into the learning process by the use of different active learning methods (3rd year students on average 72.11% of the lesson, 4th year students devote 66.44% of the lesson and teachers 67.85% of the lesson).

Despite that favourable finding, it is important to note that the differences between the teachers within groups are quite big (3rd year students: min=37.78, max=98.33; 4th year students: min=35.56, max=86.67; teachers: min=15.56, max=99.26); details are presented in Figure 1.

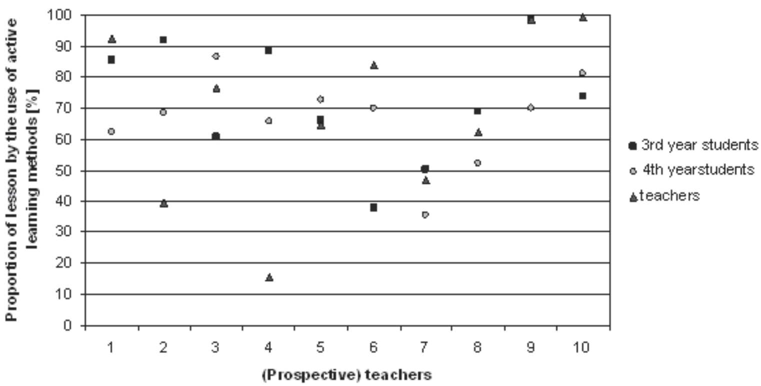

Figure 1: Proportion of time in lesson in which teachers from certain a group use active learning methods

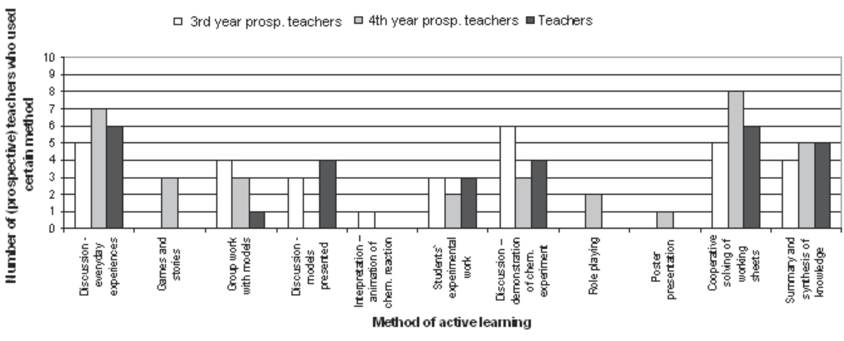

Figure 2: Active learning methods integrated into lessons by different groups of (prospective) teachers

Figure 2 shows which active methods were most used among the (prospective) teachers in our sample. Thereby, discussions about pupils` everyday experiences and observations and the cooperative solving of work sheets were used by more than half of the teachers from all three groups of (prospective) teachers. From figure 2 it can be seen that the 3rd year students found active involvement of pupils with the models more important than their 4th year student peers, and also that the teachers are more prone to discuss about models based on their demonstration, than to instruct students to work with models in order to come to their own observations and conclusions.

Conclusions and implications. The main findings of the study and their implications for the future practical pedagogical training of prospective chemistry teachers as a part of their tertiary education are concerned with: (1) *Understanding of the term active learning methods* - similarly as already proposed in previous studies, our study confirmed that for prospective chemistry teachers the term active learning has more an intuitive connotation then a well established definition. They have used it to describe methods by which pupils are involved in activities at very different levels of their participation. Since the use of active learning is vital for the effective learning process, it is crucial to clarify with pre-service chemistry teachers what are the significant components of a certain teaching and learning method if it is to be regarded as pupils` active learning and

(2) *Purposes for the use of active learning methods in teaching chemistry* -prospective teachers listed a number of purposes for the use of specific active learning methods: students` argumentation of the purposes for particular active learning methods proves that most of the prospective teachers are aware of the wide range of possibilities for the effective use of active learning methods in teaching chemistry.

Concerning the future implication it would be profitable to extend the present study through further research, e.g. in the following areas: (1) evaluation of the quality of the knowledge gained by pupils through specific active methods in comparison with methods, in which pupils are more passive; the state of the art immediately after lessons and also from the knowledge durability point of view, (2) study of added value in terms of pupils` competences gained through specific active methods, (3) evaluation of the efficiency of prospective chemistry teachers` use of specific active methods in comparison to their use by in-service chemistry teachers and (4) investigation of prospective chemistry teachers` capability to select the most suitable method for a particular classroom situation.

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Development of a Large Scale Assessment Instrument for Measuring Chemistry Teachers' Professional Knowledge

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Keywords: Test construction, content knowledge, pedagogical content knowledge, chemistry teachers

Background, framework and purposes. A main variable determining successful teaching is the teacher and his or her professional knowledge. Although there are different definitions about the meaning of professional knowledge, following differentiations are generally accepted: content knowledge [CK], pedagogical content knowledge [PCK], and pedagogical knowledge [PK].

CK is knowledge of subject-specific content and methods. It is much more than the subject matter knowledge, which is learned by students, or even everyday knowledge (Baumert & Kunter, 2006). CK is based upon academic grounding, whereas it is formed by curricular working and structuring of subject-specific content for teaching.

PCK is the attribute which distinguishes between a content specialist and a teacher (Shulman, 1987). It is based on subject-specific knowledge about teaching and learning of specific contents. "PCK (…) is constituted by what a teacher knows, what a teacher does, and the reasons for the teacher's actions" (Baxter & Lederman, 2006, p. 158). By comparison to this excerpt knowledge can be subdivided into three areas (Paris, Lipson, & Wixson, 1983). First, declarative knowledge includes knowledge about facts and represents "knowing that". Procedural knowledge means "knowing how", which contains knowledge of specific procedures. Finally, conditional knowledge is the "knowing when and why".

The last professional knowledge dimension PK is knowledge about broad principles and strategies of classroom management, organization and learning strategies.

During the last few years, studies have used this trisection of teachers' professional knowledge. In 'COACTIV' (Baumert et al., 2006) could be shown, among others, that there are characteristic differences between teachers from distinct school types with regard to the correlation of CK and PCK in mathematics (Krauss et al., 2006). Teachers of upper schools show a higher correlation (r = .96) between CK and PCK than teachers from lower level schools (r = .64). With regard to mathematics teachers of upper schools these domain-specific dimensions are empirically not distinguishable, whereas CK emerges as precondition for PCK. While there are some quantitative studies concerning teachers' professional knowledge in mathematics, for example, there is no comparable study in chemistry so far.

Main goals of this study, which is embedded in the project ProwiN (Borowski & Tepner, 2009), are to develop and to evaluate test instruments for measuring CK and PCK of chemistry teachers. Furthermore, statements about characteristic variations in professional knowledge of teachers from different school types and different federal states are being pursued. Moreover, the study will examine if there is a correlation between the two subject-specific dimensions of teachers' professional knowledge in chemistry, CK and PCK.

Methods. In the main study, three hundred chemistry teachers will be asked to complete a CK test and a PCK test in paper pencil form. Both tests have a processing time of 45 minutes, centre on the topics 'chemical reactions using the example of acids and bases', 'chemical bonding', and 'structure of atoms and the periodic table of the elements', and give attention to all three knowledge areas: declarative, procedural and conditional knowledge.

The CK test splits between chemistry themes of curriculum till 10th grade, after 10th grade, and themes of the basic study at university. The PCK test does not separate between these curricular classifications, it differentiates between three facets: students' preconceptions, experiments and models.

Participating teachers belong to two different types of secondary schools: one part of the sample consists of teachers working at an upper level school, while the other part works at a lower level school. Furthermore, the investigation is conducted in two different federal states. These differentiations allow statements regarding the assumed existence of school-type-specific and federal-state-specific characteristics of professional knowledge and its nature. By correlating CK and PCK tests, it is possible to evaluate the relation of these two dimensions of professional knowledge.

Results. At the moment (October 2009), a pre-pilot study regarding the relevance of item content and clearness of tasks has been finished. With the help of these results tasks will be reworked. The pilot study will start in January 2010 so that there will be first results of the pilot study in June 2010.

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Chemistry experiment in educational film and problem teaching in secondary schools

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Laboratory experiment constitutes an important element of research method in Chemistry teaching. In the process of solving problem tasks, the experiment fulfills the motivating role as well as it serves the purpose of discovery and evaluation.

There are numerous possibilities to use educational videos in Science teaching. Studies in this area have been carried out at educational centres all over the world. However, several issues need to be discussed whilst showing such film to students. Here are some of them: what contents have been shown in the film and how they can be remembered; how to improve memorizing the information and what techniques might be applied to do so; how to estimate the growth of knowledge and what tests might be used; what is the students' reaction to the film; what actions might be taken in order to enrich the film and what home assignments might be given to students.

A package consisting of twenty organic chemistry films for junior high schools have been prepared at the Department of Chemical Education. The films show chemistry experiments and their structure is supposed to fulfill a verifying function especially in problem teaching. The films have been made in three different versions. The first one presents chemistry experiments with the correct course and it may be used in teaching Chemistry in the advancing part of the lesson. Students may be familiarized with the reagents and equipment which need to be used for the experiment to be successful.

The second and third versions show the experiments in which incorrect substrates and equipment have been used or the course of the experiment was incorrect. These versions as well as the correct one may be used by students who need to revise the material once a portion of it has been covered.

It is assumed that the films might evoke students' involvement and interest in the subject, they might develop intellectual experience as well as facilitate perception of new information. They may be used in order to revise and remember the information for a longer period of time than if it was only presented verbally, to present the students with fragments of reality which are impossible to observe directly. They may be played at any moment, they allow speeding up the natural course of events which take much more time in reality or slow them down if they occur too fast to be perceived with the naked human eye.

Preliminary research has been carried out into educational efficacy of films on a group of students from High School No VIII in Poznań. In the experiment carried out in 2006, eighty two students were divided into three groups (three classes). The growth of information and educational efficacy of the films were specified for four taxonomic categories of teaching aims, i.e. for memorizing the information, understanding it, applying it in typical situations as well as in problem situations. Based on the obtained results, the growth of knowledge as well as educational efficacy of the films was calculated.

Three groups of students participated in the research, i.e. one experimental and two control groups. All of the groups were taught according to the same scenario with the use of problem method. In each class students did experiments based on traditional instructions based on problem approach. The experimental group used three versions of the film as a revision of the material covered. The first of the control groups used only one version of the film (the 'correct' one) to revise the material. The other control group used only their own notes to revise.

Preliminary results of the didactic experiment point to the fact that the experimental group students obtained better results. Therefore it became clear that the didactic means under discussion influences favorably the process of chemical education especially with respect to understanding and applying information in typical situations but also in problem task solving.

Results of the didactic experiment have shown that the students taking part in the experiment achieved better results. The educational effectiveness of the instructive films studied was estimated as 28% in the field of problem solving approach to laboratory tasks, 22% in the field of information remembrance, 22% in the field of information understanding, 40% in the field of application of information in a typical situation and 37% in the field of solving problem tasks. The use of instructive films was found to have beneficiary effect on learning chemistry, especially in the field of use of the information learnt in typical situations and in solving problem tasks.

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A Chemistry Course Concerning Science-Technology, Society And Environment (STSE) in Vocational High Schools: A Chemistry Newsletter Each Month

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Secondary education involves at least four-year general, vocational and technical educational institutions based on primary education. Major aim of secondary education is to provide the students with information about common cultural elements, to make them familiar with societal problems and with needed solutions, to make them aware of the ways to contribute to country's socio-economic as well as cultural development and to prepare them for their future educational and occupational life based on their interests, ability levels and skills (Official Gazzette, 2009). In our country, secondary education is organized around two domains, namely general education, and vocational and technical education. The school in which the current study was carried out is a part of vocational and technical secondary education pattern. The purpose of the educational institution is to train man-power for several domains of jobs as well as to prepare the students for higher education.

In our country, the student profile of the vocational high schools is much lower in contrast to that of general high schools in terms of certain characteristics. The data collected from the examinations affecting the students' school choices and achievement levels of the students in chemistry courses suggest that majority of the students attending vocational high schools has minimal level of interest to chemistry. This study was carried out in order to develop solutions towards the problems experienced by the students in chemistry courses and to contribute to their views about science, technology, society and environment (STSE). The STSE approach aims at making possible for students to better comprehend and understand the science courses as well as scientific topics and at encouraging those students with creative and distinctive thinking styles and at making the boring and unrelevant subject matters more interesting and attractive for the students (Aikenhead, 1992; Yörük, 2008). The major aims of the current study are to make the students aware of the fact that chemical topics are interesting and closely related to daily activities and to encourage the students to develop a reading habit in relation to scientific works in order to eliminate their indifference to these topics.

The sample of the study includes a total of sixty high school students. The data of the study were collected through the use of the attitude scale regarding chemistry course and the STSE attitude scale. Monthly chemistry newsletter was published with a group of randomly selected ten students. This newsletter has been publishing beginning from November 2009 until June 2010. At the end of the study, the data collection tools will be readministered to the sample. The newsletter contains chemstry topics studied in the classrooms, technological advances, environmental issues and related crosswords and activities. It is carefuuly designed so as to include the chemistry topics of the past month and those themes that reinforce the students' comprehension of the topics. In other words, the chemistry topics studied during the past month are reorganized and presented using a different method to the students in the newsletter. The objective is to show that chemistry is an inevitable part of the daily life. Newsletters are distributed firstly to the sample of the study and then to all students in the school with the assistance of the school administration. It is observed in the past three months that this practice motives the students towards chemistry course and faciliates the development of reading habit as well as reinforces the habit of reading scientific publications and produces a different attitude towards environmental issues. Therefore, the study helps students to feel that life-long learning and paying attention to chemistry topics faciliate the recognition the relationship between daily life and chemistry.

In conclusion, it is found that using distinct teaching methods instead of traditional ones students can be made more interested in chemistry and their achievement levels can be positively supported. In other words, as Wittgenstein points out, *"Solutions can be found reorganizing the known."*.

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Retrieval of chemical reactions: images or schemes

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Keywords: chemical demonstrations, teaching, description, scheme of reaction

Demonstration experiments are widespread in teaching chemistry. There are many claims that demonstrations improve teaching. However, there is insufficient experimental evidence that it really does. The role, the target and the mechanism of the impact are not clear. There are claims, that demonstrations promote active engagement among students [1], increase pupil attention and task involvement [2], help to create mental links between previous and new learning [3] and provide cognitive conflict that is effective for learning [4].

Our hypothesis was that bright demonstrations are memorized and stored in the long-term memory and then are recalled while reconstructing schemes of reactions. To check this hypothesis we compared achievements in recollection of the observations and in writing of schemes of the corresponding reactions (the recollection of brutto-formulae of products and reagents).

The experiment employed 20 students (14 y.o) that studied at accelerated classes, school #192, Moscow. All the students were highly motivated. The experiment was conducted within regular learning time as a part of the syllabus in chemistry. The participants were not aware of the experiment.

The experiment consisted of study (half a year) and test (40 minutes) stages. At the study stage various processes were demonstrated once a week for 45 minutes. Their appearance allows identifying at least one of the products. During the demonstrations the students had to write down their observations and connect the observations with the equations (made by a teacher). Their notes were regularly checked and marked, as if it was an ordinary learning task. While checking, the commentaries were written to all the mistakes and the most typical mistakes in descriptions were discussed at the classroom next lessons.

The test stage was arranged as an ordinary school test. The students were given eight tasks, requiring to complete schemes of reactions (basing on the reagents and conditions) and to describe the appearance of the processes. All the processes were chosen from those shown in demonstrations. The students were not aware of it beforehand, so they did not prepare intentionally.

Schemes and descriptions were marked separately. If the description included all the key features, it got 1 point, if only a part – 0.5 point. The scheme with all the reagents and products got 1 point, with some omitted formulae of correct products or included incorrect – 0.5. Totally wrong or absent descriptions and schemes got 0 points.

Comparing achievements in descriptions and schemes for the same process, we got the following results (an answer means a scheme and a description of one process by one student):

- a description is better, than a scheme (the score for description is bigger) – 11 answers;
- a scheme is better, than a description (the score for description is smaller) – 68 answers;
- a description and a scheme are equally good (0.5 or 1 point) – 20 answers;
- a description and a scheme are equally bad (0 point) – 61 answers.

One can see, that students are more successful in writing schemes than in describing processes they have seen. This is true for each particular student as well. It means, that schemes are primary in long-term effects of studying chemistry and images are secondary. Even if images are stored in the long-term memory, they are rarely stored apart of schemes, whereas schemes can store or be recalled apart of images. It is confirmed since six answers with correct descriptions were fitted to the wrong schemes, but only one answer gave a correct description that did not fit any scheme.

This conclusion is also proved by no correlation between the two types of scores (Fig. 1). On the other hand, the lack of correlations means that the reconstruction of a description basing on the scheme requires special skills, which formation was independent on the whole syllabus.

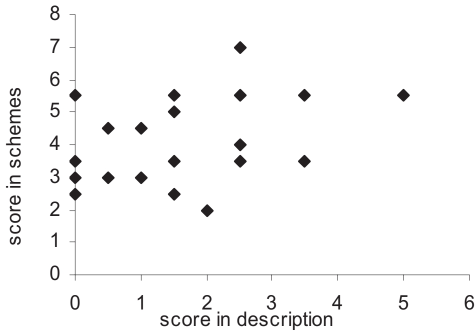

Fig. 1. The correlation diagram between scores in description and in schemes.

However, the above made conclusion is not universal: still in 11 answers descriptions were better. Moreover, in two answers descriptions were given without schemes. So, some images do remain in the long-term memory, but usage of images in problem solving is much less effective, than direct usage of schemes.

The given results show that recollection of appearance of a process does not help to conclude the scheme of the process. The things are opposite: predominantly schemes help to reconstruct appearance (not always successful). Images of appearance almost do not remain in the long-term memory and it is ineffective to appeal to them while solving chemical problems. However, it does not prove, that demonstrations are useless for teaching chemistry – they can contribute to formation of scheme-writing skills or to transferring of the schemes from the short-term memory to the long-term. The present study also reveals the problem of scheme-description connection: even the knowledge of a scheme does not provide the right description.

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The Challenges Posed by PISA to Science and Chemistry Teaching in Mexico

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Background. In this paper we present a methodological approach for the development of scientific and technological literacy in Mexican Upper Secondary Education (USE). This methodology is being implemented in a local USE school system in Mexico. Initially, the methodology was designed on the basis of a project for education innovation funded by the Federal Government (Zorrilla, 2008) between 1999 and 2001. Later on, the project was supported by two local USE school systems, at State level and since 2009, one of them has made it part of its programmes. From its initial results it was clear that this methodology impacted permanence at school for students at risk of dropping out. Graduation in schools in the project rose by at least 30%. Improvements in academic achievement for all students were noticeable, but less dramatic than in graduating. The methodology has undergone an overhaul in order to take advantage of a recent educational reform in Mexico. The challenge remains increasing permanence, graduation and academic performance in PISA type questions. The methodology emphasises setting up a support structure for students academic work combining: i) Science teaching based on the design of curriculum support material with a constructivist orientation, ii) tutorials and iii) systematic teacher-teacher and teacher-student communication outside the classroom. This paper gives an example of the way it improves Science and Chemistry teaching and learning. It also works with other subjects.

Framework and Purpose. The improvement of teaching and learning at the school level comprises scientific literacy and student academic performance in PISA type questions. The results of PISA 2006 (OECD:2006) showed that half of the total Mexican student population surveyed found themselves at level 1 or under that level in Science. These results correspond to an education system that has had to cope with the both the expansion of participation in education and a rapid rate of population growth. Enrolment increased nearly a hundred fold over the past 60 years. USE schools in major urban areas (77% of the population lives in urban areas) are large and often enormous, with a total enrolment of over 1000 students and in some cases up to 8000 pupils. Normally, these schools operate two shifts, one in the morning and one in the afternoon. Usually, there are no student lockers or home rooms. Class sizes are very large. The sheer vastness of these schools makes it difficult for young students (aged 15-18 years at this level) to establish close contacts with their teachers. Exacerbating this problem, the staffing systems of many upper-secondary schools pay teachers *by the hour* for delivering classroom instruction. Teachers are either in front of a class or they are not in the school.

Up to the recent reform, there had been few attempts at rationalizing the USE system and no structural measures were taken to support local initiatives dealing with teaching and learning problems and opportunities. In 2008 the Mexican Ministry of Education enacted a Comprehensive Reform of USE (SEP:2009). This Reform provides a Common Curriculum Framework (CF) organised in terms of competences in four main disciplines: Mathematics, Experimental Sciences, Spanish and Social Sciences and Humanities. The Reform leaves it to the individual institutions to implement the necessary changes in order to adopt the CF.

Methods and results. The methodology focuses on providing students with a more personalised academic support structure by means of: i) Constructivist-oriented curriculum support materials increasing the weight of practical, technological and applied science and mathematics content in existing curricula; ii) Small group tutorials and periodical individualised dialogue-based interviews with all students iii) Regular team work meetings of all teachers in order to analyse the results of their methods and materials and their fundamental beliefs and attitudes as regards their concepts of teaching and learning. In the project, schools give and additional small payment for teacher time dedicated to these activities. The support structure is put to good use in all four main subjects. One good example is in the study of models in Science and Chemistry: The use of models for the study of atoms and molecules is a permanent source of interest for teachers working on prediction of chemical changes (Harrison & Treagust:1996). This is particularly relevant for teachers espousing Constructivist learning theories that emphasize the active role of the learner in the construction of knowledge. The construction of ideas, on the part of students, for understanding reality is part of everyone's experience. These ideas influence school learning however much they vary from one student to the next. Scholars have identified them for a long time, calling them mental models (Norman:1983) or alternative conceptions (Carrascosa:2005). We know that the way an idea is represented can be instrumental in making it functional for a student. That is why students often prefer models representing atoms and molecules as part of discrete and concrete structures. The orbit model of the atom that likens it to the solar system is a quite popular option. Other examples of the importance of detecting and correcting some of the ideas students have obtained from every day experience is the greenhouse effect and global warming (Okhee & *al*.:2007; Taylor & Lyons :2008) The advantages found by those students who represent phenomena in such ways often disappear when they are left to think by themselves a given task or when they are asked to solve an unfamiliar problem. This unintended consequence of the use of an analogical model for a PISA type question is addressed in the project by two types of measures: i) Tutorials are used for discussion on the limitations of metaphors or analogical models in scientific work. ii) Teachers dedicate some time in tutorials and personal interviews with students to discuss beliefs and attitudes as regards their scientific concepts (Taylor & Lyons :2008). These representations are thus corrected by engaging in metacognitive reflections spanning tutorials and the classroom, by means of the support structure.

Conclusions. The initial results of the project are very encouraging insofar as permanence in school for students at risk has increased over 30% and academically students do seem to develop their capacity to deal with PISA type questions by means of this support structure in comparison with students without such a support in control groups. Evidence is still in the process of being analyzed and will be ready in approximately a year.

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The Organisation
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The Organisation for the Prohibition of Chemical Weapons (OPCW) is the implementing body of the Chemical Weapons Convention (CWC or Convention). The OPCW is given the mandate to achieve the object and purpose of the Convention, to ensure the implementation of its provisions, including those for international verification of compliance with it, and to provide a forum for consultation and cooperation among States Parties.

Chemical Weapons Convention
The CWC aims to eliminate an entire category of weapons of mass destruction by prohibiting the development, production, acquisition, stockpiling, retention, transfer or use of chemical weapons by States Parties. States Parties, in turn, must take the steps necessary to enforce that prohibition in respect of persons (natural or legal) within their jurisdiction.

All States Parties have agreed to chemically disarm by destroying any stockpiles of chemical weapons they may hold and any facilities which produced them, as well as any chemical weapons they abandoned on the territory of other States Parties in the past. States Parties have also agreed to create a verification regime for certain toxic chemicals and their precursors (listed in Schedules 1, 2 and 3 in the Annex on Chemicals to the CWC) in order to ensure that such chemicals are only used for purposes not prohibited.

A unique feature of the CWC is its incorporation of the 'challenge inspection', whereby any State Party in doubt about another State Party's compliance can request the Director-General to send an inspection team. Under the CWC's 'challenge inspection' procedure, States Parties have committed themselves to the principle of 'any time, anywhere' inspections with no right of refusal.

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