Proceedings of the 2^{nd} European
Variety in Chemistry Education

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of the 2nd European Variety in Chemisty Education

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Preface

Charles University – Faculty of Science together with Division of Chemistry Education EuCheMS, Royal Society of Chemistry Tertiary Education Group and ECTN holds between 27 and 30 June 2007 in Prague its 2nd European Variety in Chemistry Education conference. The first one took place in 2005 in Krakow (Poland) and it follows in more than ten-year-long tradition of similar conferences held by the Royal Society of Chemistry and the Physical Sciences Subject Center of the Higher Education Academy in the United Kingdom.

The on-coming 2nd European Variety in Chemistry Education conference has been jointly organised by the Department of Chemistry Education and the Department of Analytical Chemistry of the Faculty of Science, Charles University in Prague.

The main aim of the conference is to share experience and expertise on various themes from curriculum development to educational techniques, and to support importance of chemistry education in the 21st century at the university level. The organisers expect that the conference will be a good platform for the presentation of new results gathered in this field of chemistry education not only in the countries of Europe but also in non-European countries. It is also expected that the meeting will offer a good background for the co-operation between teachers, chemists and programme managers from various tertiary level institutions.

The conference proceedings include seventy-two contributions – plenary lectures, oral and poster contributions – published by authors from Europe (Belgium, Czech Republic, Hungary, Germany, Finland, France, Ireland, Italy, Latvia, Lithuania, Poland, Slovak Republic, Spain, and United Kingdom), and also from the countries outside Europe (Brazil, Canada, Columbia, Israel, Mexico, and Turkey).

The main topics of the conference are:

1. Problem and context based chemistry education.
2. New methods in chemistry education.
3. Practical chemistry education.
4. Information and communication technology (ICT) in chemistry education
5. European and national educational programmes, projects and industry-education cooperation

Plenary lectures, each of which is devoted to the general problems of chemical education, are published in the introductory part of the proceedings. The first topic involves contributions aimed at general problems of science education, at new chemistry curricula and at related new ways of chemistry teaching. Experiences in new educational technologies are assembled in the second topic. The third topic is focused on research into practical chemistry education, work in the laboratory included. The contributions on the utilisation of information and communication technology (ICT) in chemistry education are collected in the fourth topic. At last, the European and national educational programmes, projects and industry-education cooperation are the gather up under fifth topic.

All the published papers make together a good overview of problems and issues related to chemistry education in various countries all over the world. We believe that the proceedings may become a good source of information for all who are interested in university chemistry education no matter where they live or teach.

Karel Nesměrák
editor of the proceedings

Hana Čtrnáctová
chair of the conference

The 2nd European Variety in Chemistry Education
was held under auspices of the following organizations

Charles University
Faculty of Science
http://www.natur.cuni.cz/

European Association for Chemical
and Molecular Sciences
Division of Chemistry Education
http://www.euchems.org/

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Tertiary Education Group
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Trainers of Chemistry Teachers – What We Know About Them and Their Work?

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Summary. The course and effects of chemistry teachers' education depend mainly on the trainers involved in this process. Qualifications required by trainers of chemistry teachers include knowledge of chemistry, psychology and pedagogy as well as currying out research in chemical education and practical knowledge about work at school. The hitherto studies show that staff responsible for science teachers' education is differentiated with respect to preparation for proper performing of their duties. There were formulated some conclusions about conditions of improvement in this state.

Introduction

Education of a good teacher of chemistry is a very difficult task and decides about effects of his/her future work. She/he must possess good knowledge of chemistry obtained during the studies and skills concerning methods of teaching. These skills include among others planning of long term teachers' work, preparation of workplace, planning and conducting lessons, analysis and verification of the course and effects of teachers' work as well as some other special teachers' activities [1]. Their acquisition requires combination of chemical knowledge with that in the field of pedagogy and psychology. However, trainers of chemistry teachers should possess such knowledge in a larger range. Their preparation for performing this role as well as ideas and beliefs affect significantly education of future teachers. Therefore determination of optimal qualifications they should possess is necessary. Referring it to the current knowledge concerning the staff involved in teachers' training, will enable formulation of conclusion which will improve chemistry teachers' training.

Training of chemistry teachers

Independent of teachers' education system in a given country preparation for teachers job includes two basic elements – knowledge of the subject taught and knowledge how to teach. The most frequently a professional teacher training course is held during studies of a science subject. Classes in methods of teaching are condacted by staff of Faculty of Science or Faculty of Education. In Poland, like in many other countries, departments of science subjects education are the parts of Faculties of Science. This means that *e.g.* students of chemistry can choose a course qualifying for a teacher's job that is run by the Department of Chemical Education included into the Faculty of Chemistry.

The curriculum of the typical professional chemistry teacher training course is of interdisciplinary character and combines chemical knowledge with elements of knowledge in pedagogy, psychology and sociology. This can be illustrated using the example of one the basic skill acquired during such course by prospective chemistry teachers. Planning the chemistry lesson for a given theme, students analyse teaching content, which requires chemical knowledge. At the same time they determine a probable course of reasoning used by pupils during this lesson. For this item knowledge in the field of psychology is necessary. Knowledge of pedagogy will be indispensable for planning of the organization of the lesson. Sociology is helpful where achievement of assumed aims of lesson will depend on taking interpersonal relations into account.

A characteristic feature of the teaching methods classes is also the fact that they must combine theoretical and practical knowledge. Its larger part should be held at schools where students will observe chemistry lessons and then they will conduct them.

Qualifications required by trainers of chemistry teachers

Improvement of science education level and connected with it suitable training of science teachers is at present one of the significant aims set by countries tending to achieve economical and social development. Possibility of improving the teachers' education depends on possessing information about its functioning. Therefore there was prepared a document by Eurydice (The information network on education in Europe) in which the analysis of quality assurance in teachers' education was made [2]. It was assumed that the factors that should be considered during evaluation of teachers' education are: the content of the teacher education curriculum provided by the institution; teaching methods; assessment practice; the balance between professional training and general education; school placement; partnerships with school; human resources management; trainer/student ratios; student performance; student attitudes (motivation); students' opinions on the education they receive and infrastructure. Directly connected with teaching staff is "human resources management", according to which the qualifications required by teachers trainers or their continuing professional development should be evaluated. The other factors depend also on preparation for performing this role as well as on ideas and beliefs of teachers' trainers, for example elaboration of curriculum, applied teaching methods or infrastructure organization. It means that they will largely influence on course and effects of teachers' training

Qualifications required by trainers of chemistry teachers first of all result from the contents of the classes conducted by them. They must be educated in chemistry which is indispensable for many reasons. Without it, estimation if the teaching content is substantially correct is not possible. Good knowledge of chemistry and cognitive psychology is indispensable to determine the reason for difficulties many pupils come across during chemistry lessons. Knowledge of psychology is the basis for getting students acquainted with the factors influencing the course and effects of process of chemistry learning. Getting students familiar with organization of educational process requires knowledge of pedagogy from trainers of chemistry teachers.

Only knowledge in chemistry, psychology and pedagogy is not sufficient to be a good trainer of chemistry teachers. At present the results of chemistry education research are to a larger extent applied in teaching chemistry [3]. It indicates that trainers of chemistry teachers should follow the progress of this research and also carry it out by themselves. Of equally significant importance is practical knowledge of teacher job specific character. It can result from employment as a chemistry teacher that can be either earlier or simultaneous to the work at the university. They must also be aware of changes in teachers training educational system resulting many for reasons, for example from the Bologna Declaration [4]

Acquisition of the above mentioned qualification requires much work, time and first of all suitable predispositions. However, it is necessary to be aware that didactic and scientific work of trainers of chemistry teachers is not always sufficiently appreciated in the society of chemistry researchers.

What we know about trainers of chemistry teachers

Preliminary information in this respect was provided by the studies carried out a few years ago initiated by the Commission for Science Education functioning on behalf of the Polish Biological, Chemical, Physical and Geographical Societies [5]. They showed that the staff responsible for science teachers' education are differentiated with respect to preparation for proper performing of their duties and do not always guarantee sufficiently high level of science teachers' pre and post-graduate training. Some trainers of science teachers did not satisfy fully the above requirements. There were cases that choice of job was not the effect of their conscious and motivated decision but resulted from other factors. More and more frequently the heads of science education departments are scientific workers having achievements in science but not experience connected with the specific character of this department. This research was referred to the whole circle of trainers of science teachers, however its results reflect quite well the situation connected with trainers of chemistry teachers.

The positive example of position and care about development of the staff involved in science teachers' training is Germany. A few years ago due to poor scores of German pupils in science according to the PISA assessment some actions were undertaken to improve science teaching level which also included trainers of chemistry teachers. Of significant importance for development of qualifications required by trainers of chemistry teachers are also actions initiated by the European Commission such as the European Network on Teacher Education Policies (ENTEP), or the projects realized within the Socrates program aiming at improvement of pre- and in-service training of science teachers. Young trainers of chemistry teachers can profit much from summerschools for science education PhD students organized by the European Science Education Research Association

Conclusions

Positive changes in qualifications required by trainers of chemistry teachers will first of all depend on creating conditions encouraging young, clever, suitably motivated chemistry graduates to undertake this job. It is necessary to continue research whose aim is to determine important factors decisive for proper course and effects of chemistry teachers' education including the trainers involved in this process. Various forms of international collaboration provide great chance for development of qualifications required by trainers of chemistry teachers.

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Research-based development of exercises for heterogeneous groups of 1st year students of chemistry, life sciences and future chemistry teachers

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Summary. Polyvalent Bachelor courses demand structures and exercises for heterogeneous learning groups, regarding a) different knowledge backgrounds and b) different study interests. The presentation will explain a structure for introductory chemistry courses for chemists, non-chemists and chemistry teacher students and will discuss first results of empirical studies, monitoring the pre-knowledge, learning results and self-efficacy estimations.

Following the Bologna declaration, new structures of chemistry courses have been introduced at German universities. The University of Oldenburg offers chemistry courses for future chemists, non-chemists (*e.g.* biologists) and chemistry teachers. In co-operation between the responsible lecturers of all first year modules, a structure of lectures and exercises has been developed, based on and accompanied by empirical research (carried out by the department of chemical education / Chemiedidaktik). While the lectures within a module are identical for all students, the exercises are designed according to different levels of pre-knowledge, mandatory understanding for future studies and different interests referring to the areas of study. The structure will be evaluated and optimised based on results in exam papers and empirical data. This paper will discuss the empirical background, the design of the exercise courses and the first evaluation results.

Research-based development of exercises

Since 2005, all 1st year students of the introductory chemistry module have to fill in a paper and pencil test and an additional questionnaire in the first week of term, in order to be able to react to different levels of pre-knowledge. The content knowledge test items and the tasks for the exercise courses were compiled according to chemistry school curricula and the German National Standards of Chemistry [1], important concepts of the first year chemistry modules [2] and daily-life applications [3, 4]. The additional questionnaire investigates the students´ self-efficacy [5, 6] and self-estimation of their knowledge and abilities, regarding their studies of chemistry. These results are compared with the results in the content knowledge test to investigate whether the students are able to evaluate their own knowledge, abilities and weaknesses correctly.

The data of 2005 and 2006 were analysed statistically (using the program SPSS) and the results were given to the lecturers and to the tutors of the exercise courses.

These exercise courses have been organised by fields of study (*e.g.* chemists and non-chemists), but also by different levels. All students had to work out basic level 1 – tasks, chemistry students were also given level 2 – tasks and chemistry teacher students have additionally got tasks looking at school chemistry demands in relation to their own studies. The tutors – mainly student teachers in their second or third year of study – did not only get the tasks and test results for their exercise groups but also additional information on specific learning difficulties and approaches of teaching and learning, *e.g.* for the topic of stoichiometry. They have met regularly to exchange their experience and to get further support by a doctoral student in chemistry education, who coordinates the design and evaluation of the exercises and test instruments.

First results, conclusions and outlook

First analyses of data show significant differences of pre-knowledge according to the attended years of chemistry courses at school, while no correlation between the test results and the fields of study (life sciences, chemistry, and chemistry education) has been detected for the first trials. A comparison between the results of the content knowledge test and the students´ estimation of their self-efficacy presented a much better self-estimation than the real test results proved to be.

Regarding the different areas of chemistry, the results show that the knowledge about basic concepts of chemistry differs enormously. While, for example, the test results were rather satisfying for items dealing with structures (*e.g.* NaCl, methane), many students had difficulties with items where they had to formulate equations (*e.g.* Mg + H_2SO_4). We have also found well known misconceptions of empirical studies about school chemistry, for example for reactions of acids and bases or for the concept of chemical equilibrium [7, 8]. Regarding the latter, 30 % of the students believed that the concentrations of educts and products were equal for the equilibrium state, 20 % did not get the idea of a dynamic process. Only 50 % gave the correct answer.

These results had been discussed with the lecturers and tutors who were asked to put a special emphasis on the difficult areas during their courses. The results have also lead to the design and offer of additional tutorials for those students who did not have any background knowledge, *e.g.* about the correlation between the amount of substances and the number of atoms or about the rules for the formulation of a chemical equation.

Further activities are aiming at enlarging the variety of tasks for different interest groups and at the design of special tasks for teacher students. Based on experiences with the project *Chemie im Kontext* for upper and lower secondary education [3], we have started to embed basic chemical problems into different contexts, *e.g.* the calculation of stoichiometric proportions for contexts of food production, environmental problems, medicine or the chemical industry [9]. A similar design for tasks and supporting tools shall be used for the different exercise groups, too. Evaluation studies should investigate the development of students´ interest for chemistry as well as the understanding of the underlying basic concepts before and afterwards.

For teacher students, we are interested in comparing their knowledge and understanding of chemical concepts (content knowledge) with their abilities to evaluate teaching and learning approaches and tools for the same chemical concepts (pedagogical content knowledge [10]). Further studies will be carried out in this area, too [11].

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Curriculum Modernization in Chemical Education

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In our opinion a fundamental demand on chemical education today is to communicate core principles of chemistry in close combination with everyday life experiences of students as well as with convincing applications from modern science and technology. According to this requirement, research in chemistry education is challenged to develop experiments, teaching concepts and teaching materials which together enhance the interpretation and communication of chemistry in a way, that it is both, exciting and understandable.

For modern chemistry curricula we demand the cross-linking of the following categories:

- individual competences and chemistry-specific contents
- systematics of chemistry and contexts from everyday life, technology and the environment
- well-established contents from chemistry and new topics from research
- printed and electronic media

In the lecture own contributions to experiments, concepts and their integration into the curriculum are presented.

Four examples of phenomena were chosen, which are prominently important in the fields of smart materials, life science and environmental science. Their common feature is the role of light within the underlying physical and chemical processes.

The molecular processes taking place during the conversion of electric energy into light energy (Fig. 1a) and vice versa during the conversion of light energy into electric energy (Fig. 1d) are traced by two experiments, which can be explained by typical terms from electrochemistry used in the chemistry classroom, such as “electrolysis”, “galvanic cells”, “redox reactions”. The processes take place in energy-saving LEDs (light emitting diodes) and OLEDs (organic light emitting diodes) and in so-called dye-sensitized cells, an innovative kind of solar cell. From a didactic point of view, in contrast to photovoltaic cells made from silicon, dye-sensitized cells can be used to explore the conversion of light into electric

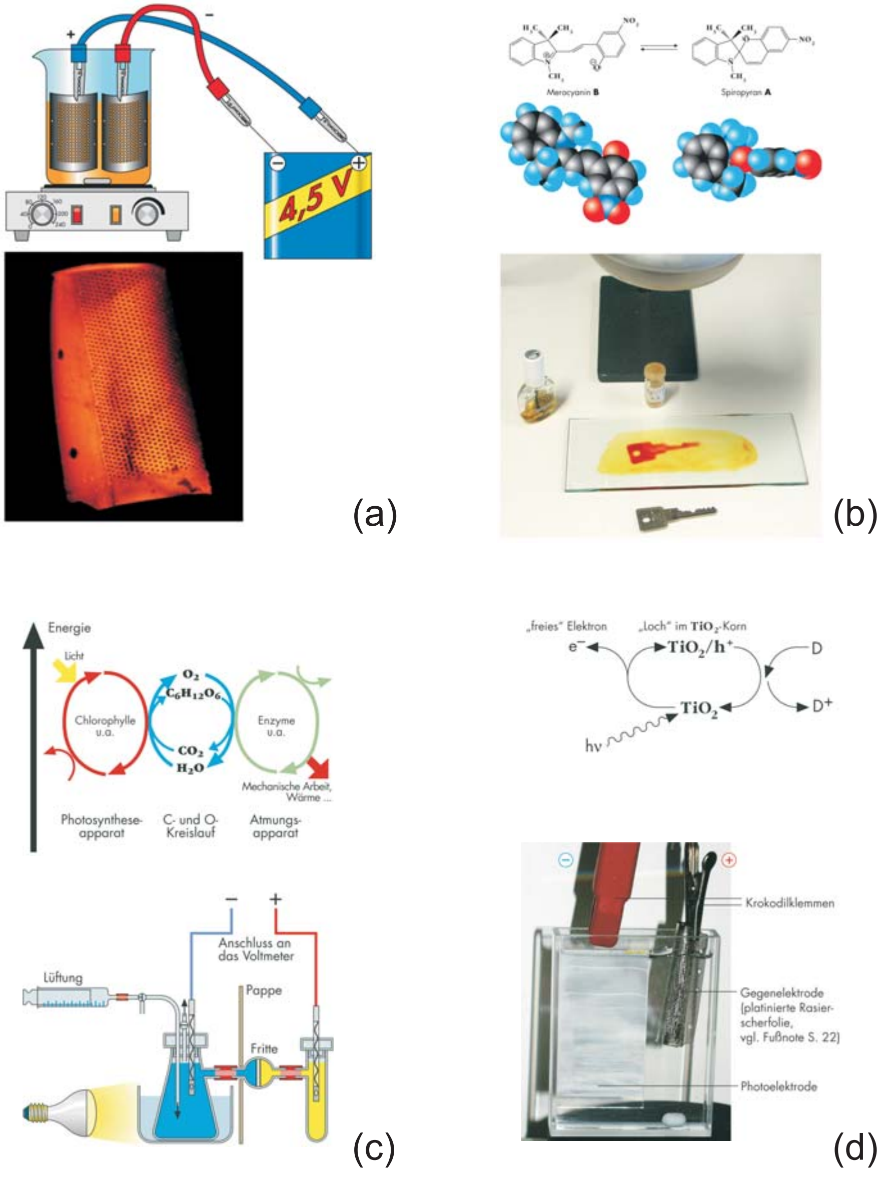

Figure 1. Novel classroom experiments for curriculum modernization in chemical education: (a) electro(chemi)luminescence, (b) photochromism, (c) simulation of the reaction cycle photosynthesis-respiration, and (d) photogalvanic cell.

current step by step in an experimental approach. In order to understand the experiments, a theoretical concept is needed which should be as simple as possible but able to explain all the processes involving light at a first reasonable level for school chemistry. The concept mentioned is the concept of the ground state and the electronically excited state of molecules and other kinds of particles, which was coined by N.J. Turro as *"the heart of all photoprocesses"* [1].

In the experiment on photochromism (Fig. 1b) a substance acts like a chameleon, which reversibly changes its colour if irradiated by differently coloured light. The experiment is suitable to investigate the reaction path of a photochemically driven reaction and the main differences between thermic and photochemical reactions. Dealing with this experiment, the limited meaning of some terms usually introduced in the chemistry classroom, *e.g.* "thermodynamic equilibrium", becomes obvious. Newly introduced terms for biological systems, smart materials and the environment such as "molecular switches", "photostationary equilibrium" and "thin-layer photochemistry" are explained by different examples.

A fourth experiment "Photo-Blue-Bottle", is demonstrated in its basic version and explained also in a more advanced version. It simulates the carbon cycle in the biosphere, that is, the cycle of photosynthesis and respiration (Fig. 1c). The analogies between the model experiment and the naturally occurring processes are explained. They refer to the reactants and their function (substrate, photocatalyst, electron donor and acceptor), and on the types and energetics (endergonic light driven reaction, conversion of light into electric energy, storage in the reduced species, exergonic oxidation) of the reactions taking place. The differences between the "Photo-Blue-Bottle" experiment and the naturally occurring processes are pointed out as well.

The selection, presentation and discussion of the experiments is meant to give an insight into our curricular research and should also hint at the scientific approach to new knowledge.

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Assessment of beyond (Just) “Knowledge” – A Doable Practice in Tertiary Chemistry Education

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Summary. Given the current striving for sustainability worldwide and the consequent paradigms shift from unlimited growth-to-sustainable development, the corresponding paradigms shift in science education – such as from dealing with problems in isolation-to-problem solving in complex systems – is unavoidable. The latter constitute a major component of the shift from algorithmic LOCS teaching – to HOCS-developing learning. In our test-oriented society a HOCS-promoting assessment is the key for a meaningful change to take place; the assessment of *beyond* “knowledge” in chemistry education is a *must*, if we want our students to become independent critical system thinkers, capable of evaluative thinking/decision making and problem solving. Selected examples of “how to do it”, here presented, demonstrate that the assessment of beyond (just) knowledge is a doable practice in tertiary chemical education.

Introduction/Background and Rationale

Given the current striving for sustainability worldwide and the consequent paradigms shift, such as from unlimited growth to sustainable development, correction to prevention and from options selections to options generation, the corresponding paradigms shift in education, is unavoidable. In science education, tertiary chemical education included, paradigms shift such as from “reductionist”-to-system critical thinking, answering-to-questions asking, and dealing with issues/problems in isolation-to-problem solving in complex systems, constitute major components of the contemporary overriding shift – from algorithmic teaching requiring, mainly, lower-order cognitive skills (LOCS) – to higher-order cognitive skills (HOCS)-developing learning (Table 1) [1, 2].

Indeed, a dominant component of the current reform in science education is a purposeful persistent effort to develop students’ HOCS of question asking (QA), critical thinking (CT), system (lateral) thinking (ST), decision making (DM) and problem solving (PS), as opposed to traditional algorithmic based LOCS, in the context of both – the specific contents and processes in the sciences and the interrelationship/interfaces of science-technology-environment-society [3, 4]. In reality, however, the development of the former leading, hopefully, to students’ acquiring the capabilities of ***evaluative thinking*** and ***transfer*** [5], is rarely actually pursued, in science and chemical education at all levels.

Table 1. Paradigm shifts in Science/Chemistry, Technology and Environmental Education

From:	***To***:
Teaching	Learning
Algorithmic, LOCS teaching	Higher-order cognitive skills (HOCS) learning
Knowing facts and applying algorithms to solve exercises and accomplish tasks	Conceptual learning for decision making, problem solving and transfer
Imparting knowledge (for "knowing")	Developing HOCS for proficient *doing*
"Reductionist" thinking	System/lateral, critical thinking
Dealing with topics in isolation or closed, isolated, highly controlled components	Dealing with *complex*, open systems
Disciplinary teaching (chemistry, biology, physics, *etc.*)	Interdisciplinary teaching
Science and technology per se (in dealing with environmental/sustainable development)	Integrating science-social science in the science-technology-environment-society (STES) context
Teacher-centered, authoritative, frontal instruction	Student-centered, real-world, project/problem-solving/research-oriented team learning

Accumulated experience and research-based evidence, worldwide, suggest that the persistent implementation of specifically-designed and developed HOCS-oriented promoting teaching strategies and assessment methodologies constitute the key for the attainment of meaningful/significant both interdisciplinary and disciplinary "HOCS learning" (*e.g.*, [5, 6]), in tertiary science – and secondary chemistry teaching, respectively. Significantly, in our test/assessment-oriented society and its educational systems, tertiary level included, the examinations-based assessment is, therefore, the starting point, continuing focus and determinant factor for any meaningful change to take place. Thus, the assessment of *beyond* "knowledge" – the contemporary cornerstone of examinations/testing in chemistry education – is a *must*, if we want our students to become independent critical system thinkers, capable of evaluative thinking, decision making and effective problem solvers in the chemistry education and the science-technology-environment-society (STES) contexts.

Illustrative ("How To Do It") Examples

The following are selected examples of (a) HOCS-promoting examination types, which were successfully applied in chemistry and science education courses in tertiary education; (b) questionnaires used for assessing science students' QA and DM capabilities, either just "base-lines", or within formative/summative pre-post design; and (c) illustrative chemistry and/or STES-oriented exam question, requiring HOCS for their resolution. All these demonstrate a doable practice, evidenced by research, going beyond "knowledge" – to *question asking*, *decision making* and *problem solving* in students' assessment in tertiary chemistry (and science) teaching.

Example 1. The Eclectic Examination (EE) [8] **and the Individual Eclectic Examination (IEE)** [9]
The Eclectic Examination constitutes a means for the assessment of students' performance on HOCS-requiring tasks assignments and missions. It consists of:

QUESTIONS – to be answered
PROBLEMS – (requiring HOCS for their resolving)
TASKS – to be performed
SUGGESTIONS – to be developed
IDEAS – to be generated and rationalized
OPINIONS – to be defended or rejected
STIMULATIONS – to respond to
EXPERIMENTS – to be suggested-/devised/designed
ALTERNATIVES – to be chosen or generated and backed consistently

The IEE is a HOCS assessment device based on, and constructed in accordance with, each *individual* student's, or group's, mid-term, or final project, or mini-research assignment. It consists of the same elements of the EE but, by definition, has no one, pre-determined, standard format and thus it is different in different settings and contexts.

Example 2. Examinations where Students Ask the Questions (ESAQ) [10]
The core element of the ESAQ is a pre-arranged oral examination class session in which the course professor is examined by her/his class students. In this contradictory to the traditional, algorithmic-type "pencil and paper" class examination, the students examine their professor *orally*, using their home-formulated two-to-three relevant and *meaningful* questions related to the course, one of which is to be used for the class examination, followed by their submission to the course professor – for grading – towards the end of the examination session. Two-to-five of the students' formulated questions (which have not been treated during the class session) are selected by the professor and redistributed to all course participants to serve as a student-designed take home examination. The latter (students' responses) are reviewed, graded and returned to the students accompanied by appropriate feedback (individually, in writing, and collectively, orally, within a class session discussion).

Example 3. The HOCS evaluation questionnaire (HEQ) for the assessment of Question Asking and Decision Making capabilities [9].

1. Read the following paragraph. Formulate three questions that you would like, or think are important, to ask, concerning the subject(s) dealt with in the paragraph.

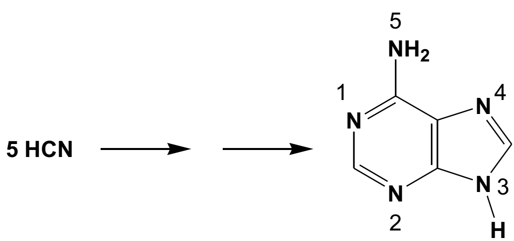
   "Resources and energy: What are the future options and alternatives?"
   Almost every aspect of the Western world is based on the consumption of energy and products derived from the finite crude oil and natural gas resources. There are sufficient reserves of coal that could lead to the production of enough synthetic fuel and gas for the present times. However,

*energy alternatives (*e.g., *solar, wind, tide and waves) should be developed to satisfy the need for the production of electricity. This would involve the substitution of diminishing resources by available non-finite resources. Nuclear energy is another possibility. Future alternatives concerning resource exploitation and energy supply require an in-depth analysis and intelligent decision and the sooner the better.*

2. In your estimation, is the subject dealt with in the paragraph relevant to you? Explain.
3. Can you, based on the given paragraph (and the information it provides), decide on the desirable alternatives of energy supply in your country? Explain your answer.
4. In case you think that you need more information in order to decide, intelligently, on the desirable alternative, formulate two questions that you would ask for answers before making the decision.
5. Formulate two criteria that guided you (or will guide you) in your decision concerning the most desirable alternative.
6. Briefly explain the pros and cons of the alternative(s) that you have chosen with regard to future implications. Compare your alternative(s) with any other alternatives that you did not choose.
7. In your estimation, are (1) *societal* and/or (2) *values* and/or (3) *political* (distinguished from the scientific-technological-environmental) considerations involved in your decision/choice of the desirable alternative? Relate to 1, 2, 3 in your answer and explain.

Questions [12, 13]

1. One of the best ways of checking the purity of PCl_3, which is used in the manufacture of saccharine, is to compare the mass spectrum of a sample with that of pure PCl_3. Chlorine has two naturally occurring isotopes (^{35}Cl and ^{37}Cl, relative isotopic abundance ~75:25, respectively), whereas phosphorus has just one (^{31}P). In your opinion, is the given relative isotopic abundance for the Cl atom relevant to the method here presented for checking the purity of PCl_3? Explain and defend your response.
2. One of the theories concerning life formation on earth attributes a special importance to the HCN molecule which was, apparently, abundant in the primary global atmosphere. Thus, for example, it is possible to envision adenine (**1**) as an HCN pentamer



1

a) Is **1** an aromatic substance? Rationalize.
b) Which of the adenine's nitrogen atoms (1–5) is the most basic? Explain and rationalize.
c) Which spectroscopic method (UV, IR, NMR) would you suggest to use for determining the adenine structure? Explain!
d) Suggest at least one chemical reaction to apply to adenine, from the result(s) of which you would be able to obtain some idea about the chemical properties of **1**.
e) In your opinion, are hydrogen bonds possible in **1**? Explain and rationalize.

Conclusion

Our accompanying research findings and longitudinal application of this and related HOCS-promoting educational practice suggest that, although the road towards HOCS learning and STES-oriented chemistry literacy for sustainability is rocky, the assessment of beyond (just) knowledge is, nevertheless, a doable practice educationally and, therefore, it not only can, but also should be done!

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Communicating Science: Writing

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Summary. This work discusses how Communicating Science can be used to teach Science and also Communication into undergraduate courses. A Communicating Science activity was introduced to students of the first term of Chemistry undergraduate course. During these classes students had the opportunity to discuss the role of Communicating Science to society, the strategies to write a text for a variety of audiences, and to discuss Science subjects. Classrooms activities that feature speaking, reading and writing orchestrated with Science subjects were used to enhance the cognitive processing of information and communication.

Introduction

Since the beginning of the civilizations, humans have tried to understanding the Nature. Ancient civilizations have proposed models to explain the existence of Universe and the role of human been.

At the beginning, people involved in these studies of the Nature were called philosophers. Around the 16th century a new methodology to investigate Nature has appeared. It was the beginning of the Sciences activities. The adepts of this new approach were called naturalists and around the end of the 18th century they were called scientists. In the past time, the communication between people studies Nature was done by direct contact, letters and books. However, the 20th century has testified an enormous change in the communication of scientific information. Scientists use specialized journals and magazines to relate their results and proposals. They use a writing way, which is specific to their colleges of scientific activities. It is very difficult to general audiences, which are not involved with the issue to understand the scientific publications. This proceeding has been very efficient to the Science developing but it has generated an enormous gap scientific community and the society. This gap has created the necessity of communicating science activities, which get information from scientists and communicate them to society, using vocabulary can be understood for every one [1].

The process to disseminate scientific knowledge to the population is called scientific literacy, and it is the must important objective of the communication of science.

Besides the teaching sciences, to prepare students to communicate is essential. They must be able to communicate orally and written form. Both skills require practice, and thus, the science curricula should provide opportunities for settings in which speaking and writing skills can be enhanced. Science educators have argued that science classrooms ought to be active learning environments in which students construct personal meanings within the classroom community [2]. Some constructivist approaches have emphasized the personal construction of knowledge in the individual experiences within the learning environment are paramount, whereas others have underlined the importance of social processes in mediating cognition [3].

Communicating science can be used to teach the sciences and also communication.

There are two ways to use material of communicating science in the education process: students can read (or watch movies or play special games, *etc.*) to learn a number of issues are important but will not be discussed in the classroom. They can also to produce communicating science activities. In this case they will need to choose an issue, learn about it, and then write about it, but they can not use the same language of the texts book and specialized magazines. They should produce texts that general audience can read and understand.

With the objective to teach Science and also communication, a communicating science activity was introduced to 60 students of the first term of the course of Chemistry.

Methodology

During these classes they had the opportunity to discuss the role of communicating science to society, the strategies to write a text for a variety of audiences, and to discuss science subjects. Two experiences were done, in two different situations. One, 40 students, has occurred in a small city in the countryside of São Paulo state and the other, 20 students, in the capital.

For one of them, 40 students, the theme chosen was “Water”. The activity was called “The issue of water in Barretos region”.

The students should do some research and reading about collect, treatment, distribution and discharge of water in a city. Afterwards they should choose a specific and real community and to write a text about the use of water in it. The communities chose were: some small cities in São Paulo state (where students live), some nearby plants of sugar cane which produce sugar and ethanol, one fertilizer industry, one meat industry and one orange juice industry.

On the second case the 20 students could choose any subjects between themes that were in evidence on media like nanoscience, molecular biology, biodiesel, *etc.*

To compare the two groups of students we considered the texts produced by them focusing on the articulation of scientific content and communicating strategies that had been presented on their productions.

In the first case, besides to read about water, the student had to visit the chose community, to make interviews with persons work there, make pictures with typical equipments, which are not present in every system of water using.

On this way, students have read a lot, and also have make decisions about appointments with workers, adequate questions in interviews, and pictures to be taken. Then, they have write texts with communicating science aim.

In both groups students were been prepared to communicate with different audiences, focusing on written texts that were published in an electronic science magazine [4].

The use of writing activities as a learning strategy has received considerable theoretical support from scholars in different kinds of scholar situation [5, 6].

Considering the knowledge should be socially constructed, in a social cultural context, there was the preoccupation to insert the theme in the student contexts. It is interesting to observe, most of them work in the industries they chose to talk about. This way they could have write about their own reality. This has motivated them a lot.

On this study, the analysis of the texts elaborated by students have been used as qualitative method of analysis.

Results

According to the texts that were elaborated by students the collaborative work with analytical writing enhances the retention of science knowledge by students. Analyses of these texts suggest that writing was used for organizing their ideas into a coherent response that respected grammatical and syntactic conventions. Writing or explaining requires a reflective logical stance that encouraged students to refine their thinking thereby enhancing their conceptual understanding. Critical thinking and writing has been improved on this class. As students write, they are creating a text for others to read. Students' comprehension improves when they are called upon to reformulate in their own words what they have learned. They build systems of organization and make new information their own.

The findings suggest that speaking and writing are important for sharing, clarifying and distributing knowledge among other students, while explaining and formulating ideas together are all important structure during class discussions about preparing a text to communicate science.

Writing skills are really important tool for the retention of science knowledge, but that speaking skill are a necessary precursor on a collaborative work for communicating science.

Communication to certain audiences, *e. g.*, high school students' and teachers or undergraduate students, can positively affect interest in science and retention. Recruiting students into science and technology fields can be enhanced through effective communication of the excitement of science.

Implications

We believe that language-based learning strategies can be introduced in the science classroom for enhancing the process of education, considered as that knowledge is socially constructed within a socio-cultural context. On this way, we introduced science students at university level to Communicating in Science Education subject, especially about writing, and the ability to develop a coherent, written argument. Classrooms activities that feature speaking, reading and writing orchestrated with science subjects were used to enhance the cognitive processing of information and communication.

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Discourse Analysis into the Preservice Training of Chemistry Teacher

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Summary. In this work, we present an approach on methodology of teaching where students are required to analyze sequences of chemistry teaching in secondary schools. We utilize discourse analysis to help preservice chemistry teachers to reflect on their pedagogical strategies and discoursive interactions.

Introduction

The problem of educational innovations in chemical education might be properly treated by analyzing the complexity on the basis of methodology of teaching. The preservice chemistry teacher should have deep knowledge of the objectives on the classes, type of classes, topic of the course, preparation of students and other factors, that influence directly and indirectly the results of the educational process. The preservice teacher should know theoretically and practically each one the modern methods and to apply them correctly in practice, together with other methods and technologies [1].

The significance of talk between students and their teachers, and between students, is recognized. Socio-cultural theories of learning draw on Vygotskian theory can provide a way of considering these issues in terms of the way ideas developed on the broader social plane of the classroom may be appropriated by individual learners [2].

The research presented here explores the role of interactions between the teacher (preservice teacher) and students during chemistry class. The aim of the study is to develop an understanding of the role of discoursive analysis of interactions between teachers and students on the preservice courses and to be able to provide further guidance for teachers on how to consider this issue when they prepare class activities.

Methodology

A multiple case study methodology has been adopted for the study. The data for this case study consisted of: video-stimulated-reflective-dialogues in which video clips of recorded class were watched with the class preservice chemistry teachers and their interpretations were discussed, as weel the observations of a sequence of lessons (episodes) in the classroom with data recorded using both fields notes and digital video and analysis through an interpretative analytical framework drawing on discourse analysis. The analytical framework draws on the work of Mortimer and Scott in which episodes of lessons are characterized on two dimensions: interactive-non interactive and authorative-dialogic [3].

The two dimensions can be arranged to generate four classes of communicative approach according to figure 1.

	INTERACTIVE	*NON-INTERACTIVE*
DIALOGIC	*Interactive/Dialogic*	*Non-interactive/Dialogic*
AUTHORITATIVE	*Interactive/Authoritative*	*Non-Interactive/Authoritative*

Fig. 1 Four classes of communicative approach

The integration of digital video into the research process that would facilitate and support classes in which teachers and preservice chemistry teachers jointly analyzed digital recordings of lessons in order to build theories of teaching and learning. Preservice chemistry teachers are of course present in the collection of the data but are often less likely to be involved in the analysis of the data. Using video-stimulated-reflective-dialogues to promote reflection seems to help preservice teachers to reflect on their own teaching and they are supported to construct their own meaning of teaching practice. Working in this way, help them to transform research findings into practical action which has an immediate impact on classroom practice and pedagogy.

Results

We use digital videos to document chemistry teaching and learning processes in order to support the discoursive interactions analysis of the classroom and to reflect jointly with preservice chemistry teachers about their own learning process. The problem in analyzing videos is the complexity of data. So to try to solve this problem, we try to find ways to reduce that complexity for preservice chemistry teachers. We developed guidelines for reflective papers and edited some video clips focusing on some classroom episodes for example: introduction of practical lab class, standard discoursive interactions, etc. Students are required to analyze short sequences (episodes) of chemistry teaching in real classroom from high school.

According to our results that any kind of practice is the best way in preservice chemistry teachers training in which teachers (preservice) interact with students to promote meaning making on the social plane of chemistry classes.

Discoursive analysis provides a means of examining the text of a transcript and showing how meaning has been developed at different levels, both the more obvious content and also the less explicit messages about relationships between the students and about the nature of the subject under discussion and this approach is embedded within the analytic framework adopted here.

An extract from transcripts of the case as presented here to discuss how the analytic framework leads to here interpretation of the data.

The lesson was about Forensic Science. The episode is not presented here in its entirety. Before, students were introduced to forensic techniques and after that some case studies was presented for them. They were required to select among the available techniques which one was more suitable to help to solve their case study.

For this group, they had a piece of metal, and the problem is to try to identify if the spot on metal was blood. Students had some time to discuss and justify their choice, after that they made the test to notice if their option was correct.

(I) teacher: "So some students chose the phenolphthalein, do you think that they made the right choice? Do you agree?"

(R) students: (moving their head showing they agree)

(F) teacher: "OK, they chose the phenolphthalein, so what happens?"

(R) student: "The hydrogen peroxide react with phenolphthalein over the metal surface and we noticed that there wasn't blood"

(F) teacher: " Ok, there wasn't blood, Why?"

(R) student: " Because it took a long time to react and change the colour to pink"

(F) teacher: "Excellent. You are right. That spot wasn´t blood. You choose the right technique."

On this episode, the teacher discusses with students the simulated forensic problem where students were required to choose the most suitable forensic technique to try to solve their simulated problem. We can notice how they conducted the case studied. According to the discourse analysis the interactions between the teacher and his students generally followed an IRF pattern (initiation – response – feedback) in which the teacher interacted with some students. This episode can be characterized as taking predominately an interactive-authorative communicative approach. This conclusion was elaborated based on students analysis that was done with them.

The interactive approach engaged students to participate on the class activities. They had some peer discussions to justify the reasons of their choice. On this way they had possibility to elaborate their argumentation. The preservice teacher did not give the right answers but he was conducting the students to find the solution of that case study based on the scientific knowledge and help students on their argumentation.

The preservice teachers were really interested doing these analysis and they reflected about their own performance. Here we present just one episode of the lesson that took about 7 hours.

Implications

If we want to raise the quality of chemistry teaching and learning, it is important to know more about what happens in classrooms. Videos-stimulated-reflective--dialogues give us the chance to get an inside view, but even more they are a valuable tool to make preservice teachers reflect upon chemistry teaching and learning process.

On this way, digital videos can be used to initiate reflective processes and support the discoursive interactions analysis of the classroom.

We consider discoursive analysis an important tool to foster the professional development of teachers. In our point of view, learning as a social process, all participants are jointly responsible during these activities. We use digital videos to make preservice chemistry teachers reflect upon their pedagogical strategies and discoursive interactions, which preservice teachers and their teachers can use to reflect in a collaborative work about what happens in chemistry class, what indicates quality, what about their own learning process and which improvement might be necessary.

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In Search of Chemistry Students' Previous Ideas Related to Chemical Bonding

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Summary. Chemical bonding is a tough topic to be learned and taught. Revising the literature we found many alternative conceptions of high school students regarding this theme. University pupils have also a hard time getting along with this topic. So, we got involved in a research project whose aim is to improve understanding of chemical bonding in early university courses.

This paper presents the methodology employed, the selection of the sample and the written test used to find out university chemistry students' previous ideas, related to chemical bonding. We present some of our findings and our interpretation of them

Introduction

Chemical bonding is a tough topic to be learned and taught, and yet, it is central for understanding Chemistry. Revising the literature we found many alternative conceptions of high school students regarding this theme [1–4]. We also knew that our university pupils have a hard time getting along with this topic, and relating properties of substances with some "kind" of chemical union.

At the same time, we did not find General or Inorganic Chemistry textbooks that focused a unified approach [5] of chemical bonding, even though they included Pauling's electronegativity concept and, some of them Fajans' rules, all the texts that we reviewed presented three different and unrelated kinds of bonding: covalent, ionic and metallic.

So, we got involved in a research programme*) whose aim was to improve understanding of chemical bonding in university courses. Our first step in this research was to find out university chemistry students' previous ideas related to this theme. In this paper we talk about the methodology employed, how we selected the sample population, including the written test used and its application. We present some of our findings in quantitative graphs; we describe some of the previous ideas expressed by our pupils and our interpretation of the overall results. We will show that our students hold many of the reported previous ideas, as well as some new ones.

*) *Sponsored by Dirección General de Asuntos del Personal Académico (DGAPA) of UNAM.*

Methodology

We selected the tool to be applied to search students' previous ideas related to the theme and decided to use a written test. The test is made up of several open, multiple choice and false and true questions. We used a pilot group to test this instrument and, as a result, made some changes on it. Later on we picked up over 200 students from first (General Chemistry, third (Inorganic Chemistry) and fifth (Organic Chemistry)) semester, enrolled in different careers, at the Faculty of Chemistry, of the National Autonomous University of Mexico (UNAM). We applied the written test twice during the academic semester in each group, once before and once after the topic was approached in the classroom.

Our findings

Table 1 shows a summary of must difficult questions and the related topic, in decreasing order; so, question No. 10 was the must difficult for our students.

Figures1, 2 and 3 illustrate some of our results, the blue bars show the average grade got by the group of students before and the pink ones are the average grades got after the theme was approached in the classroom.

Table 1. The ten most difficult questions and related topic in written test

Question Number	Related topic
10	Unified bonding [5]
5b, 7	Structure of a metal (Al)
5c	A solid non metal structure (graphite)
5d	A gas (H_2) structure
5a, 22	An ionic compound (NaCl) structure
9, 27	Inter-intramolecular forces / properties
11	Role of valence electrons in bonding
16, 4	Role of electronegativity in bonding
24	Properties of substances / bonding
3	Bonding modalities

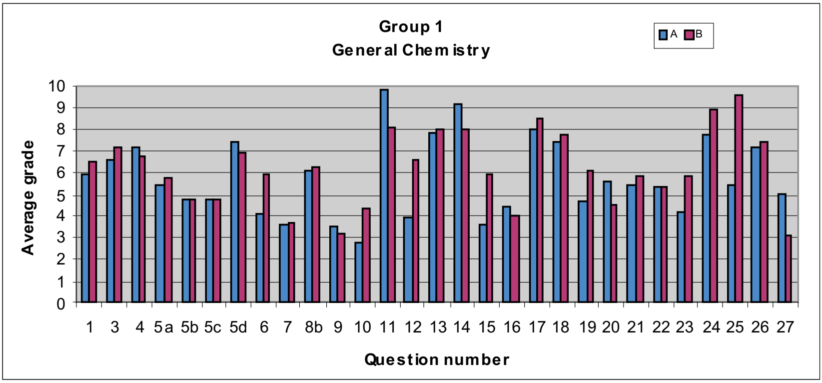

Figure 1. Results obtained in group 1 (General Chemistry) before (A) and after (B) the theme was approached in the classroom.

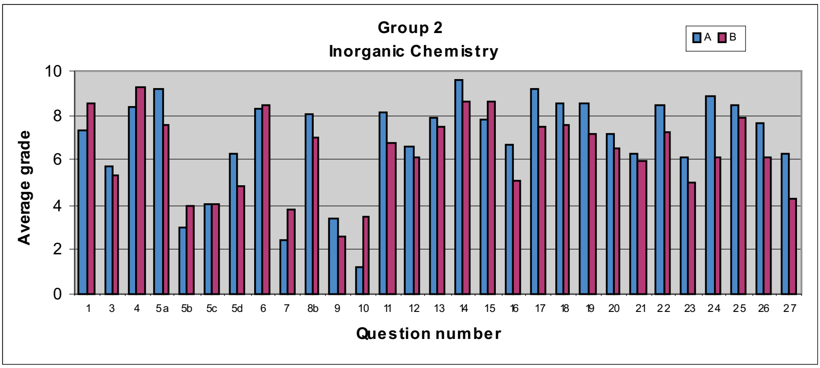

Figure 2. Results obtained in group 2 (Inorganic Chemistry) before (A) and after (B) the theme was approached in the classroom.

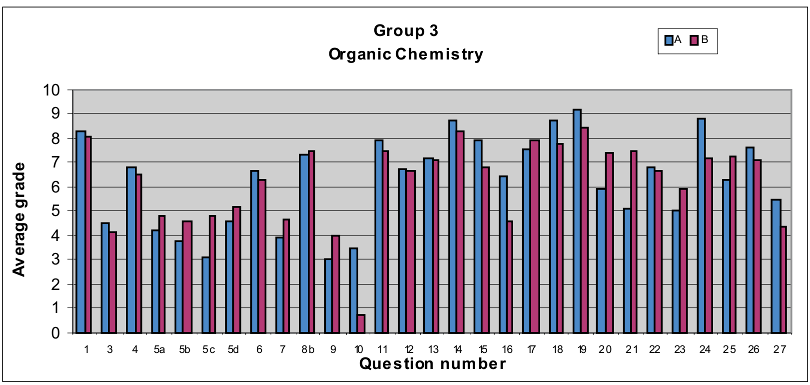

Figure 3. Results obtained in group 3 (Organic Chemistry) before (A) and after (B) the theme was approached in the classroom.

Our interpretation

We believe that university students' alternative conceptions related to chemical bonding have a scholar origin, and are closely related to the analogies used by teachers and textbooks.

The curriculum also plays an important role; since our students hardly know something about chemical bonding in metals; but, this topic is absent in General Chemistry, Inorganic or Organic courses.

Some of the previous ideas found can also be related to the historical development of the concept of chemical bonding, especially those related to the rigid classification that our pupils make of substances and materials, separating them into ionic (inorganic), covalent (organic) or metallic (something else), without understanding the electrostatic nature of bonding in all of them [5].

Conclusions

- It is very important to approach explicitly previous ideas of students in university courses; especially those related to chemical bonding, since this topic is central in learning and understanding Chemistry.
- We must change the way we teach chemical bonding and develop didactic strategies to promote conceptual change in our students.
- It is needed to develop new didactic materials and textbooks to support teaching and learning towards conceptual change.

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Equilibrium Problems: How To Solve Them

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Summary. Ionic equilibrium problems are solved using a set of formulae. Because of that, students are not able to solve ionic equilibrium problems in a systematic way: often a new problem is solved in different wrong ways. A logic approach based on chemical information developed about thirty years ago will be presented.

Introduction

As Henry Freiser warns us, the didactic of ionic equilibrium calculation must avoid *"the Scylla of oversemplification to achieve 'clarity' and the Charybdis of 'cumbersome' rigorous equations"* [1]. Ionic equilibrium problems in General Chemistry textbooks are still solved using some formulas derived from the Butler 5 % approximation rule [2]. The drawback of using memorized formulas to solve problems is that they are shortcuts and avoid a systematic reasoning. In practice, this approach leads the student to solve ionic equilibrium problems using some rote-learned formulas or an algorithm; they can solve problems without processing the information and referring to a correct chemical representation. The student has to ask himself questions in order to decide what formula to use: *Is this a buffer solution? Are we at the equivalence point? Is the hydrolysis appreciable? Can the dissociation of this weak acid be considered negligible?*

Sometimes, this approach leads to the application of a procedure that turns out imprecise or wrong results, because the student does not remember the hypothesis that make the approximate formula work. This method fails because the student cannot estimate the result with the necessary precision. Often, this method leads to correct results, but the logical and the critical thinking abilities of the student are used at a very low level. On asking students to find the hydrogen ion concentration of a water solution of acetic acid $1 \cdot 10^{-7}$ mol dm^{-3} ($K_a = 1.753 \cdot 10^{-5}$ mol dm^{-3}), much to my surprise, someone solved the problem in this way

$$[H^+] = (c_a K_a)^{1/2} = 1.32 \cdot 10^{-6} \text{ mol dm}^{-3}$$

where c_a is the total acid concentration. How is it possible that $[H^+] = 13.2 \times c_a$? (ref. [3]). Referring to acid solutions, textbooks always work examples where $[H^+] = c_a$ or $[H^+] = (c_aK_a)^{1/2}$ and where c_a is the total acid concentration, without ever considering the water ionization. In this way, students memorize a generalization of the hypothesis in the form *"All* p*'s are* q*"*; this is a logical implication: *p* implies *q*. In our case *p* is "acid solution" and *q* is "there is no need to consider the water dissociation" [4]. The same can be said about the Henderson--Hasselbach equation [5]: all these approximate equations fail under some circumstances.

The method here proposed uses a logic reasoning scheme that all students can apply and it also needs some information from the theory. This method improves the ability level of all students and lets poor students become better students. The ideal method has to:

1) have a great degree of chemical insight;
2) lead to a precise result.

If we define the percent of relative error E as the absolute value of

$$E = (1 - [H^+]_{approx}/[H^+]) \cdot 100$$

where $[H^+]_{approx}$ is the found result and $[H^+]$ is the correct result. The correct result is the result obtained using a sounding solution procedure from a chemical point of view and which satisfies the verification, taking the significant figures into account. A good method of calculation, using three significant figures, is one that produces results with E no greater than 1%.

How this method works

The method here proposed uses a problem solving approach [6]:

1) Find the problem and categorize it;
2) Represent the problem and evaluate the result;
3) Make a plan for the solution;
4) Carry out the plan;
5) Verify the result.

The categorization of the problem (buffer solution, acid-base titration, *etc.*) is useful because it can activate in the student's mind a useful scheme. So, categorization helps also in the representation step. The problem is represented using the information derived from the ionic equilibrium theory [7]:

1) Always the water is ionized according to the equilibrium: $H_2O \leftrightarrows H^+ + OH^-$ and always must be verified the ion product of water: $[H^+][OH^-] = K_w$. Sometimes the H^+ coming from the water ionization must be taken into account.
2) Strong acids and bases are completely ionized; ionic salts are completely dissociated [8]:
   $HCl \rightarrow H^+ + Cl^-$
   $NaOH \rightarrow Na^+ + OH^-$
   $NH_4Cl \rightarrow NH_4^+ + Cl^-$
3) Weak acids and bases are partially ionized; conjugate species undergoes hydrolysis: $NH_4^+ + H_2O \leftrightarrows NH_3 + H_3O^+$
4) Normally we use the mass balance equation and the electro-neutrality condition for verifying the correctness of the result, together with the invariance of the costant(s).
5) The only approximations allowed are of a numerical nature:
   $1.00{\cdot}10^{-2} + 3.45{\cdot}10^{-7} = 1.00{\cdot}10^{-2}$. The maximum tolerable error is 1 %.

Now, the student can evaluate the result: acidic, basic or neutral, using the *D* factor (difference between the acid-base balance equilibrium) and visualize the water equilibrium with diagrams, as suggested by Guenther [9]. When appropriate, at this point it is possible to redefine the problem and make a plan for the new solution. The student then carries out the calculations and from the obtained $[H^+]$ value can evaluate if $[H^+]$ derived from the autoionisation of water must be taken into consideration. At the end, the student must verify the correctness of the result by checking these equations:

1) Mass balance equation
2) Electroneutrality condition
3) Dissociation constant/s

If the conditions are fulfilled, taking significant figures into account, students know that they have solved the problem in the correct way. The method works independently from the concentration of the solution and a number of examples will be presented [10].

Conclusions

It is worth to point out that every ionic equilibrium problem can be transformed into a polynomial equation [11–20] and solved rigorously with the aid of computers. But, the main purpose of these calculations is to improve the logical thinking of students and the recognition of the chemical system they are dealing with. So, computer use does not replace the chemical reasoning required to solve ionic equilibriums. Furthermore, this method of solving ionic equilibriums converges quickly; iterating the procedure twice or, rarely, three times, one can obtain the correct $[H^+]$ value. This method has been used in our university for a number of years; it can be successfully used in all stoichiometric calculations encountered in general chemistry. It works for monoprotic weak acids (or bases): for acetic acid $1.00 \cdot 10^{-7}$ mol dm^{-3} this method leads to the same result as that found using Guenther's method [9, p. 37–38]. For poliprotic weak acids (or bases) it works independently from the ionization constant's ratio K_i/K_{i+1} [7].

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What Chemistry Topics Do Students Find Difficult?

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Summary. This study involves the identification of topics that Irish University students find difficult in Chemistry. It also investigates the affects that having done Chemistry as a school subject or not, Chemistry ability, Mathematics ability and Gender influences the topics students find difficult or very difficult. Students were asked to complete a questionnaire listing the topics covered in basic Chemistry courses, which asked them whether they found each topic difficult or easy. A six point Likert scale was used. The students were also asked to identify which five topics they found most difficult, ranked 1 to 5. This paper highlights the topics that Irish University students find difficult in Chemistry. Topics identified by Irish students are similar to results of studies carried out in the UK by Ratcliffe [1] and Scotland by Johnstone [2]. Having done Chemistry at school, Mathematics ability and Gender were also proven to have an effect on the topics students chose as difficult of very difficult.

Introduction

According to Johnstone [3]: *"Chemistry is a difficult subject for students. The difficulties may lie in human learning as well as in the intrinsic nature of the subject."* According to Chiu [4]: *"Chemistry is a world filled with interesting phenomenon, appealing experimental activities, and fruitful knowledge for understanding the natural and manufactured world. However it is complex."* As a result of the complex nature of Chemistry and the fact that it is one of the most conceptually difficult subjects on the school curriculum, it is of major importance that anyone teaching Chemistry is aware of the areas of difficulty in the subject.

Our aim was to investigate the topics covered in a general University Chemistry course and identify those topics that are perceived as difficult by the majority of students, in order to isolate the areas where extra help is required.

Pupils in Irish primary schools (age 5–12) have studied Science through a broad science syllabus called Social, Environmental and Scientific Education since 2003. For the first three years in Irish secondary schools pupils study a general Science course, which encompasses areas of Biology, Chemistry and Physics. For the final two years of their secondary education pupils have a choice to study the following science subjects: Biology, Chemistry, Physics, Agricultural

Science and Physchem (Physics and Chemistry). A detailed description of the Leaving Certificate Chemistry syllabus and the Junior Certificate Science syllabus can be accessed in [5].

Methodology

The Questionnaire

The questionnaire listed the different topics on the Leaving Certificate Chemistry Syllabus along with additional topics students would have studied in a General Chemistry course. The topics were listed in alphabetical order in an attempt to encourage students to think about the topic they were considering.

The main body of the questionnaire invited students to give their reactions to the different topics. They were asked to categorize the topics as difficult or easy, using the six point Likert scale shown on Fig. 1. This Likert scale was an amalgamation of the ones used by both Ratcliffe [1] and Johnstone [2] in their investigations.

The second part of the questionnaire was a free response question and invited students to identify the top five most difficult Chemistry topics in their opinion, number one being the most difficult topic, two being the second most difficult topic etc. This question was used to assess the validity of the results obtained from the first part of the questionnaire and to give students an opportunity to identify the topics they found most difficult.

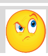
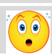
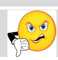
Topic	1 Very easy	2 Easy	3 Neither easy nor difficult	4 Difficult	5 Very Difficult	6 Never studied it
						

Fig. 1 Extract from questionnaire showing the Likert scale used in this investigation

The Group

The students that participated in this study were a first year group from the University of Limerick who had just completed an introductory General Chemistry course. The sample contained 136 students.

Analysis of Responses

Responses were analysed using the software package SPSS 13.0. Initially the responses to each topic were analysed and the topics, which appeared as being difficult or very difficult for the majority of students, were identified. The second stage of analysis involved looking at the influence of having done Chemistry for the Leaving Certificate or not, Ability at Maths, Ability at Chemistry and Gender affected the responses. Spearman Rank correlations were run on all topics against the above variables in order to determine where there were significant relationships. Chi-squared and Phi and Cramer's V significance tests were also carried out. For the purposes of this investigation students with a C3 or higher grade in higher-level Maths and Chemistry were deemed as being strong at that subject.

Results

Identification of Difficult/Very Difficult Topics

Tab. 1 Top ten topics identified as being difficult and very difficult (n = 136)

Topics identified as being difficult	No. of responses (% of group)	Topics identified as being very difficult	No. of responses (% of group)
Chemical Equilibria Calculations	46 (34%)	Chemical Equilibrium Calculations	27 (20%)
Equilibrium Constants	43 (32%)	Redox Reactions	26 (19%)
Redox Reactions	41 (30%)	Writing Chemical Formulae	26 (19%)
Electrolysis	41 (30%)	Volumetric Calculations	25 (18%)
Equilibrium	39 (29%)	Shapes of Molecules	25 (18%)
Transition Elements	38 (28%)	The Mole	23 (17%)
Electronic Structure of Atoms	38 (28%)	Reaction Rates (effect of temp, particle size etc)	22 (16%)
Acid- Base Equilibria	37 (27%)	Concentration of Solutions	22 (16%)
Chemical Equilibrium (effects of temp.)	37 (27%)	Equilibrium Constants	22 (16%)
Concentration of Solutions	37 (27%)	Percentage Yields	21 (15%)

The first part of the analysis involved determining the topics that the majority of students had difficulty with. These responses were gathered at the end of a General Chemistry Introductory module. The following table represents the top ten topics students identified as either difficult or very difficult in this sample group ($n = 136$).

Topics which scored high in both categories (difficult and very difficult) are as follows: Chemical Equilibria Calculations, Redox Reactions, Equilibrium Constants, Electrolysis, Volumetric Calculations, Concentration of Solutions, Shapes of Molecules, Writing Chemical Formulae, Equilibrium and The Mole.

Fig. 2 highlights the topics which appeared most frequently in the second part of the questionnaire – the free response question. It also indicates the number of times the topics appeared as the students choice for first most difficult, second most difficult etc. Percentages are of the total choosing that topic.

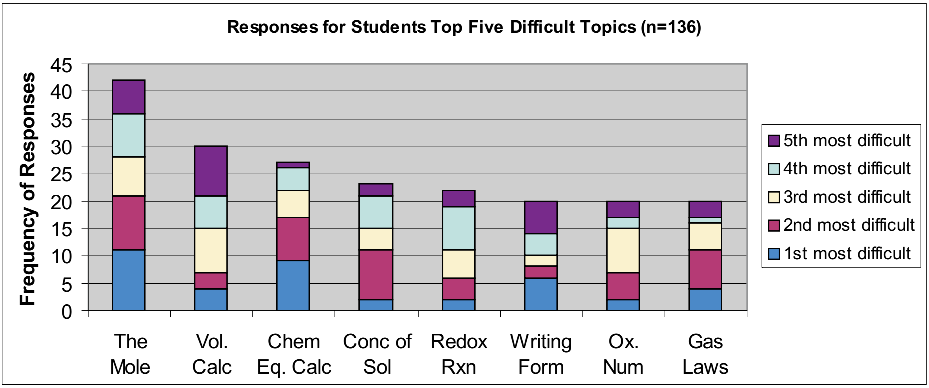


Fig. 2. Responses to the free response question (n = 136)

When we compare results of both sections of the questionnaires, topics that appear in both include: Chemical Equilibria Calculations, Redox Reactions, Volumetric Calculations, Concentration of Solutions and Writing Chemical Formulae.

Variables that influence the topics that students find difficult or easy

Students who had taken Chemistry for their Leaving Certificate were less likely to find topics difficult or very difficult. In total students who had taken Leaving Certificate Chemistry found 36 topics easier that those who had not taken Chemistry for their Leaving Certificate.

If a student had a strong Mathematics ability they had less difficulty with a number of different topics. These topics were Analysing Results of Experiments, Balancing Equations, Gas Law Calculations, Faraday's Law, The Mole, Catalysis, Ionic bonding and Writing Chemical Formulae. The majority of these topics have a high mathematical content and thus it follows that students who are weak at mathematics would find them difficult. Prior Chemistry ability did not effect how easy or difficult students found the different topics. Another variable that influenced whether a topic was difficult or easy in this group was Gender. Females had more difficulty with certain topics compared to males. Females found Chemical Equilibrium Calculations, Electrolysis, Gas Law Calculations, Ionic Bonding and Polymerisation much more difficult in comparison with males.

Discussion

On comparing topics that Irish students and Scottish students [2] find difficult the following emerge as common to both groups: Writing Chemical Formulae, Volumetric Calculations, Redox Reactions, Equilibrium and Chemical Equilibria Calculations.

Two studies from the UK show some other similarities. The work of Mary Ratcliffe [1] indicates that Irish and UK student share similar problems with Shapes of Molecules. Differences in syllabi make it difficult to compare these studies further. A study carried out by Bojezuk [6] on topic difficulties in O and A Level Chemistry also compare with Irish students opinions. At O level, similar topics identified by UK and Irish students as being difficult were Titration Calculations, Electrolysis and Redox Reactions. At A level Chemical Equilibria Calculations posed both UK students and Irish student's difficulties.

The student's ability at Mathematics has been shown in this study to have an effect how easy or difficult they find a particular topic. This finding is supported by the work of Cotton [7] who stated that *"students with little mathematical background feel disadvantaged and, indeed, resentful"*. He noted that *"even those with AS or A-Level mathematics were not confident in their handling of the mathematical parts of Chemistry"*. Work by Coll *et al.* [8] also indicate that *"numeracy is the major issue"* for Chemistry students.

Once the areas of difficulty in Chemistry have been identified it is important to determine why students find these particular topics problematic. A number of reasons for difficulties in Chemistry have been cited in research studies and could be linked to Irish students finding certain topics difficult.

Some possible reasons indicated in research for Chemistry being difficult include:

1. The inability of students to apply what they learn in class to the world around them (Ashkenazi [9]).
2. A high percentage (~50%) of students in a general Chemistry course being in the concrete operational stage of learning (Ashkenazi [9]).
3. The fact that certain topics cause overload with which the students cannot cope. These topics require students to operate at macro, molecular and symbolic levels simultaneously (Johnstone [2]).
4. Students bringing their own ideas and possibly misconceptions to Chemistry class. These misconceptions cause problems for students when they attempt to process new material in Chemistry (Nakhieh [10]).

Conclusion

This study has provided some useful information on the areas and topics in Chemistry where Irish University students are finding difficulties. It has highlighted the effect that poor Mathematics ability has on how easy or difficult students find different Chemistry topics to be.

This work forms part of a larger study, which aims to:

a) Identify the Chemistry topics that Irish students have difficulty with, including second level pupils,
b) Isolate the reasons why they find the topics identified difficult and,
c) Develop, implement and evaluate teaching approaches to reduce these difficulties.

This survey has identified areas where third level students have problems. It is highly likely that these problems have their roots in their secondary level experience. Further investigation will confirm or discard this theory.

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The Role of Didactics of Chemistry in Moulding Teachers' Priorities of Goals in Chemical Education

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Summary. The role of didactics of chemistry is to show students the way of defining educational goals. The research were carried out which aimed in revealing the goals that teachers would distinguish in their teaching chemistry and how much time they would need to realize the goals. The results of the research showed that even a short didactics of chemistry course allows students the pigeonholed knowledge of notions and definitions to change into general use of the issues and, in consequence lets teachers improve the skills of problem solving.

Introduction

Correct defining educational goals plays a crucial role in chemical education, but many teachers sometimes have problem to judge, which goals are important and have to be realized, and which ones are of minor importance. Invention of teachers is limited by detailed school curricula and with competencies that pupils have to gain finishing every stage of education. The role of didactics of chemistry is to show students the way of defining educational goals.

In the years 2006–2007 Silesian University in cooperation with Pedagogical University of Kraków and Academy of Physical Education in Katowice organized *Postgraduate studies for teachers in frames of ICT foreign language and the second subject*. There were 11 different *second subjects* and among them chemistry. Studies were financed by European Union Structural Funds and Ministry of National Education and they were meant for teachers employed at school or educational institutions. The Chair of Chemistry of Pedagogical University of Kraków led the chemistry branch for teachers from Małopolska.

The *Postgraduate studies for teachers in frames of information and communication technology (ICT) foreign language and the second subject chemistry* lasted 3 semesters (515 hours) and the curriculum included such courses as:

- basics of chemistry;
- analytical chemistry;
- organic and bioorganic chemistry;

- inorganic chemistry;
- environmental protection;
- basics of molecular spectroscopy;
- quantum chemistry;
- biochemistry;
- elements of crystallography;
- physical chemistry and thermodynamics;
- health and safety-at-work legislation;
- didactics of chemistry;
- information and communication technology;
- English.

During the first classes of didactics of chemistry the research were carried out which aimed in revealing the goals that teachers would distinguish in their teaching chemistry and how much time they would need to realize the goals. The students were given a round sheet of paper that represented the whole time that was meant for realizations all the goals. They had to divide it into pieces that represented individual aims. The same research was done during the last classes in order to find out what role the classes played in changing teachers' outlook.

Results

The results show that the point of view of the teachers has changed. First of all after the course they were able to show much more goals to realize during chemistry education. In the beginning they were not able to distinguish more than 5 aims. Students mainly identified the educational goals with names of the courses, that they had attended during two previous semesters of the studies. Teachers just listed inorganic chemistry, organic chemistry, and biochemistry instead of specifying the range of knowledge and skills that they would have transferred to pupils. In the questionnaire that they filled out at the last classes the teachers listed:

- teaching the definitions of basic notions;
- basic chemical theories;
- the rules of naming chemical compounds;
- the rules of classifying chemicals; *etc.*

The analysis of the results shows that students supposed that theoretical knowledge was more important than skills and made up 50 % of all the educational goals. they completed the didactics of chemistry course they changed their minds and they decreased the importance of theoretical knowledge to 30 % of all educational goals and increased the role of skills.

Teachers before the course could not plan out their curriculum correctly and in consequence they have left about 25 % unscheduled time. After the course listeners did not have any trouble with scheduling their work.

The time the teachers would have provided for chemical experiments decreased from 19 to 14 %. This decrease is a consequence of rigorous rules of storing and recycling of chemicals as well as using filmed experiments delivered by publishers of the textbooks.

During the didactics of chemistry course teachers noticed how far important safety in chemical laboratory and rules of safe laboratory work are, however the growth from 2 % up to 8 % is not satisfactory since teaching pupils how to use chemicals safely is one of the priority tasks of chemical education.

The results of the research at the beginning of the course showed that teachers did not pay appropriate attention to solving text tasks. They scheduled 3 % of the whole time only to do this exercises, however, after they had completed the course they increased the time needed for solving text tasks to 12 %.

The 4 % growth (from 1 % in the first questionnaire up to 5 % in the second one) in the time the students would have spent on environmental protection occurred.

Teachers think that informative technologies should be used more often in the education process. Moreover pupils ought to be taught how to use ICT. Students also noticed that not the whole time is used effectively and some elements of the lesson is just waste of time.

The first experiment revealed that teachers, even those experienced ones who have worked as teachers for several years, did not mention about bringing up pupils. Upbringing is an important and an integral part of education process. The didactics of chemistry course changed teachers' thinking and in the second research they reserved 7 % of time for upbringing.

Finally, in the second research teachers paid attention to teaching of "chemical thinking" and scheduled 3 % of time for that purpose.

Conclusion

As a result of didactics of chemistry course the significant change in determination of educational goals by teachers – listeners of the postgraduate studies occurred. The pigeonholed knowledge of notions and definitions changed into general use of the issues and, in consequence allowed teachers to improve the skills of problem solving.

The results revealed that didactics of chemistry is very important in teachers' training process. In frames of the classes students not only learn the right way of passing the knowledge but also they get holistic point of view on chemistry curriculum.

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Teacher Pre-Learning as a Problem included in the "Ciekawa Chemia" ("Interesting Chemistry") Handbook

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In 2006, students of Polish junior high schools[*)] were presented a new chemistry handbook titled "Ciekawa chemia" ("Interesting Chemistry"). The handbook was designed as a set of three student's books with CDs, and two teacher's books with CDs. Not only are the experiments described in the handbook baffling, puzzling and astonishing for the learner, thus performing motivational, exploratory and verifiable functions, but they also encourage the learner to cast a new look at te surrounding nature. Applied to solving problems, which require making discoveries, these experiments are the basis of observation. With their help, the learner can determine a given state of affairs or explain certain phenomena. Furthermore, when used in solving problems which demand explanation or anticipation, these experiments help check the results of hypotheses put forward by the learner.

At the preliminary stage of the classes taught using "Ciekawa chemia" ("Interesting Chemistry"), their participants pose a problem. This is usually done by the teacher, who presents students with a laboratory problem task that can be introduced as either a written instruction to conduct an experiment, or a set of directions displayed on a computer screen or put down on the board. The tasks usually contain a research problem prepared in a ready-made form. The role of students is to find answers to the questions included in those problems. The pace at which all these activities are done is controlled by the teacher, who can also resolve the learner's doubts, give advice and fill in the gaps.

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*) Education in Poland is being realized in parts:
- part I classes 1–3 of primary school, integrated education;
- part II classes 4–6 of primary school, education based on the group of subjects;
- part III 3 year junior high school;
- part IV 3 year high school or vocational school;
- part V universities, technical universities

The new education system has been introduced on 1st September, 1999.

The problem tasks described in “Ciekawa chemia” (“Interesting Chemistry”) are usually solved directly by conducting experiments which are subject to theoretical cognition, i.e. they are governed by theory. All experiments conducted by students can be classified according to the following, basic set of activities:
1. set the experiment’s goal;
2. prepare and plan the experiment;
3. conduct the experiment;
4. compile its results.

The research methods proposed in “Ciekawa chemia” (“Interesting Chemistry”) are aimed at stimulating the learner’s analytical thinking and encourage them to unravel the riddles of nature via experiments. Even if they do not manage to conduct all of the handbook experiments, or fail to succeed in some of the cases, the learner will likely perceive their surroundings differently once they read the handbook [2].

Resolving the problems described in “Ciekawa chemia” (“Interesting Chemistry”) encourages students to come up with ideas that can be verified by respective experiments. As a result, they face a problem task that is characterized by its complexity, far greater than most ordinary tasks. Dealing with problem solving tasks of various types is a significant part of the “Ciekawa chemia” (“Interesting Chemistry”) handbook. These problems can be resolved both empirically and theoretically by putting forward either empirical or theoretical hypotheses. To confirm empirical hypotheses, one has to conduct successive experiments. However, to answer *“why?”* questions, one has to resolve some theoretical problems, too. Thus, every learner follows the cognitive path, which involves empirical observations, abstractness, and practice. Such teaching, aimed at problem solving, educational processes are aimed at establishing an active cooperation among learners in the course of forming and resolving problems. Instead of removing obstacles from their way, the teacher pinpoints problems to the learner and teaches them how these obstacles can be overcome [3].

The suggested didactic methods can deliver positive results provided that one of the basic demands of the educational system is met, namely that the teacher is optimally prepared to teach lessons, both in terms of content, methodology and form. Some of the intermediate stages of teacher training are analyses of the available software, preparation and realization of applications, the conduct of methodology classes within a microteaching system, and, last but not least, participation in discussions with peers. For these purposes, prospect teachers have to be trained in using up-to-date computer hardware to facilitate their didactic and educational output.

"Not only must such training be concerned with hardware but also with software, including programming. Only then will conditions be met on which the concepts of multimedia teaching and didactic programming can become an integral piece of the pedagogical puzzle at all of its levels, from kindergarden to university". [4]

The teacher who teaches didactics according to the strategy of multimedia education has to merge school and extraschool knowledge with stimulating the learner's cognitive and emotional activity, controlling the learner's self-education, and improving the learner's ability to resolve problems independently [5]. The teacher is responsible for selecting the right information carriers and grouping them into sets adjusted to the learner's perceptive and emotional potential, the learner's mental maturity and their knowledge of a given information carrier. Therefore, it seems worthy of consideration to think of how to facilitate the teacher's work so that they could not only teach according to the new teaching standard but also utilize the achievements of multimedia teaching discussed above.

At the initial stage, software training for teachers should introduce the goals and issues achieved and discussed using a given type of software. It should also determine how, when and by which type of users will the software be used. IT seems a useful didactic solution to prepare the teacher to create their own selections of software adjusted to their current curricula. For this purpose, the teacher can be suggested to use software tools allowing for creating educational programs that contain images, outlines and animations of compound models, as well as for incorporating film sequences into the software's structure, paralleling real-life experiments via laboratory interfaces, and outlining the user's activities such as filling reaction equations or performing calculations [6].

One of the reliable teacher training methods, as far as software is concerned, is the microteaching system introduced in 1960 at Stanford University in the USA. Used in regular chemistry teacher training, this system has proven to be successful in training teachers in using computer software for the purpose of teaching chemistry. It is based on classes taught in groups of several people, each of whom teaches their own, 10–20 minutes long lesson that is later assessed by both the supervising teacher and the peers. The lesson is taped, which allows for replaying the lesson during critical discussions. This method is aimed at gaining a quick and relatively precise knowledge of teaching procedures followed during didactic classes, as well as at improving the prospect teacher's teaching efficiency as far as learning new teaching methods is concerned.

At the initial stage of software utilization in teaching chemistry training, an analysis of the necessity of applying educational software to teaching a certain type of lessons, as well as an analysis of its capabilities, are carried out by the board of teachers headed by a supervisor. Their consecutive task is to prepare a multimedia program using a given programming language. Having discussed a scenario of such a program and its didactic capabilities, the teachers work out a lesson plan that takes some appropriate didactic means into consideration. The outline is later assessed and, after optional amendments, becomes a blueprint of a scheduled lesson. The teachers teach fragments of that lesson using a computer and other didactic means. A computer room thus becomes a laboratory workshop in which the rest of the teachers perform the roles of students. Each lesson is taped, replayed and followed by a discussion during which the use of computer in teaching chemistry, as well as the issues connected to the taught subject are pondered over. After amending the lesson, it is re-taught using the same method or, if needed, a different way of its conduct is chosen.

Many teachers initially approach microteaching classes with reserve. They are insecure about their abilities to teach lessons in an environment other than the one they know from their ordinary day. What they are most afraid of is not the mere inability of using a given computer software and hardware properly, but rather the way they will be perceived by their colleagues. The atmosphere of preparations for the lessons relieves this tension and, despite the momentary stress connected to the lack of self-confidence as far as the use of video appliances is concerned, the majority of the trainees tend to like the visual component of the training. This is so due to the fact that not only does this technique allow one to hear oneself the way they are heard and seen by others but it also allows for observing the influence of one's behaviour and personal features on others. It can be claimed, therefore, that the microteaching method proves to be successful also with respect to improving those teaching methods which utilize computer software, and that it can be used effectively for this purpose. Not only does this method provide satisfying results as far as the teacher's experience is concerned but it also provides material benefits such as selections of computer software prepared by teachers, sets of lesson plans using computer software, and video recordings containing a range of sample chemistry lessons supported by computer software. These materials can serve lots of teachers as a pattern of optimal application of computers in educational processes.

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Knowledge of Solutions Taken towards Environmental Protection – The Survey among Students

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Summary. The survey has been conducted which measured the familiarity with renewable sources, biofuels, and biodegradable materials among I year non-chemistry students of the University of Gdańsk and V year students of Chemistry and Environmental Protection major on the University of Gdańsk (future chemistry teachers).

Introduction

Actions taken towards environmental protection are recently one of the priorities of the European Union's policy. The goal of these actions is among others the limitation of emission of greenhouse gases to the atmosphere, and what follows, the deceleration of climate changes, as well as decrease of constant waste which is mainly composed of used plastics. These goals are realized mainly by support of and promotion of obtaining energy from renewable resources, as well as, the use of biodegradable polymers for the production of packaging.

There is a need for an educational campaign which will promote the necessity of environmental changes and the resulting benefits. Such a campaign will help to receive a social approval and a wide range for changes in energetic and packaging. One way to promote the knowledge about renewable resources of energy and biodegradable plastics is the introduction of these topics to chemistry teaching programs on all teaching levels.

As it is well known children and youth obtain knowledge about the surrounding world in school. This is where they should learn about any new ecological developments in energetic and packaging. Perhaps, in the future the paste of development of new technologies used to protect the environment will depend on their knowledge and beliefs. This is why it is very important to create the feeling of responsibility for the environment in young people and familiarize them with actions which can be taken to protect the environment, starting in their early years.

However, these days not in all obligatory (approved by the Ministry of National Education) programs and chemistry textbooks, the information about renewable energy sources has been introduced. On the other hand, the topics on biodegradable materials have not found a place in chemistry teaching programs and hardly ever are mentioned in school textbooks. Still prevailing are topics concerned with obtaining energy from fossil sources and production of polymers from oil products.

In order to learn about the level of knowledge in the discussed area among youth, a survey has been conducted which measured the familiarity with renewable resources, biofuels, and biodegradable materials among high-school graduates and first year non-chemistry students of the University of Gdańsk. The highest scores were received on questions regarding renewable energy sources. All of the respondents were able to present at least two examples of such sources. The most often pointed sources were wind power, hydropower and solar energy. Least known were ways to obtain energy from biomass (8 % of respondents). Their knowledge on renewable energy sources students have gained mainly in school (54 %). Other participants gained their knowledge from television programs (33 %), Internet (16 %) and/or newspapers (12 %). Out of all respondents, 29 % met with the use of wind power, hydropower or solar energy in their near surroundings.

Another topic, biofuel, is less known among graduates. Only 20 % knew what biofuel is. Among other answers one could find statements such as, that this is non lead fuel and “so-so” environmentally friendly or that it is a traditional fuel with an addition of plant components. About 42 % of respondents are not for the use of biofuel and believe that it damages car engines. All of the survey participants who responded negatively to the usage of biofuel did not know what biofuel is.

Least known among respondents are biodegradable materials. Although, they were heard of by 70 % of surveyed, they mainly heard of “biodegradable packaging”. Most students did not know precisely what biodegradable materials are and 12 % knew that they decay in environment in relatively short time without the emission of any harmful substances. They learned about them from television, newspapers and Internet. School was the only source of information for 12 % of respondents. Among all participants only 4 % knew about the existence of polymers on the base of starch. The rest of students listed paper and cardboard as an example of biodegradable packaging.

A similar type of survey has been conducted on a group of future chemistry teachers – five year students of Chemistry and Environmental Protection major on the University of Gdańsk, participants of a pedagogical course. Results obtained from this survey are much better from those obtained from the first group surveyed. However, due to the role which these respondents will have in the transfer of knowledge, the results are not satisfactory.

As before, the information on renewable sources of energy was best known to students, still 10 % of them could not provide an example of such a source. Their knowledge students gained mainly from television, newspapers and Internet. Some of them obtained the knowledge of renewable energy sources during their studies (53 %), out of which for 17 % of respondents studies were the only source of information.

Biofuels were less known to respondents. Only 5 % knew what biofuels are. 44% of students knew only that they are environmentally friendly. Among other 51% of responses, one could find answers such that biofuels are fuels with an addition of plant oil (20 %) and even a statement that these are fuels which do not contain heavy metals (1 %).

Biodegradable polymers were heard of by 89 % of respondents, out of which 26% learned about them during their studies on one of the mandatory lectures, where this topic was mentioned. Perhaps, this is why 39 % of respondents could answer the question what biodegradable polymers are well. Still many, similarly to the other group, could not give an example of a biodegradable material other than paper.

The introductory survey described above shows that the knowledge on new trends in the energetic and packaging sectors used to protect the environment is not common. High school is not an exhaustive source of knowledge about renewable energy resources, biofuels and biodegradable polymers for youth, just as chemistry studies are not for university students. Due to the importance these topics are gaining, one should introduce them to the recently being modified Chemistry Program on different teaching levels. Above that, the topics on renewable energy, production and kinds of biofuels as well as on biodegradable materials should be introduced to mandatory subjects in university chemistry studies.

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Assessment of Student Perceptions in Project Based Chemistry Applications

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Summary. While improving teaching-learning process, just evaluating performance is inadequate. Students' beliefs about learning process, perceptions about learning gains, expectations about the course and their perceptions about how much of their expectations are met have great importance. By this way, teaching activities could be developed or reorganized. Therefore, in the extent of this study project based applications has been conducted and students' perceptions about learning gains in these activities have been determined by using SALG questionnaire (Student Assessment of Learning Gains). The results have displayed that working on a subject which students interested in and conducted applications in which students actively participate in have been very effective.

Introduction

Today, students should be educated as individuals who can reach sources, use the knowledge and transform it instead of being a knowledge store [1]. Students need to learn more than learning inert knowledge; the learning experiences which meet students' needs should be real and meaningful [2]. Therefore, teaching methods in which students participate actively and the teacher is a guide should be used. In the extent of the study, with project based learning applications related to the "environmental protection", it has been aimed to develop students' awareness related to the subject. Teaching and learning are together in project based learning. According to Thomas [3], in project based learning environments, students meet complex problems which focus on their learning needs [4]. Students' thoughts and expectations related to the activities in the classroom and their perceptions about learning gains play an important role while determining the efficacy of the course process. Seymour *et al.* [5] in their study administered SALG which was originally designed for chemistry faculty concerned to discover the efficacy of undergraduate teaching modules and determined student perceptions in the pedagogy class. Middlecamp *et al.* [6] in the extent of SENCER project adapted SALG to the science courses which focus on real life events and invite students to the scientific investigation. Middlecamp and Phillips [7] in their study, in the extent of "Environmental Chemistry and Ethnicity" course developed some innovations and designed new activities. In the extent of the course, to determine the effectiveness of the activities and innovations, SALG was administered to the students.

The aim of the study

The aim of the study is determining students' ideas about learning process, their perceptions related to the learning gains, their expectations related to the course and how much of these expectations realized following to the project based learning applications and making suggestions to improve learning process in the highlight of these information.

Samples

42 students attending to Hacettepe University, Faculty of Education, Department of Chemistry Education have participated in the study.

Method

The study has been conducted in the extent of Chemistry Education Seminar Course in 2006–2007 Fall semester. In the extent of the course, project based learning model has been practiced. Students have worked in groups of 3. The teams have chosen a project question related to "Environmental protection" and prepared a schedule. At the check points the researchers have controlled teams' work. After all teams have completed their projects, they have presented their projects electronically in the class. Students have discussed related to the projects. Following to the presentations, SALG has been administered to the students. Some examples of students' project are: "How can be the wastes classified? What are the ecological effects of them?", "What are the effects batteries and medical wastes on the environment? How can be these effects decreased?", "What are the advantages and disadvantages of the herbal organism whose genetic structure is changed through some purposes?", and "What are toxicology and environmental toxicology?".

Instrument

Students Assessment of Learning Gains (SALG) has been administered to determine students' thoughts about learning process, their learning gains after completing the course, their expectations related to the course and how much of these expectations have been met [8].

Findings

Students' responses to the items in the SALG questionnaire have been analyzed. The distribution of student responses to each item has been investigated. Some examples of students' responses are given below.

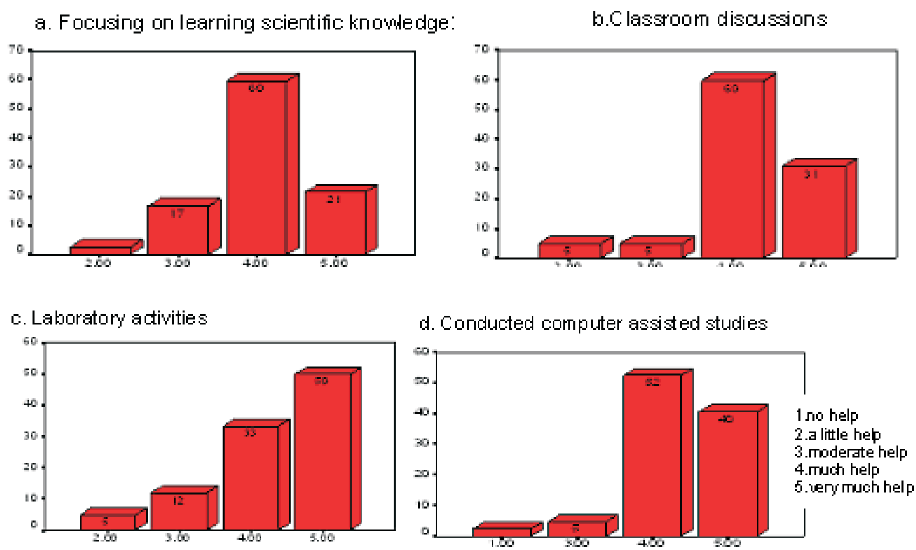

Fig. 1 Distribution of student responses to the question *"How much did each of the following aspects of the class help your learning?"*

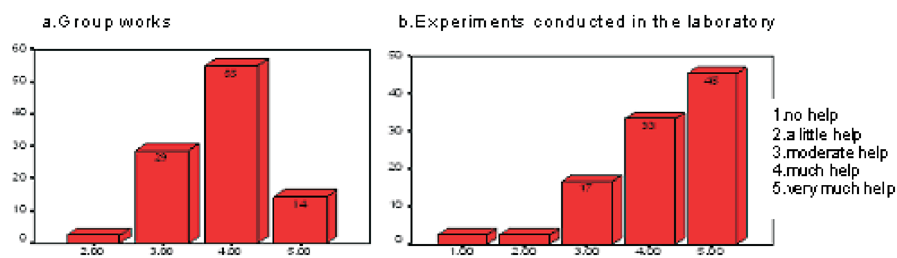

Fig. 2 Distribution of student responses to the contributions of classroom work, laboratory experiments on their learning

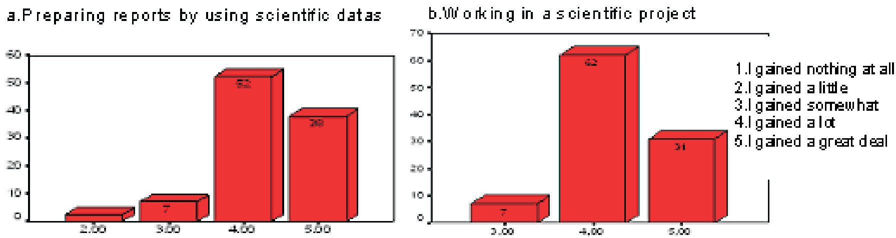

Fig. 3 Distribution of student responses to the question *"To what extent did you make gains in each of the following as a result of what you did in this class?"*

Results and discussion

Searching for the factors that affect students' learning will help reorganizing teaching environment and planning teaching activities. In the extent of the course, project based learning activities have been conducted. Investigating the effect of the classroom activities on students' learning will help determining the qualities of the course, how much of the demands of the students have been met and planning learning process in the highlight of students' responses. Distribution of students' responses which they have rated highly in the section *"How much did each of the following aspects of the class help your learning?"* are displayed in Fig. 1 and 2. Related to "focusing on learning scientific knowledge" item, 60 % of the students have rated as "much help" and 21 % of them have rated as "very much help". Related to "classroom discussion" item, 60 % of the students have rated as "much help" and 31 % of them rated as "very much help". Related to "laboratory activities" item, 33 % of the students have rated as "much help" and 50 % of them rated as "very much help". Related to "conducted computer assisted studies" items, 52 % of the students have rated as "much help" and 40 % of them rated as "very much help". Students have worked in groups of 3 in project based learning activities. At the beginning of the semester, students have informed about project based learning scientific research. "Environmental protection" subject has been chosen as main theme in project based learning practice since the instructor planned to develop students' environmental awareness. In their projects, students have conducted experiments if it is necessary. Discussing projects in the classroom has provided opportunity for students to present their learning outputs and share ideas. Students' responses to the SALG have displayed that the activities contributed to their learning. Student centered, practice based activities and using technology in education help to increase students' interest and learning. Also, students' expectations related to the course are important for evaluating teaching-learning process and restructuring it. Students have had highly positive perceptions related to developing some scientific skills and this displays the effectiveness of the conducted methods. Distribution of students' responses which they have rated highly in the section "To what extent did you make gains in each of the following as a result of what you did in this class?" are displayed in Figure 3. Related to "preparing reports by using scientific data" item, 52 % of the students have rated as "I gained a lot" and 38 % of them have rated as "I gained a great deal". Related to "working in a scientific project" item 62 % of the students have rated as "I gained a lot" and 31 % of them have rated as "I gained a great deal". One of the aims of the course is developing students' reasoning skills and helping them to use knowledge in daily life problems. Students responses have displayed that project based learning activities have helped students to gain mentioned abilities.

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The Effects of Goal Orientation and Self-Directed Learning on Pre-Service Chemistry Students' Achievement

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Summary. The complexities of life in the twenty-first century have brought to the forefront of educational thinking the need for students in schools to be supported in developing their capabilities, qualities and dispositions for effective lifelong learning. This adds to the importance of embracing motivation for learning and self-directed learning as a goal of education at all levels [1]. In this study, the effects of pre-service chemistry students' goal orientation and self-directed learning abilities on students' achievement were investigated. The sample of the study was 60 pre-service Chemistry students' attending to Department of Chemistry Education, Faculty of Education, Hacettepe University. Regression analyses revealed that goal orientation and use of self-regulated learning strategies are significant predictors of students' chemistry achievement.

Introduction

The complexities of life in the twenty-first century have brought to the forefront of educational thinking the need for students in schools to be supported in developing the capabilities, qualities and dispositions for effective lifelong learning. This adds to the importance of embracing motivation for learning as a goal of education at all levels [1].

There are number of theories on motivation. Even though these theories of motivation are different, in all of them two important elements can be found: need and readiness. Adar [2], working in the field of student motivation, postulated the existence of four different motivational types of student, based on the predominance in a student of the following "needs": (*i*) the need to achieve, (*ii*) the need to satisfy one's curiosity,(*iii*) the need to discharge a duty, and (*iv*) the need to affiliate with other people. Social cognitive learning theory views motivation as a function of individuals' thoughts rather than some instinct, need, drive, or incentive as examined by Freud [3], Hull [4], and Maslow [5]. Through the lens of social cognitive learning theory, six motivational constructs have been classified into three general families [6]. The first family refers to individuals' perceptions about their ability to accomplish a task. It includes constructs such as self-efficacy, locus of control, and attributions. The second family pertains to individuals' reasons or purposes for engaging in a task. It encompasses constructs such as goal orientation and intrinsic versus extrinsic motivation. The third family refers to individuals' techniques and strategies for accomplishing a task and includes self-regulation. Individuals' reasons or purposes for engaging in a task also play an important role in cognitive theories of achievement motivation

Goal orientation

An achievement goal is what an individual is striving to accomplish [7]. Dweck [8] and Dweck and Leggett [9] identified two motivational patterns that are associated with differences in individuals' goal orientation. The first is the "mastery response", associated with learning goal orientation. Learning goals have also been called mastery goals Ames and Archer [10], task incentives [11], and task involvement [12] . The second motivational pattern is the "helpless response", associated with performance goal orientation. Performance goals have also been called ego incentive [11] , or ego involvement [12]. Goal orientations are behavorial intentions that determine how students approach and engage in learning activities [13]. Dweck and Leggett [14] proposed that the goals individuals are pursuing create the framework within which they interpret and react to events. In the domain of intellectual achievement they identified learning (Mastery) goals which individuals are concerned with increasing their competence and performance goals in which individuals are concerned with gaining favorible judgements of their competence. Meece *et al.* [13] found that goal framework is useful for conceptualizing the influence of individual and situational variables on students' motivational patterns in classroom learning situations. Students who have learning goal orientations are assumed interpret their effort as positively related to their ability to accomplish the task [6] and they primarily focus on mastering the course material. They value the learning process itself and they often look for challenging assignments where they put in more effort and use more effective learning strategies to the learn material [13, 15, 16].

The Concept of Self-Directed Learning and Its Importance

Knowles [17] defines self-directed learning as the ability of an individual to determine his/her own learning needs, learning targets, required human and material resources as well as evaluating the products of learning through using the correct learning strategies. Beitler [18] found that the individuals, whose self-directed learning skills have developed, also improved their problem solving, creativity, and invention skills. In the study by Pachnowski and Jurczyk [19] self-directed learning features of students were assessed in web-based courses within a distance learning program at Midwestern University. The researchers e-mailed Guglielmino's 5-point Likert-type scale of Self Directed Learning Readiness to students and the evaluation showed that self-directed learning was a good indicator of achievement. The benefits of self-directed learning could be determined through the student type that it develops. When studies on Self-directed Learning are examined, it is observed that students who learn through self-directed learning had great awareness and responsibility for making learning meaningful as well as expressing themselves [20].

Method

Sampling Of The Study

The sampling of the study was 60 pre-service chemistry teachers who were attending Hacettepe University, Faculty of Education, Department of Chemistry Education.

Self-directed Learning Readiness Scale

The Self-directed Learning Readiness Scale (SDLRS) was developed by Guglielmino [21] in order to assess individuals' self-direction skills, conditions, and attitudes in learning. It consists of 58 statements, in which the assessment is made through a 5-point Likert-type scale [22]. The structural validity of SDLRS is obtained through content validity. The content validity was obtained through expert opinions while developing the scale. Its structural validity has been supported by many researchers since 1981. The last time when the validity of SDLRS was obtained was in Canada and the USA with a sampling of 3.151 individuals over a Split-half Pearson Product Moment Correlation, in which it was determined to be 0.91 [22].

Goal Orientation Scale

Failure motivation scale is a Likert Type Scale consisiting of 16 items. In the development stage of the scale a sample consisting of 165 students was used. After the analysis reliability of the scale is 0.81 and variance is 30.

Table 1. Model summary and ANOVA analysis

a) Model summary

R	R^2	Adjusted R^2	Std. Error of the Estimate
0.558	0.311	0.287	12.870

b) ANOVA analysis

	Sum. of Squares	d*f*	Mean Square	*F*	Sig.
Regression	4193.024	2	2096.512	12.657	0.000
Residual	9275.620	56	165.636		

Findings and conclusion

In order to find the effect of self directed learning readines and goal orientation on students' chemistry achievement regression analyses were conducted.

Regression analyses revealed that goal orientation and use of self-regulated learning strategies are significant predictors of students' chemistry achievement. They together predicted the students' chemistry achievement as 31 %.

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Relationship between Chemistry Education and Media

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Introduction

Serving chemistry subjects as news in written and visual media is a situation that can be met so frequently and in many cases chemistry subjects are presented in real life situations. Hume *et al.* define students' learning chemistry from the news with constructivist learning theory [1]. They applied CIITN Project, which they developed with this aim to Organic Chemistry lesson, and showed that Media Based Learning activities affected students' attitudes [2]. Usage of digital learning materials in Nutrition Chemistry Education was investigated in the content of research Project that continued for four years and teaching materials were evaluated by teachers and students as Project [3]. On the other way, evaluation of the results of scientific researches conducted in chemistry education, in media provides the society opportunity to learn about the Project subjects and results [4]. Similarly, discussing the educational materials Internet discussionboard gives addition to the realisation of chemistry education easily [5]. Today, above media sources, computers and Internet are used for education.

Aim of the Study

The content of chemistry education contains all the subjects related with life and environment. These subjects are taught as main subjects of chemistry education in Primary Education as life science and science; in secondary education as chemistry and in higher education at departments of Chemistry, Chemistry Engineering and Chemistry Education. As a result, students attending to the multidisciplinary branches, recognise chemistry. On the other way, everyday written and visual media tauch on the subjects related with chemistry and announce it to the public opinion.

Subject

Subject of the study consists of students at Hacettepe University:

1. The 76 chemistry pre-service students that will work as chemistry teachers in the near future.
2. The 80 students attending to the Department of Administrative Sciences and educated in the social subjects.

Method and Applications

Brain storming

The subjects served as news in media contains actual subjects of chemistry and the interesting subjects can take place in media. But the point that important is that the levels of the subjects, reliability, its operation, and target people. In some cases, the subjects that take place in media as news has positive and negative effects on education. Brain storming applications in the mentioned subjects were conducted with 76 pre-service students and the results were collected in a logic map with the subject of "Media and chemistry Education”. In the realised brain storming applications, relationship between media and chemistry education were collected in the above mentioned subjects and a logic map is prepared.

1. What subjects take part in media?
2. Do these subjects have place in chemistry education?
3. Do the subjects have positive-negative effect on education?
4. Is media news reliable? (Is the news correct?)
5. Do they have contribution on chemistry education?
6. Are the subjects new and interesting?
7. Do they have effect to give people knowledge and make them be aware?
8. At which level are the media subjects presented?
9. Can media take the interest of people related with chemistry?
10. Is the approach of media is a solution to some problems?

Relationship between Chemistry Education and Media.

According to the obtained data, a scale for investigating the relationship between media and chemistry education is prepared. The applied likert type scale (Tab. 1) consists of 20 items and its reliability is 0,918.

Table 1. The "Relationship between Chemistry Education and Media" Scale

Name-Surname: No: Class: Gender:	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. With the help of media, I understand how chemistry is related with daily life.					
2. I did not learn from the TV programmes that hurricanes are not a result of global warming.					
3. I learned the effects of global warming from media.					
4. Knowledge related with chemical guns can not be learned through media.					
5. Learning the formation of global warming through media caused more effective learning.					
6. I think that I learned about nuclear stations and their effects effectively from TV programes and newspapers.					
7. When the harms of cigars are described in media, emphasizing the damages of chemicals inside to the human body, caused an increase in my interest to chemistry.					
8. Media is not an effective organ that caused us to learn what is happening around world.					
9. I use the knowledge related with chemistry that I learned from media effectively in chemistry lessons.					
10. The way of handling the chemistry subjects in media, hinder my motivation to chemistry lessons.					
11. Making people be aware of environmental protection with the help of media is more effective.					
12. I do not think that TV programmes related with teaching chemistry in daily life will not give any contribution to chemistry education.					
13. Media follows the effect of fossil fuels more consciously.					
14. I can not learn effective knowledge about chemicals used in our daily life from press.					
15. I learned the importance of natural gas from the news in newspapers and TV for the first time.					
16. I do not read the news related with chemistry in newspapers.					
17. I think that when cartoons related with chemistry are prepared, the interest of children to chemistry will be higher.					
18. I do not think that I am aware of green house effect from the news in TV and magazines.					
19. I learned the chemical effects of some medicines first of all from media.					
20. I learned from the news in newspapers. Why cars working with gas are dangerous.					

Results and Applications

In the content of the study, in order to evaluate the chemistry subjects met in media, "Relationship Between Chemistry Education and Media Scale" is applied to chemistry pre-service students that are familiar with the chemistry subjects and students at Department of Administrative Sciences at Hacettepe University that are not familiar with chemistry subjects and the results were compared.

In the Tab. 2, the answers of inquired students to the "Relationship between Chemistry Education and Media Scale" and the mean scores are given. The 60 % of the Chemistry Education students participated to the evaluations stated that chemistry subjects given in media are correct and educational. The 45 % of Department of Administrative Sciences students' participated to the evaluations stated that media subjects are educational. More than half of the students could not relate the chemistry subjects in media.

Table 2. The answers of examined students at Hacettepe University students' to the "Relationship Between Chemistry Education and Media Scale"

Opinion	students of	
	Chemistry Education	Administrative Sciences
Strongly disagree	2.74	11.01
Disagree	22.46	21.69
Undecidec	15.74	21.20
Agree	42.49	35.34
Strongly agree	16.57	10.68

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Laboratory Courses in Analytical Chemistry – Some Discussion Remarks

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Summary. There has not been approved detailed curriculum on the analytical chemistry laboratory courses yet. Seeing that the practical ability to analyse is so essential for chemists, a great attention must be paid to preparing and conducting the laboratory courses on analytical chemistry. The discussion on the analytical chemistry laboratory courses could be especially focused on (*i*) duration and organisation of the course, (*ii*) trained techniques, (*iii*) samples used for training, (*iv*) selection of the particular experiments for the course, and (*v*) training of other useful skills and abilities.

Introduction

Although analytical chemistry is only one area of chemistry, the good knowledge of it and furthermore the ability to do analysis is essential for all chemists. *E.g.*, in the USA more than 22 % of active chemists identified themselves as analytical chemist and more than 25 % of active chemists state that their working area is analytical chemistry [1]. The great importance of analytical chemistry on quality of mankind's live, on the growth of economy, on various parts of science (medicine, biology, archaeology, *etc.*) is broadly known.

The teaching of analytical chemistry is usually performed on tertiary level of education (on the universities). According to the European Chemistry Thematic Network (ECTN) the analytical chemistry should form about 17 % of BSc teaching time [2]. Although there is the approved text on analytical chemistry by the Federation of European Chemical Societies (FECS) [3], there has not been approved detailed curriculum on the laboratory course yet. Seeing that the practical ability to analyse is so essential, a great attention must be paid to preparing and conducting the laboratory courses on analytical chemistry. There is a useful review on learning in the laboratory [4], but it is very general and not touching analytical chemistry. The discussion on analytical chemistry laboratory course could be especially focused on following points:

- duration and organisation of course;
- trained techniques (chemical analysis *vs.* instrumental methods);

- samples used for the training (artificial *vs.* real samples);
- selection of the particular experiments for the course;
- training of other useful skills and abilities (*e.g.,* manipulative skills, sampling and preparation of samples to analysis, the ability to plan experiments).

Duration and organisation of laboratory course

One of the important questions on the analytical chemistry laboratory course is the duration of course, or better to say how much teaching hours should be devoted to the work in the laboratory. The FECS suggests 150 hours of laboratory course for BSc level [5]. If the one semester takes about 12 weeks, it means 12.5 hours of analytical laboratory course per week in one semester or 6 hour of laboratory course in two semesters. As the lectures on analytical chemistry are usually in the 3rd and 4th semester, the laboratory course should be held in the 4th and 5th semester.

There are two conceptions of the laboratory course organisation: (*i*) the block course, *i.e.* the laboratory course from 8.00 a.m. to 4 p.m. in duration of two weeks (10 working days) once per semester, and (*ii*) the batch course, *i.e.* the 6 hours laboratory course each week of the semester. Both concepts have pros and cons. The block course allows to make the time-consuming experiments, the students are forced to plan the timetable of their experiments, but they are not able to listen to the other lectures during the laboratory course. On the other hand the batch course allows the students to attend the other lectures, but the time limit forbids to make the time-consuming experiments. There is one solution of those contraries – putting off the laboratory courses at the end of semester (*e.g.,* to the last fourth part) and more intensive lecturing in the first 3/4 of semester.

There is one more question concerning the organisation of the course: Should the student practise alone, in the pair, or in a group? The best solution is to combine all these possibilities: to start with individual work and afterward form the working groups for solution of more complex experiments.

Trained techniques

At the present time the majority of analysis is performed via instrumental methods. One can ask: Is it reasonable to train also the classical methods of chemical analysis (the proof of cations and anions, the wet chemistry)? The answer should be positive. There are several reasons for doing it: (*i*) the classical methods of chemical analysis belong to the fundamental knowledge of every analytical chemist, (*ii*) these methods are still used in the commercial laboratories (for the rare, or rough and quick analysis), (*iii*) the measuring on instruments should cause the “black-box phenomena”, *i.e.* some students do not consider the processes in the instrument (*e.g.,* the separation of the sample in gas chromatograph) they “only” insert the sample in the instrument and copy down the number on device computer screen. But of course at the same time the instrumental methods must be involved in the laboratory course besides the classical methods. The proportion of chemical and instrumental analysis could be about 2:3.

There is also the first Internet laboratory teaching on analytical chemistry[6], but this teaching must not substitute the laboratory course. It should be useful only as a pre-training.

Samples used for the training

The majority of the samples used for the training in the analytical chemistry laboratory course are artificial, *i.e.* they are prepared by the laboratory technicians. The only one benefit of using these samples is that the tutor knows the right contents of the sample. But the analysis of a white water-soluble powder or a colourless solution is not very good for student’s conceptions of the real samples.

So the better idea is to use the real samples in the laboratory courses. It is possible to employ various food or pharmaceutical products, *e.g.,* the alkalimetric determination of acetic acid in vinegar, the chelatometric determination of zinc in zinc ointment. Or it is possible to use real matrices with spiked analyte, *e.g.* the HPLC determination of polycyclic aromatic hydrocarbons in wastewater.

Selection of particular experiments for course

There are a lot of laboratory experiments used in the analytical chemistry laboratory courses. But in most of laboratory courses the identical particular experiments are used for a long time. It should be very beneficial to change them at times. A plethora of new analytical experiments have been published in the chemical literature, most of them in the *Journal of Chemical Education.* Harvey published in his book [7] very excellent survey of experiments for each branch of analytical chemistry, classical methods included (see the “Suggested Experiments” at the end of each chapter of his book).

Training of other useful skills and abilities

The analytical chemistry laboratory course allows to integrate other activities for the training of useful skills and abilities of the students.

The very useful activity is sampling and preparation of the samples to the analysis. The sampling is essential to obtain the accurate results, however it is very rarely involved in the laboratory course. The students should be trained in preparing and homogenisation of the sample before analysis at least; *e.g.*, if the homogenisation in the mortar is omitted at the argentometric determination of chlorides and iodides in mixture, the bad results are obtained.

The essential skills for analytical chemist are calibration and standardisation. The examples of these procedures should be part of the laboratory course, *e.g.,* the calibration of glassware (volumetric flask, burette), the standardisation of a titrant solution. The right treatment of glassware is one of the neglected areas of the training. The right and complete purification of glassware is essential, especially for trace analysis. Therefore some experiments on this point should be also involved.

The ability to plan experiments and compare the results of various methods should be developed on more sophisticated experiments. *E.g.,* very useful experiment is determination of zinc and cooper in brass. The brass is dissolved in nitric acid. The zinc is determined by gravimetry (by the $(NH_4)_2HPO_4$) and by chelatometric titration. The cooper is determined by electrogravimetry (by electrodeposition on a platinum cathode) and by iodometric titration. The students must plan their experiments in order to properly use time and limited quantity of sample. They should compare the results of very precise analysis by gravimetry with less precise titration.

For the advanced students the special analytical chemistry laboratory courses (short-term stays) should be arranged. It is very beneficial if they are organised in the co-operation with some commercial companies [8]. Students are involved in the solution of the real analytical problems. Moreover, the stays could result in the job offer from the side of those companies.

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Context-based open-ended problems in chemistry

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Summary. Many problem solving actives encountered on undergraduate programmes are algorithmic and require lower order cognitive skills to be applied in order to reach a solution. We have developed a number of open-ended problems that use a real life context and require the application of higher order cognitive skills. Students' cognitive style has been determined and correlated with success in solving these open-ended problems. Early indications are that there is a correlation between field independence and problem solving ability.

Introduction

The concept of graduateness has often been described in terms of the development of intellectual or higher order cognitive skills (HOCS) [1]. There has been much research on the development of higher order cognitive skills. Previous knowledge is the building block for the development of higher order skills [2]. Problem based learning is successful in developing a range of transferable skills whilst engendering enhanced understanding and intellectual skills [3] and setting learning within a meaningful context has also been found to be effective in enhancing higher order skills [4].

Success in problem solving is often used as the test of higher order skills development. Problems in chemistry, or any discipline, come in many styles [5] categorised problems according to three factors; whether data was given, whether the method was familiar, and whether the goals of the problem are well defined. Using this model Johnstone identified eight types of problem ranging from Type 1, which is purely algorithmic, to Type 8, which has no given data, uses unfamiliar methods and has ill defined goals.

The influence of cognitive style on student success has been investigated in relation to algorithmic problem solving in chemistry [6]. This study used the information processing model [7, 8]. *Information processing* is an attempt to suggest mechanisms for learning arising from a number of psychological schools. *Perception* is controlled by what we already know and is what we use to select and filter information. *Working Memory Space* is used for further processing. If the processed information is to be stored we look for connections in our *Long Term Memory* [9]. One problem is that Working Memory Space [10] has a finite capacity in each individual and we can consequently handle only a limited amount of information at a given time.

The use of a meaningful context has been shown to motivate and enthuse learners [5]. Johnstone [11] has stated that chemistry exists in three forms which are:

• the *macro* and tangible: what can be seen, touched and smelt;
• the *submicro*: atoms, molecules, ions and structures; and
• the *representational*: symbols, formulae, equations, *etc.*

Chemistry can be taught almost entirely from the submicro and representational forms with the macro, or real life, aspects often being divorced from the rest of the subject. Where this approach has been changed to set learning and problem solving within a real life context evidence has demonstrated that students engage much more enthusiastically with their learning [12, 13].

The use of additional context can make a problem or course more engaging but can make it more complex, enhancing the load on working memory. In such cases an individual's ability to extract relevant information from a complex situation could enhance their success. This ability is called field independence [14].

Methodology

The aim of this research was to develop a set of open-ended problems [15] with a real life context that are defined as Type 5–8 on the Johnstone scale. The effect of working memory capacity and field dependence/independence on student success with the problems was investigated. The relationship between problem style and context and student motivation and engagement was also investigated.

A set of problems were designed and evaluated for level of difficulty. In evaluating the level of difficulty all steps in the typical solution of a problem were identified. These included algorithmic manipulations, identification of contextual factors or estimations, and the application of scientific concepts. A typical example of a problem is given here:

> *The rivers and oceans contain levels of dissolved gold of between 5 and 50 ppt. Extraction of gold from seawater has been seriously considered many times. Approximately how many kg of gold are present in the world oceans.*

Students were submitted to paper and pen tests to evaluate their working memory capacity and their degree of field dependence. Their attitude to problem solving was evaluated by means of a questionnaire. Second year students were organised into small groups according to their level of field dependence. They then tackled the problems in these groups. After each problem the tutor lead a debriefing and feedback session. A number of second year students were selected to be interviewed about the problem solving sessions to gain feedback about their experience of the sessions. Third year students attempted to solve the problems individually. All the problem solutions were analysed and assigned a mark. These problems do not lead to a single correct answer that can be marked right or wrong. Instead, approach and strategy has to be evaluated. Student performance was analysed against the cognitive factors of working memory and field dependence using the SSPS software.

Results and Discussion

Early results show a few general indications: There appears to be a correlation between A level scores and problem solving ability. Attitudes towards problems with real life or work related context have increased positively. All of the students found the more open ended problems more challenging yet more enjoyable than conventional ones. From the sessions with the 30 05/06 Year 3 students, where all the problems were tackled individually there is an indication of correlation between M capacity and attainment, problem solving ability. From 60 06/07 Year 2 students' sessions, where problems were tackled in groups and individually, there appears to be a correlation between Field Independence and problem solving ability.

The interviews with year 2 students proved encouraging with plenty of positive comments about the problems. *E.g. "fun, got to discuss and decide which route to take to solve problem", "explore range of answers and knowledge of chemistry", "better to have questions in context!", "everyone threw in own ideas and* *discussed"*, *"had to use brain in a better way"*, *"enjoyed whole experience, exercised mind"*.

More statistically significant data will emerge with repeated sessions with each year of the chemistry degree course and this year's second year students will be followed throughout their course enabling a longitudinal study to assess improvements in problem solving ability with practice. Further interviews and case studies will take place and analysis of exam scripts to assess performance on algorithmic problems will enable comparisons to be made with the new problems.

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Case Studies for Practicals in Analytical Chemistry

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The European Association for Chemical and Molecular Sciences (EuCheMS) promotes co-operation between scientific and technical societies in the field of science and practice of chemistry in Europe. Its Division of Analytical Chemistry (DAC) is a network of chemists working in all fields of analytical sciences. The DAC Study Group "Education" promotes Chemistry studies and recommends the "Eurocurriculum II for Analytical Chemistry" [1] as a guideline for teaching Analytical Chemistry at universities. In order to facilitate the implementation of Eurocurriculum II, elaborated examples of laboratory exercises for various topics in the curriculum should be provided as case studies. They should be used in analytical practicals, primarily on the B.Sc. level.

The initial goal is the development of a set of case studies, whose topics correspond to the content of "Eurocurriculum II for Analytical Chemistry". Here we describe a model for a case study. The study deals with the determination of calcium in drinking water. Calcium is one of the most important physiological elements and one important source is drinking water, which contains up to 170 mg dm^{-3} of calcium. The students should assume they are chemists in a commercial laboratory. A new customer orders the determination of water hardness (which includes calcium content) in samples of drinking water. Students have to decide which analytical methods to apply in order to meet constrains imposed by the costumer and to test them.

Protocols for the determination of calcium concentration in water samples by most common techniques including Flame Atomic Absorption Spectroscopy (F-AAS), Spectrophotometry, Complexometry and Flame Emission Spectroscopy (FES) are provided. Students should establish the methods (or a selection of them) in their laboratory and use them to analyse their own samples of drinking water. If not all methods are available in the particular laboratory or they exceed the time available for the exercise, corresponding results can be taken from our case study document.

After practical work, the students have to compare all implemented methods. Objective criteria (accuracy which includes precision and trueness) and subjective criteria (required sample volume, robustness, analysis duration, instrumental effort, chemical products, consumables needed, manpower required) have to be discussed [2, 3] and the preferred method with respect to the customers' requirements and constrains has to chosen.

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The Relationship Between High School Students' Chemistry Self-efficacy And Chemistry Achievement

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Summary. The purpose of this study was to investigate the relationship between high school students' chemistry self-efficacy beliefs and their chemistry achievement as measured by a chemistry examination. The sample of the study consisted of 150 high school students taking chemistry class. The result of correlational analysis indicated a significant positive correlation between chemistry self-efficacy beliefs in cognitive skills and chemistry achievement. Students with high self-efficacy beliefs in cognitive skills tended to have higher grades in chemistry. On the other hand, correlation between efficacy for laboratory skills and achievement appeared not significant.

Introduction

Recent research studies indicated that students find most of the chemistry concepts difficult to understand. Due to the abstract nature of chemistry, students are not able to explain chemical principles in molecular level and apply them to real life. Social cognitive theory [1] proposed that people's self-beliefs have a great influence on their thoughts, behaviors, and performance. Among these beliefs, perceived self-efficacy, which is defined as *"people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances"* [1, p. 391], constitutes the central part of the theory. In schools, students with high self-efficacy tend to choose more challenging tasks, show more effort, and do not give up easily. This explains the reason of different academic performance of students even with the similar ability.

There is a bidirectional relationship between self-efficacy and student achievement. Bandura [2] stated that students interpret the results of their previous experience with the task and develop beliefs about their capability. In particular, students who perform successfully in executing a task will believe in their capability, thus their sense of efficacy will be enhanced. Likewise, highly efficacious students will perform better. Accordingly, in the related literature, there are numerous studies providing evidence for the relationship between science self-efficacy and achievement [3–7]. These studies revealed that science self-efficacy predicts achievement better than other variables like gender or parental background. In chemistry, Dalgety and Coll [8] reported that students did not have high self-efficacy in all areas of chemistry; students believe in their ability less in advanced skills such as tutoring peers and designing experiments. In order to enhance student achievement and engagement in chemistry, self-efficacy construct should be considered by researchers.

The purpose of this study was to investigate the relationship between high school students' chemistry self-efficacy beliefs and their chemistry achievement as measured by a chemistry examination.

Methodology

Sample

The sample consisted of 150 of 10th grade chemistry students (72 Females, 77 Males, 1 non-respondent) attending a public high school in northern region of Turkey.

Instrumentation

Chemistry self-efficacy scale (CSES) developed by the researchers was administered to the students in order to determine their chemistry self-efficacy beliefs. This scale included 22 items on a nine-point rating scale, ranging from "very poorly" to "very well". It consisted of two subscales as confirmed by exploratory factor analysis with maximum likelihood estimation: efficacy for cognitive skills and efficacy for laboratory skills in chemistry class. The overall percentage of variance extracted was 51 %. The internal consistency of the two scales was estimated by the Cronbach alpha coefficient, yielding a coefficient of 0.84 for chemistry self-efficacy for cognitive skills and 0.94 for self-efficacy for chemistry laboratory.

Data Analysis

Pearson's *r* correlation coefficient was calculated by using SPSS program to examine whether there is a relationship between students' self-efficacy beliefs and achievement in chemistry.

Results and Discussion

In general, high school students participated in the study had moderate levels of chemistry self-efficacy beliefs with respect to chemistry self-efficacy for cognitive skills (M = 6.02, SD = 1.18) and self-efficacy for chemistry laboratory (M = 4.83, SD = 2.21).

The results of correlational analysis showed that there was a significant positive relationship between self-efficacy for cognitive skills and achievement ($r = 0.26$, $p < 0.01$), indicating a moderate correlation. In other words, highly efficacious students in cognitive skills tended to have higher grades in chemistry. On the other hand, correlation between efficacy for laboratory skills and achievement appeared not significant ($r = 0.03$).

The results of this study are consistent with the aforementioned literature. However, the reason for not having significant relationship between self-efficacy beliefs in laboratory skills and achievement may be related to the instructional methods used in their chemistry classes. In this study, high school students have less experience in laboratories during instruction and therefore their self-efficacy beliefs may not be correlated with achievement. As proposed by Bandura [1, 2], as students gain more experience in chemistry laboratories, their self-efficacy beliefs will be enhanced.

Future studies should employ qualitative research in order to explore students' self-efficacy beliefs in depth. In addition, studies utilizing experimental design are needed to search for instructional strategies that improve students' self-efficacy beliefs.

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Content Analysis of Children's Preconceptions about Chemical Phenomena as an Important Resource for Further Analysis of Predispositions required For the Preconceptions Development

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Summary: In the article we are aimed at analysis of a primary science education environment. We are searching for an understanding how strongly the described situation can be caused by a presently preferred conception of science education at our schools (with accepting analysis of Hofstein, Kempa research [1]). We are planning also a content analysis of children ideas about chemical phenomena. The results can prove the predictions flowed from the presented analysis.

Introduction

The draft of our article is based on three predictions. These predictions personate a man's attitude towards science in an ontogenetic conception. The nature seems to be very interesting for every child in its early age. It is not only interesting, the nature is predominantly perceived by children also as inspiring, mysterious and unpredictable. Simply said it has all important presumptions for an effective arousing of a learning motivation (*1. the nature is interesting*). Later, when the learning is concerned to an understanding of causality, the nature in its learning process becomes less interesting. Within decreased interest for learning science we can recognize increased concern over products of science. All testify to a fact as if people start to refuse a searching for causalities and technologies of observed objects and phenomena (*2. no interest for learning science*) even It seems like people can later realize how important the science for a society is (*3. science is essential*).

1. The nature is interesting (problem of motivation)

May be it is only a fashion trend, may be we should elaborate the situation more. People are generally interested in the nature. In many cases they soulfully protect it, spending whole free time in it, bringing it to their homes, observing it with a wonder and an admiration. Children use to be strongly influenced by attitudes of parents before they are able to build up own attitudes. But it would be a great mistake if we speak about concern over the nature only from view of a fashion trend or an attitude acceptance. Primary the situation is caused by incentives of understanding the nature that surrounds us. We need to understand the rules and principles of our life environment and to accept them. Increased concern over the nature is spontaneous and very strong mainly in an early age. Except the concern for the nature we still can recognise a quite positive attitude to a science and scientists (more about the topic *e.g.* [2] and [3]).

2. The lost interest for science learning (empirism versus abstract manipulation)

A child has to learn how to react to the environment and cognize its evident form. The child becomes in contact as many times with chemical phenomena as with physical, biological and other phenomena. The child accepts and explains them within his/her actual resources. The concepts about the phenomena are usually build up predominately on own experience. This experience can be elaborated to concepts mainly on an empirical level without a notable logical manipulation. It seems like children have no tendency to search for principles of observed phenomena. They have tendency only to understand its evident form and an explicit behaviour [4].

Uncommon, unusual and special situations motivate children to learn. That is why the science lessons are becoming more and more enriched with used materials, tools, experiments and demonstrations (object teaching). The learning process starts to be interesting at least in phase of the practical activity realisation. The aroused interest for learning should be lead to an active formation of possible explanations. But the experiment is usually degraded to a simply observation, a try, a demonstration or a simple practical activity. The educational value of the experiment decreases. The principal conception of the experiment is changed into a method for arousing a children's interest for the lesson which is aimed at a knowledge transmission (more about the problem in [5]). The activities used for the motivation arousing usually do not have any explicit (sometimes also implicit) connection to the consequent educational activity. We have to say that usage of science tools and a science experimenting is inappropriate and seems like laic. Surprisingly we can say that appropriate usage of an experiment can make the science learning easier for primary pupils. The real experiment develops child's cognition but with inappropriate usage we can expect only utilization of its motivational, applicative and confirmative function.

By an analysis of information gathered via an experimental activity the structure of knowledge system continuously changes. We can recognise a construction of a hierarchy in the knowledge system. The hierarchy is built on information relations (associations). A lot of thinking effort is needed for building up these associations. And even we are able to invest a lot of effort; finally we do not have to be successful. If we want to build up a functional connection between two concepts, the content of the concepts need to be well constructed and stabilised. It means that if we would like to build up an applicable knowledge the first we need to be aimed at building up small ideas about everyday phenomena. The real problem of our primary science education is that we are forcing pupils to pay a lot of effort to build up connections between concepts, but the content of the concept is not sufficient and adequate. The result is that the expended effort is often fruitless and the usable knowledge system is not constructed. Because of the effort and because of the failure the pupils perceive the primary science education as very difficult and unlike to their previous nature concern.

3. Science is essential (an extensional starting point)

The science is really essential. That is why we need enough number of people aimed at the science. Primary science education plays a significant role in this process. In the following text we are trying to describe those characteristics of a primary school pupil thinking which notably inhibit pupils in understanding of abstract conceptions. On the basis of this description we are trying to suggest what kind of changes in a primary science education would facilitate the chemistry education.

Children's thinking is concrete

Chemistry is a science aimed at phenomena explanation in its base level. Sensuously notable are only some of the phenomena exteriorizations. When the concept of chemical phenomena is constructed the hypothetic and inductive thinking need to be used (more about usage of these cognitive abilities in [6]). Primary school pupils are not able “to think chemically”. Very simply we can say that “to think chemically” means to think abstractedly. Even we do not want to push primary pupils to use something they do not dispose of; we would like to tend pupils to develop that kind of concepts which can help them with a further creation of chemistry knowledge.

Children perceive knowledge as absolutely valid

There is no need for a revision and an improvement of knowledge perceived as absolutely valid. We can rely on the absolutely valid knowledge. But, if the knowledge is not a valid one at all, it can cause an inhibition of a more adequate concept creation (as it is described by constructivism; [7]; [8]).

The ability of generalization and induction is not well developed

The things we are not doing often are more difficult for us. And we are afraid of things we have never done before. It is the same with a creation of chemical concepts. Children often do not risk a construction of own idea about a science phenomenon with an inductive method. More often they reproduce already generalised knowledge and what is more, they really have no need for a deductive analysis of the knowledge. This knowledge system exists only for itself and for a cognitive development has no meaning. It would be better if we continuously lead the children to a regular and spontaneous usage of an induction as a research method, so the children could be well prepared for a creation of own generalised concepts [9].

Children are not able adequately apply their concepts on observed reality; their ability of comparison is not well developed

It is important to not forget that a development of cognitive abilities is closely connected with a development of concepts. The cognitive abilities are developed according to what kind of concepts we are constructing. If we step aside the abstract concepts on a primary science education, the pupils will have more problems on a secondary level to understand them. Mainly it is because they were not led to think about phenomena illustrated by the abstract concept. The topics like light, heat, sound, magnetism or chemical reactions are not in our content of a preschool and primary science education; even the children have so much experience with the phenomena. Pupils are not changing their thinking algorithm from day to day; even the cognitive abilities are in permanent development. And we have to say that the main target of a primary science education should not be focused on explanation what is light or chemical bounding, but we should lead the pupils´ thinking to make an explanation on more concrete level. For instance, the pupils should be able to understand how the shadow creates, how the funnel of straw is used, how sand and salt behave in water and so on.

Most of children's science conceptions are not well organised and confirmed (the everyday experience is not used very well)
More generalised idea which represent a set of reciprocally connected partial ideas (concepts) can be constructed only in a case, when the child has enough material from which the more applicable idea can be constructed (via generalisation; [10]). If we count a number of matches in one mach-box, we cannot say how many matches use to be in the mach-boxes. More mach-boxes we recount, more reliable our generalisation can be. If we would like the children to understand concept of chemical bounding, elementary particles, energy, chemical reactions, mixtures, solutions, *etc.*, we have to facilitate children the construction of partial ideas about common realities [7]. The mentioned chemical concepts are results out of a generalisation process. A success of the concept construction lies on the children's previous experience [11]. It is possible to use a life experience or by the same way a practical field education experience [12]. When the children are not successful in the abstract concept construction, they use to reproduce information provided in textbooks to be successful at least in a whole school evaluation.

Children's observational ability is imperfect
Other problems flows out of this imperfectly developed ability. For instance the pupils are not able to work with experimental variables on appropriate level. Beside this, often they are not able adequately identify an exception. Respectively, their ability of identifying the exceptions out of errors in an observation or an experiment is inadequate. Misconceptions result out of this imperfectness and also pupils are not able to get a result out of gathered data too.

The pupils are not able to argue (they are not led to analysis of causalities)
Relatively long time ago the characteristic of scientific thinking has been defined. The definition speaks about a necessity of releasing out of empirism. Empirism is (in principle) only an instrument of cognition, not the cognition. To build up a knowledge system we need to elaborate empirically gathered information in an abstract level of thinking. A present primary science education lead children to rely on the empirism and what is more, they are also led to present empirically gained

information as a result of the cognitive process – the knowledge. The real, applicable and explanatory knowledge must be elaborated to more generalised form [13]. If we would like to make the chemistry education more effective, we should continuously lead children from empirism to a construction of hypotheses and tests of these hypotheses. A process of hypothesis construction is not easy (according to [4]); it requires a lot of effort (energy), concentration and a variance of thinking (creativity). Also because of this the children not very gladly leave an always surprising and playful empirism and accept a demanding and challenging looking for causality of observed phenomena. That is why they are often loosing their primary interest for science learning.

Conclusion

The content of the science education in its different levels is not thoughtfully organised concerning the main target of a cognition development. The knowledge gained at lower level does not help pupils to understand phenomena which they need to understand in upper level of the education, especially when we are speaking about chemical phenomena. The content is aimed at knowledge without analytical attitude. Primary science education should deal topics which treat of abstract concepts like light, heat, energy, chemical bounding, *etc.*, because we need to develop cognitive skills not the generalised concepts.

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Activation Methods in Education of Chemistry Students at Tertiary Level

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Summary. Tertiary education has been recently undergoing considerable changes, mainly in relation to a implementation of three-stage study. But a new structure of study often lacks a innovation of content and methods. Traditionally, there prevails a method of lecture with follow-up tutorials. However, research proves a low preparedness of students to solve practical tasks. Therefore, within the framework of newly Bch. and Ms. study programmes, the main focus of our department is to create and verify interactive teaching methods for students in the subjects related to the science and chemistry education.

Introduction

Tertiary education in the respective EU member countries has been currently undergoing considerable changes that are mainly linked with a gradual implementation of three-stage study – Bch., Ms. and Ph.D. study [1]. However, a new structure of study often lacks a necessary innovation of content and educational methods. In contrast to lower levels of education, there traditionally prevails the lecture delivered by the teacher and followed by tutorials where the students are expected to practise the material of the lecture and largely the material acquired through memorizing. Then students experience problems when applying the knowledge, formulating and solving the tasks; they are not able to push ahead and defend their opinions, *etc.* Therefore our department focused on the development and testing of non-traditional teaching methods for students of Faculty of Science, Charles University. Within the framework of newly designed subjects for bachelor and master study programmes, methods of activation (interactive) teaching have been developed and verified in practice for the subjects related to the issues of science and chemistry education.

New structure of tertiary education

After two years of preparation, Faculty of Science, Charles University started in 2003 a consistent realisation of separate bachelor and follow-up master study programmes across the whole spectrum of study areas. A three-year bachelor study programme, completed with a defence of bachelor thesis and bachelor examination, and a follow-up two-year master study programme, completed with a defence of diploma thesis and state master examination is now the only possible form of study in the area of both the science and the science education.

A new form of study was also a reason for the change of all curricula and the re-evaluation of content and teaching methods in majority of subjects taught. In addition, the subjects related to general issues of science education, and chemistry education in particular, had to be re-designed [2]. These subjects stopped to be a domain of only future teachers, but also the students of other study areas and programmes show interest in them. Authors are involved in designing the content and teaching methods for these subjects such as *e. g.* "Theory and practice of science education" and "General issues of chemistry education".

Innovation of content and methods in tertiary education

Content innovation in the subjects focused on the issues of science and chemistry education mainly reflects a new conception of science education at the beginning of the 21st century, a change in educational strategy is based on the active approach of students to their study, and thus on activation and interactive teaching methods [3, 4]. By the time the students start their studies of the above subjects, they have already completed most of specific subjects; some of them even the fundamentals of pedagogy and psychology. However the practice shows that at that time the students were used to perceiving the findings referred to at the lectures as given facts and to acquiring them largely at the level of mere formal knowledge. It is evident that a lot of acquired findings will be soon forgotten, and that the students lack a considerable amount of knowledge from special subjects and also from pedagogy and psychology. Therefore, our aim was to seek the way of how to optimize the teaching in science and chemistry education. We started from not only the available literature but also from the results of research and from the experience of our own and a lot of our colleagues, who have been involved in these issues for many years [5 –8].

Concerning the content of "educational" subjects, the following topics have been designed and realized in practice:

- Science (chemistry) education and its respective levels.
- Aims, conception and content of science (chemistry) education at the respective levels.

- Strategy of science (chemistry) education (teaching methods, forms and implements).
- Basic pedagogic documents for teaching – educational standards, educational programmes, curricula and syllabi.
- Implements for science (chemistry) teaching – classical tools and aids, and multimedia teaching tools.
- Learning tasks – theory and practice of development and use of tasks in science (chemistry) education.

There are the following levels of education: pre-school education, 1st and 2nd stages of elementary school, secondary education, tertiary education and adult education. At each of the above levels, it is necessary to solve the aims, conception, content and strategy of teaching.

At first each topic must be thoroughly characterised and then specified through the use of demonstrations of materials from practice. We use *e. g.* diagrams for chemistry teachings at different types of schools and in different European countries, demonstrations of educational standards and educational programmes, chemistry curricula and syllabi, our own and foreign course books, various materials and aids for chemistry teaching (workbooks, chemistry tables, periodic table, models) *etc.* The following part of teaching is then realised in the form of seminar where the students can work with given materials and aids and solve the given tasks that reflect the needs of real pedagogic practice. Here, a large space is devoted to discussion, confrontation of opinions and search for new insights into the teaching, but also to independent work of students and its presentation in the form of reports or microteaching. Let us refer to some of these tasks: to characterise and compare curricula for different types of schools, compare the content and structure of our and foreign course books, select one of the educational levels and set the aim of teaching related to the selected curriculum topic at this level, construct a map of concepts for the topic, use of aids and other materials in the teaching, design learning tasks for the selected curriculum topic etc. Students work either individually or in groups of 2–3. Often we can follow an interesting discussion developed on the given topic that brings about different ways and options of how to solve the tasks, mainly after the return of the students from the introductory pedagogical practice where they had a chance to verify the importance of acquired skills.

A target task, which all partial tasks lead to, is to prepare and present an ICT presentation related to the selected curriculum topic at the selected level of education [10]. Students most often select the level of 2nd stage of elementary school and secondary education, often also pre-school education and 1st stage of elementary school or adult education. Surprisingly, very rare is the level of tertiary education. Prepared outcomes and ICT presentations are then presented to the other students. They are often involved in “their teaching”, ask questions, and prepare various interesting tasks for them together with a real performance of simple experiments.

Conclusion

One of the methods of how to enhance the level of teaching in science subjects, especially chemistry, is a shift from the transmissive model of teaching to the methods of cognitive constructivism and increased activity of students in the lessons. An effective tool is the up-to-date teaching content and the use of appropriate activation teaching methods, in particular learning tasks with various degree of difficulty that would make the teaching more interesting, show its link with practice and lead to the acquisition of sustainable skills.

The above aspects related to the subjects of science and chemistry education at the tertiary level were gradually realised within the years 2002–2006 through the cooperation between the teachers of didactic departments of our faculty. The two basic aims were followed. The first of them was a gradual development and realisation of selected subjects focused on science or chemistry education, while the second one is to set out the effectiveness of new teaching content and methods used in science and chemistry education in practice.

To conclude with, it is possible to state that the selected content, scope and form of teaching *i.e.* a combination of lecture and tutorial seem to be a very effective method of didactic preparation of students. Even though, so far the quantitative data on quality and sustainability of the acquired skills of students are not available, it is evident that both the content and the form of teaching were interesting for the students and enabled them to think over the basic problems of pedagogic practice, discuss them and thus make at least the first step towards the acquisition of key competences necessary for the teacher.

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Chemistry and Agriculture: A Success of Liebig's Ideas

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Summary. Chemistry plays an important role in the development of agriculture. In the 1840s Liebig introduced the idea of mineral manures and a new era began for agriculture with the employ of artificial fertilizers and their industrial synthesis. Agricultural chemistry was born, although other scientists also contributed to this fact. The study of this subject can help to reinforce the interest for science and make chemistry learning more attractive.

Objective

The objective of this paper is to discuss the role that chemistry has played in agriculture's development and to connect that role with the work of Liebig, one of the most brilliant chemists of the nineteenth century.

Introduction

From the beginning of agriculture, one of the biggest problems of the farmers was the gradual impoverishment of soils. Men realized that it was necessary to return soils the principles taken away by crops. Thus, some solutions were found, such as fallow land, rotation of crops and, mainly, the use of manures. The most important manure was cow dung, but generally it was very scarce. So, farmers added to soils bones, lime, potash and even bird dung. Anyhow, all that was insufficient and other solution had to be found. This problem was not solved until the middle of the 19th century, by means of artificial manures; that is to say, synthesized fertilizers.

Discussion

The German chemist Justus von Liebig (1803–1873) was brilliant in different fields: in pure chemistry, with important contributions in organic chemistry; in experimental work, mainly by introducing new procedures and apparatus in chemical analysis; in the way of teaching chemistry, by enrolling his students in practical research in the laboratory, and in applied chemistry [1].

Due to this last aspect, the applied chemistry, Liebig has deeply influenced man's welfare, by means of his studies in physiology and, most of all, in agriculture. He was an enthusiastic of chemistry, considering it as the mother-science of all the rest of natural sciences: the laws of chemistry would govern medicine, physiology, biology and, definitively, life. And so would happen with agriculture too. He is considered to be the founder of the agricultural chemistry, being the key point of his contribution the essential role of minerals in plants nutrition. Nevertheless, he was not the first scientist in establishing the connection between chemistry and agriculture. For instance, Humphry Davy in 1813 wrote a work, *Agricultural Chemistry*, in which he explained the "humus theory". According to this theory, organic compounds in humus were the only materials that could be assimilated by plants, whereas minerals would just stimulate this process of assimilation. On the contrary, the ideas of Liebig were totally different. In 1840 he published his book *Organic Chemistry in its Application to Agriculture and Physiology* (or simply *Agricultural Chemistry*), where he posed the "mineral theory", being minerals – but not humus – the essential material for plants. So he introduced the mineral manures, being the starting point of an extraordinary development of fertilizers industry [2].

Liebig considered that the main nutrients of plants were carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorous, calcium, iron, magnesium and potassium. He formulated the doctrine of the assimilation by plants of carbon dioxide from air. Most ideas of the modern agricultural chemistry are essentially Liegig's ones. Nevertheless, he had also very important errors. Thus, he argued that plants obtained nitrogen directly from air [3]. Because of this and other important mistakes he received hard critics. But finally he succeeded in convincing agriculturalists and farmers of the necessity of mineral supplies in soils, probably due to his scientific prestige and his power of persuasion. On the other hand, his strong character promoted polemics that curiously, in turn, promoted the agricultural research in Europe and United States. In sum, thanks to Liebig and the inorganic fertilizers, famines did not appear in many countries and men could fight better against hunger and suffering [4].

Since the 1840s important industries of fertilizers began to emerge in different points of Europe, such as superphosphates in England, by treating phosphates with sulphuric or phosphoric acid, or potash in Germany (from the mines of potassium salts in Stassfurt). Regarding nitrogen manures, they were imported into Europe from Chile and Peru as natural sodium and potassium nitrates.

However, at the beginning of the 20th century a new stage for mineral fertilizers appeared with the preparation of nitrates by means of the synthesis of ammonia from air nitrogen discovered by Fritz Haber [5].

Teaching perspectives

This subject offers the opportunity of showing students an important aspect of applied chemistry, through its influence in agriculture and, as a last resort, in our nourishment. From a pedagogical perspective, some useful ideas for the classroom can emerge, such as:

- To relate chemistry with daily life.
- To show relations science/technology/society.
- To relate different branches of science (agriculture, chemistry, biology, microbiology…).
- To connect with some important aspects of the history of science (*e.g*. biographies of scientists such as Liebig, Davy or Haber, and their contributions to science).

On the other hand, some activities can be done to reinforce these ideas (*e.g*. readings, lectures, experiments, discussions, debates, panels or searching in Internet, among many others).

All that will help to reinforce the interest of students for science and make chemistry learning more attractive. This is an important point to be taken on account, since nowadays the number of students registered in chemistry at university level has generally decreased. So, this subject can be a good contribution in this direction.

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Chemistry Popularizing by Means of Project Works Dealing with the Topic of “Constant Sustainable Development”

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Summary. The aim of the contribution is to inform about new technologies in Chemistry teaching at elementary and secondary schools. The topic is “Constant sustainable development”. We are running it within the ambit of KEGA 3/3004/05 project named “New technologies in Chemistry teaching at elementary and secondary schools with the aim to reach constant sustainable development”. The project’s main aim to educate students at elementary and secondary schools providing them with the knowledge of constant sustainable development by means of new technologies used within school classes as well as hobby groups or after-school activities. Educating students was realized by means of distant form on the basis of informational-communicational, chemical-environmental laboratory (IKCHEL). The purpose of this project was to realize and evaluate project’s competition among students considering the topics of constant sustainable development.

Challenge of constant sustainable development discussed at the summit “The Earth” in Rio de Janeiro in 1992 includes a demand “of satisfying needs of present to avoid a risk of inability of future generations to satisfy their own needs and demands.” In connection with this demand it is necessary to pay attention to the following knowledge:

- of nature: the principles of life’s existence, living conditions,
- of interaction between man and nature,
- of today’s problems: local, regional, global – their importance and possible effects.

Educating as a form of project has become very popular in American and West European schools for last two decades. Its advantages are motivation, characters of studies and researches, getting knowledge of realities and events using student’s own experiences. In Austria, project’s competitions among students have been running for several years. These activities have been supported by Austrian Ministry of Education.

To make Chemistry to be a student’s favorite school subject, we worked hard on propagating of project works with the aim of getting students to enter the project's competition with the topic of "constant sustainable development." In our procedure we followed these phases:

Phase 1. *Formation of informational-communicational, chemical-environmental laboratory (IKCHEL) and educating students by means of this laboratory on the basis of distant form*

Informational-communicational, chemical-environmental laboratory (IKCHEL) had been formed in period between January 2005 and December 2005 on website *http://kekule.science.upjs.sk,* which is the website of School Informational Chemical Service. The website enables students to find chemical and biological educational sources: educational texts, questions and tasks and procedures for experiments in agreement with Chemistry and Biology school programmers at elementary and secondary schools dealing with the topic of "constant sustainable development":

- Nourishment Chemistry – selected foodstuffs containing proteins, sugars, fats, a group of selected drinks
- Environmental Chemistry – global problems of the environment: water, air, soil, waste, recycling

Phase 2. *Formation of monitoring case*

Monitoring case created by the project's authors is defined as an element of mobile analytics and it is used for fast simple analysis of parameters of foodstuffs, water, soil, air. A set of simple mobile analytics enables to realize elementary experiments in the field of Nourishment Chemistry and Environmental Chemistry directly in the field.

A basis set enables to fix parameters of these: dissolved oxygen, nitrogen, chlorides, ammonia, oil substances, temperature and pH in water or water lye of soils. Testing is based on various as they are more attractive for students. Some of the parametrical sets in the case are presented also by regaining striping test.

Institute of Chemical Science at PF UPJŠ in Košice has formed chemical--environmental laboratory to raise quality of student's project works. The laboratory includes usage of modern elements of mobile analytical instruments as well as on-line computer results processing. It consists of the following instruments:

- *Fotometer MultiDirect* – enables to fix and analyze more than 50 before programmed, environmentally, significant parameters in different samples of

Figure 1. Monitoring case

environment (water, soil, foodstuffs, waste, *etc.*). It works on common principle of photometric which means that individual tests are in a form of tablets. The tests are absolutely safe for school experiments and they can be done directly in a place of taking, in countryside, in a factory, at school.

- *RQflex System* – works on a principle of striping photometric.

Both instruments that are the base of forming the laboratory and can be useful for practical school lessons for many specialized subject, cooperate with each other in the field of sensitivity, analysis and extent of usage. Also, there is a room with a computer, printer and the Internet.

Phase 3. *Organizing chemical excursions at the Institute of Chemical Science at PF UPJŠ in Košice*

Excursions for students of elementary and secondary schools at the Institute have been organized since October 2006 in chemical-environmental laboratory. Students and their Chemistry teacher were doing analysis of sample that were obtained for the topic of Chemistry of Environment (analysis of aluminum, chlorides, phosphates, hardness of water, urine) or for the topic of Chemistry of nutrition (analysis of iron, calcium, ascorbic acid, sugar (glucose + fructose)). All these were done on the basis of optional topic for students project works and also on the basis of literary survey for the given topic.

Students from 22 elementary and secondary schools in Slovakia entered the project's competition.

Students do project works for the following topics:

- analytic fixing of inorganic materials in foodstuffs;
- two locations in one town (water, soil, air);
- acid rains with their effects on the environment and lifestyle of inhabitants of Košice town;
- water in my surroundings;
- fixing of quality of water in Orava river and its inflows;
- chemistry and my breakfast;
- food products I consume – health and toxicity;
- chemistry of non-alcoholic drinks.

The deadline for sending student's project works is May 15, 2007. On June 15, 2007 there is going to be a conference where the best project works will be evaluated.

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Iron Experiment As an Example of Knowledge Integrating Nucleus

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Summary. The following text presents an experimental activity which promotes doing small researches using iron enriched cereals. The objective is to take advantage from experimental activities to tie the chemistry of iron with its biological function, with the technology used in its quantification, with health problems that the excess or lack of it may cause and with the social impact that they produce.

Theoretical frame

Traditionally, science teaching has been associated to transmitting all sorts of different data, facts, laws and theories, with a clear propaedeutic tendency. As a consequence, the emphasis of the experimental education was focused on the formation of future scientists. The importance that science has when a person doesn't try to be a professional in this field was completely forgotten.

On the other hand, despite the multiple technological usages that actually are conditioning our daily life, science has shown disconnected from reality and more specifically, from society. As a result, different metaphysics approaches have been generated in relation with "common sense" science which present science as something complicated, esoteric and inaccessible, only suitable for some, far from citizens' life, and potentially dangerous, which generates a prudent distrust.

The following proposal try to involve students in an activity which will make them aware of the quality of the food that is produced and consumed. Students will also reflect on the nutrients that are eaten and how their body works to assimilate them.

Objectives

- Take advantage from experimental activities to bond the chemistry of iron with its biological function, with the technology used in its quantification, with health problems that it may cause and with the social impact that they produce.
- Increase not only the knowledge of concepts but of procedures and attitudes.

Introduction

Between the existent micro-elements, iron is emphasized due to its major concentration and its vital function in the human body as a necessary ingredient in several important processes to maintain life.

Once the importance of iron in the human body was analyzed, students did the following experiment.

Really! Do we have metal iron for breakfast?

In this activity students brought a sample from the cereal they usually eat at breakfast. They registered the mass from the sample, they crushed it and they put the powder on an overhead or paper. Then, they started passing a magnet over the cereal for several minutes. We have found that this dry extraction presents some advantages with respect to the procedure that is traditionally found in literature [1], [2], [4].

Students were surprised after noticing small pieces of iron on the magnet. Therefore, some questions arose:

- Is iron assimilated by the organism?
- How much iron do I eat in the cereal at breakfast?
- Is this the same kind of iron nails contain?
- What happens to iron once it is in the stomach?
- How does the body absorb iron?

These questions, since they came from students' interest, were used as a guide to direct different small researches around this vital element. In order to answer these questions, the group was divided into teams and different tasks were assigned which required bibliographical and experimental research.

Next, the questions reviewed above will be presented along with the answers found by students.

How is it possible to metal iron to be assimilated by the human body?

After the bibliographical and Internet investigations, students reached the conclusion that it is possible for metal iron to dissolve in the stomach because of gastric juices containing hydrochloric acid which pH equals 2. They made some try outs dissolving iron powder taken out from cereal into hydrochloric acid. Students realized that iron doesn't dissolve easily in cold and diluted hydrochloric acid. Therefore, they tried rising the temperature as well as the acid concentration.

This caused students to reflect in the similarities and differences between the conditions in which they were able to dissolve the iron and the conditions that a human stomach has as well as the role that enzymes have in biochemical processes.

In which oxidation stage is iron kept in our body?

Among other things, students found that there are two types of iron in the human diet: iron- hem (contained in meat as hemoglobin and mioglobin) and the iron- non hem (contained in vegetables and dairy products as iron hydroxide (III), iron salt and ferric proteins). At the time metal iron, added to processed cereals, is consumed, this element dissolves in the stomach and is transformed to Fe^{2+} which is the chemical soluble form capable of breaking through the intestinal membrane (place where the iron is absorbed). The intestines as transportation means are not necessary for the iron that we consume through meat, because it can pass through the intestinal membrane easily.

Besides, students found that once the Fe^{2+} has entered the cells, oxidation takes place from Fe^{2+} to Fe^{3+}, which is stored as ferritine. They reported that only a small quantity of iron that is in our body is wasted through feces, urine or sweat. Since there is no way to waste the excess of iron, the absorption should be regulated, otherwise, it accumulates on tissue transforming into toxic substances.

How much iron do I consume in the cereal I have for breakfast?

First, students calculated the amount of cereal they normally have. They weighted the iron that they obtained from the sample and registered the amount of reduced iron (Fe^0) contained in each gram of cereal. They noticed that they actually consume a bigger portion than the one recommended in the package.

Also, they found the data recording that most of the healthy human beings absorb less than the 15 % from 10 to 15 mg of iron recommended in a usual daily diet. At some point, this is because the iron is not always biologically available; our body is not capable of absorbing iron when it is presented in some forms, as mentioned before.

What kind of illnesses are caused due to consuming more or less iron than necessary or recommended?

To this respect, students discovered that some consequences for consuming less iron than required are: anemia, tiredness, apathy and lack of concentration. On the other hand, an iron overdose can cause damages to the liver, heart and pancreas [5].

What kind of food has iron? Is it extracted the same way as in the cereal?
Students found that egg yolks, liver (pork, chicken, lamb and calf) wheat germ, oats, beets, spinach, steaks, peanuts, raisins, nuts, strawberries, plums, potatoes, carrots, beans and lentils among others, are types of food which provide iron to the human body [6].

The teams decided to use the same extracting technique used in the cereal in order to extract the iron from spinach. They realized that, different from cereal, the iron could not be extracted through passing the magnet close to the spinach, so, they searched for other possible techniques used for iron extraction. From this, students proposed an experimental design to determine the amount of iron contained in the chosen food.

Why is iron added to cereal?
Was we have already said one of the symptoms of having an iron deficiency in the diet is the lack of concentration when studying; also, anemia can diminish resistance to different infections, psychomotor development and the cognitive function. Even if anemia is not present, this deficiency can cause behavioral alterations, attention difficulty and deficient memory.

It was emphasized that these problems are very important from the social perspective, at the point that several international organizations provide resources to enrich food with this element. On the other hand, it was also pointed out that population with a low consumption of meat, compared to more prosperous societies, are the ones that have more illnesses due to iron deficiency.

Closing activity
Finally, a plenary session was done where each team presented the result of its research. Meanwhile, the rest of the group participated with interesting contributions and valuable opinions.

Considering the results presented here, students made a scheme which represented the relationship between the different aspects of new knowledge they obtained. This work (scheme) is presented on Fig. 1.

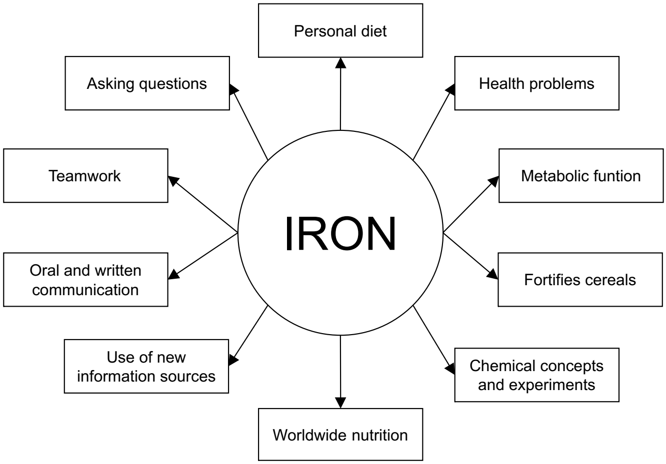

Figure 1. Representation of the relationship between the different aspects of new knowledge obtained by students.

Conclusions

This approach to practical issues resulted very interesting for the students, even when it meant more work in and out the classroom, more commitment and a more active participation. The motivation they had because they were working to solve problems that they came up with, led them to realize that chemistry is very related with other knowledge areas, like health, social aspects as well as taking a more critic posture as consumers and having the will to be better informed about problems that are important for the world.

Even more, concepts, procedures and attitudes were learned. This way the objective established at the beginning was accomplished.

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Snowballs, Sugar Paper, and Students – Enhancing Learning for Non-Chemists

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Summary. I used a variety of grouping methods and resources in my lectures in a hope to improve the learning environment for my students. I evaluated this alternative approach by getting the students to keep reflective diaries, fill out questionnaires and take part in interviews. The results and key findings from this intervention will be presented.

Introduction

After teaching one term of a "Dynamic Planet" module to Year 2 BEd primary students, I received evaluation which suggested that the sessions would benefit from being more interactive and by giving more time for the students to process their understanding during sessions. Furthermore, group work and practical activities were seen to be the best aspects of the sessions.

On reflection on the group work used in sessions, I noted that the students always worked in the same groups, and the same people always actively participated in these groups; I had given little thought to why or how I was doing it, assuming that once they were in groups, learning had to be taking place. Using these as motivation, I set about changing the teaching and learning environment in terms of group work.

Jacques [1] said that *"Two or more people interacting for longer than a few minutes constitute a group"* and this is something, which I wanted to work with. I implemented group activities into my teaching, using a variety of different grouping methods – pairs, snowballing, crossover, buzz, line-out, role-play [2–4], *etc.,* using a variety of different resources including cut-ups, cards and sugar paper. It is suggested that when students engage in these activities, they talk, discuss and argue their reasons and choices for categorising or sequencing *etc.* [2]

Additionally, I made a conscious decision to not "lecture" for more than 20 minutes with out a break. This is based on research by Bligh [5] and Johnstone and Percival [6] which describes how students attention follows a pattern during a lecture, namely a period of non-attention at the start, with the next lapse usually occurring some 10–18 minutes later and as the lectures progress the attention span becomes shorter.

I evaluated this alternative teaching and learning environment by getting the students to keep reflective diaries, fill out questionnaires and take part in interviews. The results and key findings from this intervention are presented.

Sample/Method

As stated, I was teaching on a Year 2 BEd primary module “Dynamic Planet”, which was focussed on the environment, especially the chemistry of the atmosphere and hydrosphere. The students taking this module were studying a programme to become primary teachers with a specialism in science. Science makes up about one quarter of their overall programme content and there was a total of 13 students following this specialism in year 2; 4 male and 9 female with a variety of backgrounds in science.

As described earlier, a combination of methods to research the intervention were used. A questionnaire was carried out at the start of term 2, after the students had followed the module for 1 term, then a similar one repeated at the end of term 2, focussing on the group activities done in sessions. A number of students also took part in interviews early in term 2 to further reflect on the findings from the questionnaire on term 1 activities. Furthermore, the students were asked to keep a reflective diary on the group activities in term 2 for the first 3 sessions. Finally, the standard end-of-module evaluation was also used. These various methods were chosen to allow for triangulation, which attempts to “explain more fully the richness and complexity of human behaviour by studying it from more than one standpoint”. This also helps to overcome the problem of method validation. [7]

Results

Analysis of term 1

The key findings from analysis of the questionnaires on term 1 revealed that they learnt the most from a small group activity where they had to prepare a poster on one of the cycles (C, O, N or S). Reasons for this were that it gave them the opportunity to consolidate their previous knowledge and that it allowed them to use a different approach/style to learning as it was a practical task. They also enjoyed a whole class visit to a green theme park – Eden project, as it allowed them to bond with each other and the tutors. They least enjoyed reviewing scientific papers in groups as they didn't have enough time and found them too difficult. These were further discussed in the interviews as well as general aspects to do with group work. It was revealed that despite the small group knowing each other for over a year they still felt uncomfortable discussing in class with certain people, especially areas of scientific content where they lacked knowledge and understanding.

Analysis of term 2

Overall 8 different grouping methods were used in term 2, many used more than once during the term. Small groups were seen to be the best in terms of enjoyment and learning. One student commented in their diary, following on from a small group activity where they had to rank a series of statements on water management by importance, that: *"Using the statements and putting them into an order made me realise what was important but caused small debates on where they should go which made us think more deeply and justify our opinions."* Other activities using small groups included designing a new sewage treatment process, and matching cell organelles with their function.

Table 1. Ranking for each grouping method in terms of enjoyment and learning

	Group Activity	Rank Enjoyment	Rank Learning
1	Snowball	= 4	2
2	Large (6/7)	6	6
3	Crossover	8	3
4	Line-out	3	7
5	Small (3/4)	1	1
6	Buzz	7	4
7	Pairs	= 4	8
8	Role-play	2	5

Snowball grouping, where students first think about something on their own, then discuss it in pairs and finally in a group, was ranked second for learning and also quite high for enjoyment. One example of an activity which used this was where the students had to think about ways of testing and measuring for pH. One student commented in their diary: *"Builds up ideas and knowledge as more people become involved."* Another student who ranked snowball grouping as their most effective for learning in the end of term 2 questionnaire stated that: *“it allowed me to decide on my own ideas and when I joined together I took more notice of what they said about things I didn’t think about.”*

Crossover grouping was ranked 3rd for learning. This is where each group has a different piece of writing and after a time spent on it in their groups, the groups then disperse to feed back in new groups. Reasons given for crossover grouping being good for learning was that: *“the text was informative but not too scientific based and was easier to read and understand so you could explain it clearly”* and *“I took in much more information because I knew I had to interpret it for others and summarise it. Then got to hear about other groups’ reports also which was valuable and we could compare and critique.”*

Conclusion

The aim of the intervention was to enhance the teaching and learning environment through group work. I feel that students benefited from the variety of grouping methods in terms of learning and this is supported from the various feedback received. Small group activities were noted as the most effective for learning and enjoyment, with snowballing and crossover also effective for learning. Furthermore using physical resources is seen to be an aid to learning, as it supports different approaches/styles of learning and is enjoyed by the students.

Limitations of this intervention are noted however. These include that this is a small class size and some of the strategies may not be as effective or as easy to carry out with a larger group. Secondly, the rooms used are not typical lecture theatres and instead are set-up for group work, as is the standard practice within the faculty. However, I would argue that some of the strategies are possible even in the traditional lecture theatre and with larger groups.

On a personal note, I enjoyed teaching much more in term 2 and feel it was a success. This was supported by the student’s comments when they were asked what changes could be made to the course at the end of the year *“make the teaching for the first term more like that of the second in style”*.

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The Butler Did It: The Use of Detective Fiction to Illustrate Some Chemical and Physical Properties of Gases

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Summary. The late-Victorian and early-Edwardian eras provided aficionados of detective fiction with an abundance of short stories belonging to this genre. Many of these works involve some aspect of chemistry, either in the execution of a crime or in the identification of the perpetrator. The stories discussed in this paper illustrate the lifting power of gas-filled balloons and the gas-phase reaction of hydrogen and chlorine. The use of a gas-filled balloon in the perpetration of a crime in a relatively recent comic strip is used as a link to the present day.

Introduction

The use of detective fiction to promote student interest in chemistry is certainly not a new idea [1], and many articles have appeared in the literature in which works such as Dorothy Sayers' novel *The Documents in the Case*, *The Pale Horse* by Agatha Christie, and the Sherlock Holmes stories by Sir Arthur Conan Doyle have been analyzed for their chemical content [2–4]. I am particularly interested in detective stories written around 1900, many of which have been collected by Greene [5]. In this paper, two short stories from this era, both involving the use of gases in the perpetration of a criminal act, will be discussed.

The Lifting Capacity of Gas-Filled Balloons

In *Five Hundred Carats* by George Griffith [6], the plot, set in South Africa, involves the disappearance of a 500-carat diamond from a securely locked and guarded second-storey office of a diamond company. The perpetrators, two employees who had contrived to stay in the room in order to clean some scales, took a small cylinder containing compressed hydrogen into the office, inflated a child's balloon with the gas, and released the gas-filled balloon with the diamond attached from the office window two hours before dawn. One of the conspirators, who described himself as being "a bit of a chemist", had calculated that the reduction in temperature that occurs just before dawn would reduce the volume of gas in the balloon so that it would fall to earth in the nearby hills. The diamond would then be recovered later that morning under cover of a hunting trip.

This brief synopsis suggests a number of possible discussion points and/or problems for students of various levels including unit conversions, the mole concept, and the structure of diamond; however, it is the properties of gases that are the major focus of this paper. The thieves' belief that the volume of the balloon would decrease as the temperature decreased illustrates Charles' Law, *i.e.*, volume α temperature (at constant pressure.) However, an interesting exercise for students is to calculate the volume of gas, and hence the size of the balloon, necessary to lift a 100-g diamond. Essentially, the mass that a gas-filled balloon is capable of lifting, m_{load}, may be determined by subtracting the mass of the balloon and its attachments, m_{balloon}, and the gas it contains, m_{gas}, from the mass of air that the balloon displaces, m_{air} , [7–11]. Mathematically,

$$m_{\mathrm{load}} = m_{\mathrm{air}} - (m_{\mathrm{balloon}} + m_{\mathrm{gas}})$$

or

$$m_{\mathrm{load}} + m_{\mathrm{balloon}} = V\rho_{\mathrm{air}} - V\rho_{\mathrm{gas}} = V(\rho_{\mathrm{air}} - \rho_{\mathrm{gas}})$$

where V is the volume of the inflated balloon, ρ_{air} the density of air, and ρ_{gas} the density of the gas in the balloon.

Let us assume that the hydrogen gas in the balloon is at a pressure of 110 kPa with a density of 0.099 kg m^{-3}, and that the air is at STP with a density of 1.18 kg m^{-3}. For purposes of simplification in this case, we might assume that $m_{\mathrm{load}} = m_{\mathrm{balloon}}$, *i.e.*, that $(m_{\mathrm{load}} + m_{\mathrm{balloon}})$ = 200 g, giving us a value of about 180 dm^{-3} for the volume of the inflated balloon at 0 °C. Rather a large balloon!

As a follow-up problem, an instructor could ask students how this volume would differ if helium gas were used instead of hydrogen [12] and this could lead to a discussion of the 1937 *Hindenburg* disaster. Relevant data concerning the Goodyear blimp could also be introduced [13]. The session might then be concluded by showing appropriate panels from a 2003 *Rex Morgan M.D.* comic strip in which thieves used a gas-filled balloon to steal a satellite camera lens, shooting the balloon down with a crossbow in order to retrieve the loot.

The Hydrogen-Chlorine Reaction

The hero in *A Race with the Sun* by L.T. Meade and Clifford Halifax [15] is Mr. Gilchrest, a scientist working on the development of a new explosive that is smokeless, odourless, powerful and safe. He is one step away from success when three shady characters deviously convince him that they are working along the same lines, but are having difficulty "owing to the instability of nitrogen chloride". These bogus operators insist that it would be beneficial to all concerned if they could agree to pool their knowledge and collaborate in order to bring the project to a successful conclusion. The hero accompanies the group to their laboratory and is rendered unconscious through the administration of an alkaloid, "narceine". He awakes at night to find himself a bound captive and is subsequently tied to a plank attached to a gas-filled balloon. Also attached to the balloon is a dumb-bell shaped glass vessel containing chlorine and hydrogen, each gas being maintained in its own half of the vessel. The latter is also in contact with a canister of nitroglycerine. The villains' plan is to launch their unfortunate victim aloft, at the same time allowing the hydrogen and chlorine to mix. It being night time, the two gases will not react, but they anticipate that when the balloon is in flight and dawn breaks the light from the sun will cause the chlorine molecules to dissociate and initiate the familiar violent chain reaction with hydrogen. The energy generated by this reaction was expected to shatter the glass container, cause the nitroglycerine to explode, and bring the balloon and its unfortunate passenger crashing into the sea, never to be seen again. The villains would then have sole possession of the method for making the explosive, could sell it to a foreign government, and make their fortunes. Of course, Mr. Gilchrest escapes at the last moment and the plot fails.

This story provides a unique way of introducing the hydrogen-chlorine reaction, including energy considerations, and can also be used to review the properties of electromagnetic radiation. The Cl–Cl bond requires 243 kJ mol^{-1} to be broken, corresponding to visible light with a wavelength of 492 nm, hence the hydrogen-chlorine reaction can be initiated by sunlight. A demonstration to show that the reaction is initiated by blue light, but not red light, has been described [16]. Less adventurous instructors may be content with showing their students a video clip of the hydrogen-chlorine cannon [17].

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The Use of PADs for Continuous Assessment

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Summary
Assessment at both second and third level education has come under immense scrutiny over the last decade particularly addressing the role which it can play in student learning. Particular assessment formats can be used in order to drive student approaches to learning and to encourage and/or reward those that have moved from a surface or recall approach to that of a deeper conceptual understanding of a subject. It has been shown that continuous assessment can be used to encourage students to interact with material on a regular basis, however timely feedback to the students is essential. In this study, the use of Personal Assessment Devices in continuous assessment in a physical chemistry module is reported. Appropriate questions of fixed response format were used probing core concepts covered in lecture material and students received immediate feedback on their responses. Student and lecturers opinions are reported as determined from surveys and focus group discussions.

Background and Aims

The major driving force behind the entire reform of chemistry education and teaching is the conviction held by many that it is only through the development of students' higher order cognitive skills that they will be able to function in cross-curricular environments that are demanded in the working environment [1]. A key skill included in Higher Order Cognitive Skills (HOCS) is students understanding and application of a topic, which first must be underpinned by conceptual understanding of core material. One method which has been used to develop students' understanding is continuous assessment (CA). For the students, CA offers them an opportunity to gauge what they know about material being covered in their lectures and highlights areas in which they require more understanding. For the lecturers, CA allows them to monitor the progress of their students and also provides an indicator as to how the students are proceeding with the course material. It has been shown through numerous studies that students will engage more readily in a module where they are provided with feedback on a regular basis as to their progress [2].

However when considering the addition of a CA ement to a module the lecturer must take into consideration the additional time which will be required to plan, implement and then correct all the CA material. As stated earlier, CA is of no benefit to lecturers or students if critical and timely feedback is not given. Students must be given direction as to how they are progressing with the material and lecturers must be made aware as to the overall understanding of the concepts which they are covering in their lectures thus enabling them to *e.g.* adjust the speed at which they are progressing through their course material.

In this study the use of technology, in the form of Personal Assessment Devices (PADs or clickers) was investigated to address some of the difficulties of implementation of CA. These devices have been employed with success in American Universities such as University of Massachusetts [3] and Columbia University, New York [4]. These devices reduce the amount of time required for collection and corrections of students' answers for the lecturer and also offer the students instant feedback as to their progress in relation to the questions asked.

One module was selected in physical chemistry in which to trial the PADs. Students find this module particularly challenging and lecturers have associated student difficulties with student lack of interaction with the course material and their inability to deal with the required mathematical element. To encourage student engagement with the material covered in lectures a CA element was introduced which accounted for 20 % of the final mark for this particular module. The PADs were used to as the means for conducting the CA element.

The key aims of this work are to answer the following:

- Will the use of PADs (and their novelty value) help motivate and engage students in the lecture material?
- Can the PADs be used consistently as means of carrying out CA?
- Can appropriate questions be developed for use on the PADs to deal with core conceptual issues?

Methods and Samples

The PADs used are the Quizdom Interact used in conjunction with Microsoft PowerPoint. There are five forms of questioning possible on these units, four fixed response (*i.e.* multiple choice, true/false, ranking order and sequential questions) and one numerical input.

The module chosen for this study is a Physical Chemistry module given to 2nd year University students. Approx 110 students from 4 different programmes (Analytical Science, Biotechnology, Science Education and Chemical & Pharmaceutical Sciences) take this module. It consists of 24 lectures, 12 on Kinetics and 12 on Thermodynamics. During the module the PADs were used at the end of every third lecture, for approximately 10 minutes, and involved the students answering a series of questions, usually five.

After the Kinetics section of the module, the students completed a questionnaire to determine their opinions of the PADs as a tool for CA. At the end of the module, selected groups of students took part in focus group discussions on this module.

Results

The questionnaire completed consisted of 6 statements to which the students indicated their level of agreement on a 5 point Likert scale. The key results from the questionnaire indicated that:

- 95 % of the students agreed that the PADs were easy to use,
- 85 % agreed that the questions required a deep understanding of lecture material,
- 96 % agreed that the questions were *directly* related to material covered in lectures,
- 80 % agreed that the CA element was an advantage to their learning,
- 78 % agreed that they liked questions where they could demonstrate that they understood core concepts, and
- 92 % agreed that the PADs should be continued in the same module next year.

Further comments from students indicated that the instant feedback (and the review by the lecturer) clearly showed them areas that they were unsure of. This helped them to organize their study more effectively. It also identified parts of the course that everyone else was having trouble with too. Students found that the PADs were extremely easy to use.

From the lecturers' point of view, the PADs were extremely easy to use, took up little time from the lecture and were a convenient way of determining knowledge of the lecture content at any time. One issue was the format of the questions numerical questions were not very satisfactory to use due to the precise nature of the tool. The fixed response format allowed guessing the answer. However, in the latter assessments, a series of multiple choice questions were used where the reason for the answer chosen in first question had to be selected in the second question. This format of questioning will be further developed and could be very powerful to determine misconceptions in the future.

The results of the CA element and the final examination element will be compared for each student when the final marks are available. Further work in this area will determine if there is a correlation between the student performance in CA and in their approach to learning for this module.

Conclusion

From the analysis and discussions, it is concluded that the PADs were successfully employed as a means of carrying out CA. This was successful from both the students and lecturers involved. A full analysis of student performance with the final written examination marks will be given in the poster.

Certainly from reliability issue, there were no problems with the PADs.

The design and development of a series of challenging multiple choice questions is now key to its further development.

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Teaching Innovations of Themes Difficult to Understand in Chemistry

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Summary
In this contribution we developed a project which goal was to design didactic support material addressed to teachers, in detected themes of difficult comprehension in chemistry for high school and first degree college students.

Introduction

As opposed to the diversity of the new teaching models and of the scientific teaching alphabetization that the society demands to us, is of vital importance to redefine the teaching-learning strategies as well as to renew the planning of the educational work. In the last years, the necessity to focus the educational process from the student's perspective has been seen. To start from the student's concepts, to make emphasis in the examination of their own ideas, so that once they know them, new elements of information are provided. So, they are able to re-elaborate these ideas to approach the knowledge accepted today by the scientific community.

Objectives

Based on the previous argue, we developed a project in order to design didactic material support addressed to teachers, in subjects of difficult understanding for the students with the purpose to favour our students' apprenticeship of conceptual contents, procedures, and attitudes as well as the development of thought abilities.

Development

A prior research was carried out, to identify several chemical and/or thermodynamic concepts of difficult comprehension for the students. For each one of them, didactic material was developed as a brochure. These brochures present the difficulties reported by educational investigation related to the subject's comprehension. Afterward we design a proposal for each one of the concepts, through a group of activities that promote conceptual, procedural and attitudinal learning. In this material some guides for the teaching evaluation of learning reached by the students are also included.

The format we decided to develop for the brochures takes into account the main aspects of a didactic unit [5], [9]:

1. Name of the theme to develop.
2. Didactic orientation. In this section the difficulties will be specified that according to the educative investigation, appear in the understanding of the themes to be studied. We also present the strategies related applied.
3. Content: a) Concepts, b) Procedures and c) Attitudes. The difference among these three aspects has fundamentally a pedagogical character, since it allows taking conscience of the different science teaching aspects, since normally it is focused almost exclusively in the conceptual aspect.
4. Proposed activities. The selection of strategies intends to achieve the objectives proposed. Diverse activities can be carried out such as: questionnaires, readings, teaching demonstrations, small investigations, field work, *etc.*
5. Guide for evaluation. The evaluation should be present in each one of the stages of the process, so that information will be available to us, in order to feedback students, and to improve the whole educational process.
6. Bibliographical references.

Chemical Reaction Brochure

The theme of chemical reaction is presented as an example. The reason of why it was chosen is justified. Some of the activities suggested to develop with the students are shown.

Chemical reaction is a fundamental theme in chemistry programs that has its own difficulties of learning. On the one hand, the intrinsic ones of the discipline; by the other hand, the students' thought and reasoning processes, and in addition the instruction process received in the classrooms [1].

Students tend to transfer the substances properties to the particles properties. So, there is a great influence of the macroscopic perception in the analysis of the sub-microscopic world [1], [6].

Among the difficulties of the discipline, the main obstacle (according to Bachelard [8]) is the tendency to explain the chemical phenomena by the physical characteristics of the substances. In addition to this, the existence of three explanatory levels of the matter: macroscopic, sub-microscopic and symbolic [2], [4] represent another difficulty.

Traditionally, the theme of chemical reaction is taught to begin from the difference between physical and chemical change. According to Garritz [3] to include this in the curriculum of chemistry is not convenient. Experiments that show there is a reaction going: colour change, loosening of a gas, reaction container cooling or warming, formation of a precipitate, explosions, *etc.*

Phenomena observed are associated with the writing of the chemical equations. Also calculations are carried out in which the following terms are used: mol, molecular weight, molarity, purity, yield, limiting reactive, *etc.*, concepts that students learn to deal with even without understanding them.

Didactic Proposal

Detection of previous conceptions. It is often difficult for the students to recognize when a chemical reaction occurs [7]; for example, they do not distinguish in a consistent way between a chemical change and a change of phase. With the purpose to know the students ideas about the concept of chemical reaction, it is suggested to develop an experimental activity to obtain a global panorama of the student's ideas about the topic.

Explanation in the macroscopic level. Our main interest on this point is that the students realize that in a chemical change new substances are formed. The properties of the new substances are different to those of the former ones, in their chemical and physical properties. It is suggested to present reactions, making emphasis in the initial and final state of the system, and to reflect about those changes that indicate that a chemical reaction is occurring. It is important to think about the need to identify the substances that participate in a reaction and to determine their chemical and physical properties.

Explanation in the sub-microscopic level. In this point we intend students to apply the molecular kinetic model to explain a chemical change by using diagrams to show it. It is important that the student link the macroscopic with sub-microscopic world in order to explain the chemical reaction. It is suggested to develop experiments in open and closed systems in order to think about the aspect of mass conservation.

Symbolic Level. We suggest working with the students in the resolution of exercises in order to emphasis the translation of the symbolic language to the maternal one and vice versa.

Evaluation guide. Because the intention is to know if the student distinguishes and dominates the different explanatory levels for chemical reaction, different activities that integrate them can be done.

Results

The results obtained when working with 20 high school chemistry teachers, show that they generally they use partial explanations to approach the chemical reaction topic, and that they do not make the chemical language explicit that use in their definitions. Most of them (80 %) use the word "*change*" to describe the process between the initial and final state in a chemical change, but only 50 % of them gives a brief explanation of the reason of the change (atoms are bonded in different ways, bonds are broken, …) When they explain how to characterize the final state of a chemical change, the term "*new substance*" predominates (60 %) even if they do not explain what does it mean.

Through the exercises and discussion made throughout the course, these teachers agreed that it is important to approach the different *explaining dimensions* distinguished for a chemical reaction: macroscopic, sub-microscopic, and symbolic. They recognized that they do not use the kinetic molecular model to explain the chemical reaction, that they give a great importance to the writing and balance of the equations and to the classification of the chemical reactions leaving aside the process of understanding.

Final Comment

The teacher's attitude is very important to achieve a successful interaction with students. Our motivation on teaching is reflected on which we do, but also in what we are not doing, inside and outside of the classroom.

We consider that the value of this proposal resides not only in the selection of the experimental activities, but in offering the teachers a material whose didactic structure motivate them to improve their educational practice including activities as the ones that here are presented.

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Using the Schematic Representation of Teaching and Learning Materials in Science Classes

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Summary. This paper reports the use of different types of schemas to teach and to learn chemistry and physics. The schemas used for that purpose can be classified into three types: curricula schemas (CSs), schemas of educational contents (SECs), algorithmic schemas (ASs). Schematic representation of teaching information allows the teacher to present the didactic materials in more effective way and helps students to learn science theories and concepts more meaningfully.

Introduction

The schematic representation of the education information is the effective way to reach the better understanding and learning of the theoretical concepts and practical skills by students [1–3]. The schemas used for presentation of educational material in science can be classified into three types. The first type the curricula schemas (CSs), combine concepts into systematic theoretical course programs. A second type – the schemas of educational contents (SECs), reflect the concrete educational contents of the program. The third type – algorithmic schemas (ASs) are used to help in solving problems, carrying out different kind of exercises and so on.

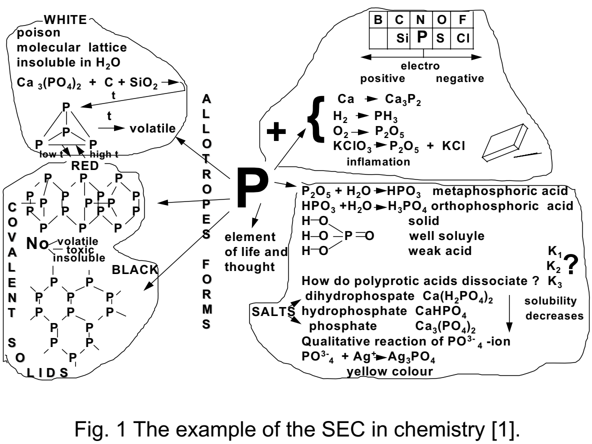

Fig. 1 The example of the SEC in chemistry [1].

The use of the schemes allows them to achieve a considerable time economy 20–25 % when teaching the subjects of the natural-scientific cycle. This allows the lecturer to give more than a single explanation of the educational material in some cases, and also enables the student to learn better [1]. The time economy, mentioned above, presents a real way which makes it possible to reduce the amount of time needed for lectures, by allowing for a corresponding time increase for independent student work (ISW) in the absence of a teacher. Control and self-control of knowledge and skills are carried out more effectively with the schemas.

It's possible to apply such schemas in ISW, which can combine with other ways of active learning, for example, students can supplement them during the learning process. It is also possible to apply different methodology. For example, students can complement the SECs with blocks without the didactic information. This learning activity allows them not only to develop in remembering the material but to master creative skills and abilities. In the ISW they can design their own SECs and CSs too.

The schemas are very useful for ISW in the process of reviewing and in the preparation for examinations. The process of students' preparation for examinations includes work with the complete set of CSs and SECS, which are spread on a surface (e.g. on the table surface) for the best way to survey sections of topic material and for the best mastering of their interrelationships see [1].

Structuring the theoretical material by means of described schemas is also very useful for the improvement of traditional Chemistry textbooks. Using CSs and SECs in the structure of textbooks can correct some of their defects and allow for a better learning of the main chemical material [1, 4]. Schemas can also be the special means for creation of new types of computer educational software for Chemistry teaching [5, 6].

Methodology

We applied these types of schemes in classes of chemistry and physics in the first semesters of the Biology and Engineering programs in the Faculty of Science of the Pontificia Universidad Javeriana. The methodology of experimental and control groups was used in this case. The schemes of different types designed by the teacher and students had been used in the experimental classes. There is the example of the SEC in chemistry in the figure 1.

For the experimental group with lower preparation in comparison with the control group the methodology of schemes supported favorably of development of the course of introduction to the physics and chemistry. It was observed that the experimental group initially was in a conceptual level of knowledge below the control group. In the end of the pedagogic experiment, it is appraised that the experimental group increased in its level of knowledge greater than the increase in the level of the control group: growth experimental group 27 % in average by question and growth control group 23 % in average by question. The difference between the first examination and the final examination for the experimental group was of 22 points, whereas for the control group it was of 11 points, so the growth in the level of successes in the examinations was almost the double in experimental group to compare with the control group. Using the different types of schemes the learning for physics and chemistry modified the education process from a new perspective, which avoids to restrict it to a vision of usual formulas. In this approach the teacher must accompany, of near way, to the student while they become familiar with the new methodology.

The application of the schemas approach in science subjects demonstrates that it is an effective means for the representation of didactic information in various types of teaching and learning activity.

Using different kinds of schemas and algorithms for presenting various types of educational material is one way to make the learning of science courses more enjoyable and effective for students. Essentially, the schemas can free students from summarising the lectures. While listening to a lecture the students consult schemas which facilitate their comprehension of interrelations and links between concepts. As CSs and SECs reflect the logical sequence of questions to each topic and the more important information in the subject, they facilitate proper allocation of material to be studied individually. It is easier to work with a textbook while referring to schematic material organisers.

Schematic representation of information is one of the tools which can contribute to restructuring of instruction toward the transition to a more creative style of teaching science subjects. Further study of schema applications in classes and in textbooks will lead to the design of more efficient teaching methods and their use will aid the purpose of improving and developing educational standards.

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"Pictures of an Exhibition" – a Possible Way to Make Chemistry more Popular

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Summary. Our Exhibition is divided into four basic topics, including medicine, communication, energy supply, and agriculture/ food safety. The posters of the Exhibition show the chemical inventions of the past 125 years. The Exhibition is available in two versions: thirty-three, 60×90 cm posters, and the other is available as a Power Point presentation electronically. Booklets were prepared for lesson-processing of the Exhibition for the two targeted groups (primary-/secondary-school pupils), according to the principles of museum-pedagogy.

Introduction

It is plausible today that we are provided by means/tools, making our everyday life more comfortable and easier. The achievements of chemistry have been integrated into our everyday life indispensably. In spite of this fact chemistry does not receive popularity either in education or in publicity. For example, about fifty years ago DuPont choose the slogan: *"Make better things for better living trough the chemistry"* that had been withdrawn owing to unpleasant publicity of chemistry.

There are two reasons for the unpleasant public judgment of chemistry: The negative criticisms in the broadcasting, and the scientists themselves, who are proud on their scientific achievements, but do not pay attention on the practical side of their results and on the public popularity of chemistry.

A further reason is the lack of basic knowledge. The chemistry education in primary and secondary schools should concentrate rather on quality issues instead of quantity, and it would be advantageous to teach history of chemistry beyond the subject, focusing on the importance of the achievements and their advantageous impacts on our everyday life. The learners may understand deeper how development of chemical knowledge and elaborating new techniques influenced the life of the human society and its role in the everyday life. Furthermore, they would pay less attention on the critical news of the media.

The importance of demonstrating practical aspects of scientific achievements has been recognized in many countries. Accordingly, the colleagues at the American Chemical Society (ACS) compiled in 2002 the Power Point Show “Technological Milestones”, demonstrating chemical inventions of the past 125 years. This Exhibition is divided into four basic topics and subunits, including medicine (27 subunits), communication (16), energy supply (20), and agriculture/ food safety (16).

We translated this slide show in our project into Hungarian. During translation we have realized that the original language usage of the show, though very interesting, exceeds the knowledge of the primary- and secondary school pupils as the targeted group. Therefore, with the permission of the authors, we changed the text from a methodological point of view.

The Exhibition is available in two versions: One consists of thirty-three, 60×90 cm posters, framed in 70×100 cm size, and the other is available as a Power Point presentation electronically (*http://www.staff.uszeged.hu/~nemethv/index.html*). All four topics consist of two additional posters, containing the table of contents and a chronology.

Adaptation of the Exhibition “Milestones of Technology”

The adaptation of the exhibition material included, beyond translation, processing too, according to the European and Hungarian mentality, and didactical changes were introduced also. The didactical changes have made possible easier understanding without influencing the message of the original text.

During translation we faced numerous difficulties. As it was originally compiled for the American population, it contained the nationality of the cited scientists occasionally and gave their first name only. We paid attention on the nationality and the full names of the cited persons. The list of the cited persons was completed with internationally acknowledged Hungarian scientists also.

We revised the English version several times, as some parts of it had been written in a very detailed fashion, using complicated terms. During our processing these terms were substituted by correct everyday expressions. Where it was impossible, we explained these terms in sentences, altogether 23 times (vacuum distillation, estrogen, liophilisation, *etc.*).

We etymologized on the opposite way too: The Hungarian term was followed by a foreign expression (stroke, glucose, syphilis, *etc.*). We gave the original description of all acronyms also (NMR, CT, CD-ROM, PET, DDT, *etc.*).

The American reader can link persons to firms; this linkage is not clear for the Hungarian visitors, therefore we included this fact in our text.

The most problematic part was the medicine, where we passed over some professional terminology and replaced with interesting and useful information for the pupils.

According to our basic intention we described those facts that we understand immediately, without any further reading, as the too complicated, hardly interpretable sentences did not call the attention of the pupils. The names of agents and medicines included only those, which are in trade in Hungary. The style of writing followed the Hungarian orthography. The passed-over informations were replaced by a few sentences, with expected basic knowledge by the pupils. Issues of environmental protection appear only a few times in the text.

In order to call attention of the readers, we illustrated the posters with 227 colour pictures, selected from a large set of collected illustrations, linking to the meaning of the texts. In contrast, the original exhibition material – except four posters – does not contain pictures. Therefore, the spectacular appearance of the posters seems suitable to catch the attention of the reader. The appearance of the posters is unique, although they differ in their colours.

Visitor's information

Booklets were prepared for lesson-processing of the Exhibition for the two targeted groups (primary- secondary-school pupils), according to the principles of museum-pedagogy. The visitor's booklet helps understanding of the material of the Exhibition by carefully selected questions, and processing the information in frame of an extraordinary chemistry lesson. As the amount of the information is too high for the pupils to understand it in all details, we offer processing in group work for the teachers. The test is not a mean for keeping discipline, or part of the curriculum, it is not suggested to be scored, but is a useful source of knowledge.

The posters were printed in the USA, the framing was paid by the Hungarian Chemical Society. The Opening Ceremony of this Exhibition took place at 13th of April 2007, at the Szeged Piarist High school. Our terminal goal with this exhibition is to present it in as many schools as possible, within and outside of Hungary in road shows, where the language of the education is Hungarian, to achieve the reputation of chemistry as a science and a subject. We work on the English-retranslation of the Exhibition material that will be offered worldwide.

How to Solve Laboratory Problems and Tasks in Chemical Education?

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Summary. Multi-sided education involves the introduction of elements of directed self-learning into the educational process. The efficacy of learning is primarily influenced by content and structure of all of the messages which constitute the source of information. One of the ways to solve problems resulting from this fact is the application of modern teaching techniques which base on multi-sided teaching and learning. Educators must employ a multitude of forms, methods and didactic means as well as design systems of teaching means and introduce new methods of educational programming.

Introduction

Educational videos facilitate the process of modern teaching. They show numerous aspects of phenomena. Processes and images combined with acoustic messages exert substantial influence of the recipients' imagination. Such videos may not only provide students with information and stimulate intellectual activity, but they can also evoke certain feelings by juxtaposing appropriate facts. They constitute the most representative element of the subgroup of audio-visual media [1].

Educational videos play a very important role in the process of chemical education. Chemistry experiment is the most important element of the lesson as it helps covey information, teach the ability to observe and draw conclusions. It may be of either cognitive, introductive, research, illustrative and modeling nature as well as it may be used to revise, verify and control the students' work. While watching educational videos students get to know chemical phenomena and are prepared to independently organize, perform and interpret chemistry experiments [2].

The faculty of Chemical Education at Adam Mickiewicz University prepared educational videos on organic chemistry experiments designed for secondary schools. Video sequences were made by means of Adobe Premiere Pro 1.5. A non-linear montage was carried out to which effective transition between sequences was added. Adobe Premiere Pro 1.5 made it possible to add graphics and soundtracks.

Three versions of the videos were made. The first one presented chemistry experiments which were carried out correctly. These films are used in teaching Chemistry according to the curricular basis. Students are presented with the reagents and equipment needed to carry out experiments correctly [3].

The second and third versions present the course of experiment in which incorrect substrates were used or the course of experiment was incorrect. These versions combined with the first one are designed for students who, having done a particular portion of the material, want to check their knowledge [4, 5].

The video was chosen as a didactic means in view of its following advantages: evoking students' interest and involvement in the content, evoking certain intellectual activities, facilitating perception of the material and expanding the time and place of learning. Videos may be used even in relatively small and poorly equipped educational centres and the information conveyed by them is remembered better than when it is presented verbally. Students are presented with these elements of the reality which are unavailable in direct observation, the reality is presented accurately, the phenomena may be replayed, their course may be speeded up or slowed down.

Research

In the research into educational efficacy of videos secondary school students were divided into two groups: the control and the experimental one. The former consisted of 94 students who used conventional printed instructions whilst doing experiments. This group revised the materials using handwritten notes. The experimental group consisted of 92 students who carried out experiments using the videos. While revising they were presented with the three versions of the videos. Before the research was started, students in both groups did an introductory test which was to determine their knowledge on selected issues. Subsequently, the students were asked to carry out the experiments either using conventional instructions or those presented by means of videos. Having done the experiment students did the final test which was to examine the increase of their knowledge which, together with the educational efficacy of the didactic means under discussion, was determined for four taxonomic categories of educational aims: memorizing information, understanding, the application of information to typical situations and the application of information to problem situations [6].

Results

It was found that in the control group the increase of knowledge amounted to 28 % with respect to memorizing, 27 % with respect to understanding, 25 % with respect to the application of information to typical situations and 36 % with respect to the application of information to problem situations. In the experimental group the increase was 56%, 49%, 65% and 73% respectively (fig. 1)

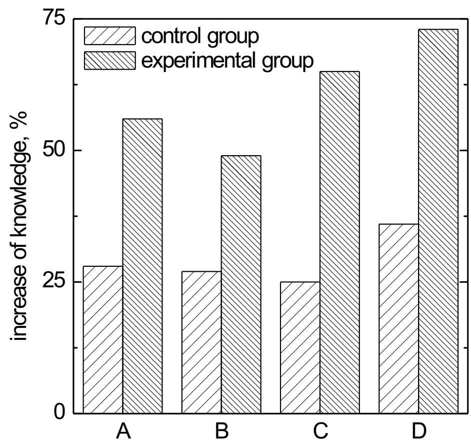

Fig.1 The increase of knowledge in the control and experimental groups with respect to the categories of educational aims: A – memorizing, B – understanding, C – the application of knowledge in typical situations, D – the application of knowledge in problem situations

Therefore educational efficacy of the video under examination in the above categories of taxonomic educational aims was as follows: 28 % with respect to memorizing, 22 % with respect to understanding, 40 % with respect to the application of information to typical situations, and 37 % with respect to the application of information to problem situations.

The results of research point to higher achievements of the experimental group of students as well as to the fact that the didactic means under examination favourably influences the process of chemical education especially with respect to the application of knowledge in typical situations and in solving problem tasks.

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Lab Work and The Understanding of Science

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Summary. Research showed that pupils often have difficulties in deeper understanding when experiments are used in chemistry lessons. In the context of a research project investigating in which ways pupils' practical activities can be used as a tool for diagnosis and assessment, instruments were developed with which some of those difficulties could be addressed.

We assumed that teacher students might face similar difficulties. Because of this we started analysing how our teacher students are conducting the experiments, to which extend they use the scientific method and if the instruments developed for pupils can be adopted to university level.

Experiences with lab work

On school level experiences with practical activities are reported for many years now and cannot leave one satisfied. It can be assumed that chemical experiments have a strong influence on nearly all parts of the chemical thinking. They are strongly linked to many fields of competence although there are several critical remarks on the practice of applying experiments in every day lessons so far.

The TIMS-study for example showed that only 10–15% of the German 13-year-old pupils are able to understand a simple experimental arrangement [1]. Lunetta [2] pointed out that pupils often work unsystematically when they have to analyse relations of cause and effect. And as a last example it shall be referred to Demuth [3] who showed that pupils often consider the manual work on an experiment to be the most important phase of an experiment.

Looking at our own teacher students at the university of Dortmund we found difficulties in understanding the scientific worth of lab experiments. *E. g.* students often do not separate exactly between the simple description of the performance of the experiment, the observation and the interpretation when writing a record. The records showed that they often were not able to understand the experimental arrangement used and could not explain why the experiment has to be performed in the way the experimental instruction told them to do.

In addition to that a significant number of the students used scientific knowledge they learned from literature to explain the observations they made, but not the own findings they should have been drawn strictly from their observations.

Instruments developed to change the design of lab experiments in schools

In the context of a research project [4] investigating in which ways pupils' practical activities can be used as a tool for diagnosis and assessment, instruments were developed in cooperation with a group of teachers and it was tested to what extent a diagnosis or assessment is possible. It could be seen that these instruments are suited for a diagnosis and an assessment of the pupils using lab work. In addition to that teachers and pupils reported that these instruments helped the pupils to understand why the experiments are done in a special way, what the meaning of the results could be and in this way led them to a deeper understanding of the scientific method.

One example for a different design of lab experiments are experimental instructions with gaps in the description of the performance of the experiment. The pupils were asked to complete the instruction-form before carrying out the experiment, often as homework. Of course the difficulty of this task depends on number and position of the gaps. In addition to that the teachers reported that the difficulty also very clearly depends on how an experiment has been introduced in the lesson and the teachers reported that this easy instrument has given them a good impression to what extend a pupil has understood why the experiment was done.

The good experience with this instrument made the teachers and the researchers involved stepping another step further by asking the pupils to develop an own experimental instruction, normally done as homework. One example that was tested with great success in Bavaria in a 10^{th} grade course (that means that the pupils were learning chemistry in the second year) can be seen in Fig. 1.

> Develop an experimental design with which the pH-value of different soil-samples can be detected!
>
> One step further: develop an experimental series: Which different soil-types do you know and which of them would be worth testing? And why?
>
> These tests are homework to the next lesson!

Figure 1. Example of changed experimental arrangement on school level

The written experimental instructions were then read by the teacher and basis of a diagnosis. All teachers report a clear enhancement of attention and interest and were astonished about how much and how deeply their pupils think about the experiments.

Transformation on university level

The positive effects the developed instruments produced on school level and the fact that our students show problems similar to the ones pupils face when using experiments made us try to adopt these instruments in a way that our students can be confronted with them in laboratory.

For this reason advanced students accompanied a group of young students doing their laboratory in inorganic chemistry. They read their records and observed them in the laboratory in order to analyse which specific problems they face as far as the scientific method is concerned.

Based on the results of this analysis in the second part of the term the experimental instructions of the detection reactions for cations were manipulated by introducing gaps in the description of the performance of the experiments.

After having filled these gaps and having conducted the experiments the students will be confronted with a sample of unknown composition and will be told which types of ions this sample could contain. The students will then be asked to theoretically develop an own separation and identification procedure which will be checked by the tutor of the laboratory in order to ensure the safety and to use this as an additional tool to learn about the students view on the scientific method.

The students will then have to conduct their own procedure and give a written reflection about the success of their method, the reasons of problems which occurred and will have to suggest ways of enhancement.

During the whole procedure the students will still be observed by the advanced students and the proposed separation procedures in combination with the students' reviews will be analysed in order to detect if this kind of inquiry based laboratory helped the students to understand the scientific method and to reduce the problems reported above.

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Small-scale teaching within large groups – empowering the tutors in a 1st year undergraduate chemistry laboratory

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Summary: 1st year labs can be challenging due to large numbers, diversity of programs, backgrounds and prior learning of the students. But it can be used to help them in developing "good habits" for learning. The role of the demonstrator was changed to tutor. This will be discussed.

Background and Aims

Laboratory work is an essential part of all undergraduate programmes in Chemistry; it provides an opportunity to develop manipulative skills as well as applying the theory covered in lectures. However, laboratory work is costly to run, heavy on resources and may not always fulfil its aims.

Aims of laboratory work have been given by Garrett [1] and while he notes that the laboratories should provide opportunities for students to develop skills in technical ability, and observation, he also notes data interpretation, presentation skills and oral communication as necessary. He also stated that the laboratory activities should provide experience in designing the experiment and consolidation of subject knowledge. These are often activities that are associated with later years of an undergraduate course and not with first year.

These three issues with regard to first year laboratories were therefore addressed:

1. *Assessment*
   Was the laboratory a real learning experience for the student?
   What were the students receiving marks for?
   Were the aims as set out above being achieved?
2. *Motivation*
   Did the student know what was expected of them?
   Could appropriate activities be developed that were challenging to all the students – including those with some prior chemical knowledge?

3. *Retention*
   Could the laboratories be used to 'get to know' the students quickly and identify the “at risk” students?
   Hence additional support could be provided if necessary.

Laboratory Activities

A range of activities / tasks were devised that complemented the lecture material. Additionally, each activity was challenging for both the student without prior experience of chemistry and those who had already completed 2 years of chemistry in second-level school. These activities have been detailed elsewhere [2]. During each 12 week semester, the students (n = 182) would also take a practical exam, give an oral presentation and complete a formal laboratory report. A laboratory notebook was the main recording method for the remainder of the experiments. In this notebook, the students completed their pre-lab exercises, noted results and observations on their activity and finally completed calculations and conclusions for each activity. Over the 24 weeks of the academic year, they completed 3 formal reports.

A key issue for us was the development and implementation of appropriate assessment strategies *e.g.* if the skill of observation was considered important, then the students should be graded on that skill. To this end we felt that there had to be many different forms of assessment throughout the laboratory session.

Table 1 indicates the breakdown of the assessment for the laboratory and Table 2 indicates the specific assessment breakdown for the ”Laboratory” mark.

Table 1. Assessment Breakdown

Laboratory Component	Grade (%)
Laboratory	60
Practical Exam	20
Presentation	20
Lab Reports	10

Table 2. Breakdown of “Laboratory” Assessment

Component	Grade (%)
Pre-Lab (written)	5
Pre-lab (questions)	10
Skill Mark	10
In-lab questions	10
Notebook	10

When such a detailed assessment was put in place, then the implementation of this was a key issue and we felt that the role of the demonstrator in the laboratory was crucial. The demonstrators in the laboratory are typically chemistry postgraduate students in their 1st or 2nd year of postgraduate training. Demonstrating is an essential part of their postgraduate training and all of postgraduate students do approximately 100 hours of demonstrating in undergraduate laboratories per year.

Empowering the Tutors

The role of the demonstrator had to change if the above assessment was to be carried out effectively. Figure 1 summarises the change in role that we envisaged for the demonstrators who were now called laboratory tutors – to reflect their more teaching role.

Lab demonstrator	Lab tutor
Answer when asked questions	Encourage thinking
Grading of lab reports	Get to know the group
Monitor benches	Assess students in the lab
Preparation chat before lab	Monitor students
Student : Demonstrator ratio (1:17)	Trained tutors
	Student : Tutor ratio (1:10)

Figure 1. Envisaged role change of demonstrators

All of the laboratory tutors underwent a training course of 2 days – one day specifically on the chemistry activities and the second day on a more general training course with the tutors from the rest of the Faculty. The Chemistry training day addressed:

- Role of laboratories, your memories of good laboratories/bad laboratories, learning opportunity, understanding, skills, …
- Why these particular activities chosen, associated learning outcomes …
- role of tutor, questioning, assessment …

Results and Discussion

Effect on Tutors

The tutors (n = 17) were all highly motivated in their role. They wanted “their” students to succeed and also they were interested in the approach taken within the laboratory. Each tutor was asked their comments on the new laboratory regime after 12 weeks and their comments are given in Table 3 and student comments are given in Table 4.

Tutors were recognised by the students as being good tutors if they encouraged them to think about the laboratory tasks. Also students were happy to have the tutors assessing them rather than the academic in charge of the laboratory.

Tutors felt prepared for their tutoring role however, they would have preferred more assistance in terms of questioning and particularly in preparation of higher order questions. The high degree of involvement of the tutor in the learning process of the student promoted an increase in the maturity of the tutor, who became more aware of the need for preparation before the laboratory session. This led to an increase in confidence observed in the tutors, who became more capable of evaluating and stimulating the students as the academic year progressed. Moreover, the tutor attained deep knowledge of each individual student within his/her group. This provided invaluable information about the students (their strengths and weaknesses), and that permitted a prompt response from the academic to correct arising problems at early stages.

Table 4 illustrates that this system helped build a relationship between the student and the tutor that was mutually recognised. The student became accustomed to being constantly challenged and recognised its educational and stimulant value. This was evident from the fact that most students saw the tutor as a person who should encourage them to think rather than provide all the answers. Student opinions of the tutor were consistent for those with and without previous chemistry background. Independent t-test analysis shows no significant difference in their response to the likert survey questions (Table 5).

Table 3. Tutor comments on laboratory experience

	Agree (%) (St/F)	Somewhat /not sure (%)	Agree Weekly/v (%)
Students responded positively to questioning within the laboratory	57.1	42.9	0.0
Students put a lot of effort into the pre-labs	35.7	42.9	21.4
Students put effort into understanding the laboratories	38.5	38.5	23.1
Students general effort increased as the semester progressed	64.3	21.4	14.3
Your students did better than the average student	25.0	66.7	8.3
Students without leaving certificate chemistry struggled more than those who had done chemistry before	85.7	7.1	7.1
I built up a good relationship with my students	92.8	7.1	0.0
I was able to spend time with students who needed my time	70.5	7.1	21.4
I found it easy to ask students challenging questions	35.7	35.7	28.6
I prepared for each laboratory session before entering the laboratory	92.9	7.1	0.0

Table 4. Student Comments on Tutoring

	Very /fairly strongly (%)	Somewhat /not sure (%)	Rather /very weakly (%)
The laboratory tutors were approachable and helpful	80.0	11.3	8.7
Even though my tutor was grading me I was comfortable asking him/her questions	82.5	10.7	6.7
The tutors questions made me think about the chemistry I was doing	82.7	12.0	5.4
Answering tutor questions made me confident/clearer about the chemistry I was doing	73.8	15.4	10.7
A good laboratory tutor is someone who …			
• tells me all the answers when I ask them	28.5	24.3	47.1
• encourages me to think about the laboratory I'm doing	92.6	7.5	0.0

Table 5. Comparison of Student Comments on Tutoring based on previous chemistry background

	Chemistry Background	*n*	Mean	Sig. (p)
The laboratory tutors were approachable and helpful	Yes	72	4.21	0.831
	No	77	4.25	
Even though my tutor was grading me I was comfortable asking him/her questions	Yes	71	4.39	0.387
	No	77	4.26	
The tutors questions made me think about the chemistry I was doing	Yes	72	4.15	0.727
	No	77	4.10	
Answering tutor questions made me confident/clearer about the chemistry I was doing	Yes	72	3.89	0.718
	No	76	3.95	

Implications for future

By changing the role of the laboratory demonstrator to one of laboratory tutor, their role in teaching and learning was emphasised. Additionally giving the tutors the names of the students rather than the benches seems to have personalised the relationship.

A key factor in driving the work of the student was in the assessment and the level of assessment that was carried out was only possible with the tutor:student ratio of 1:10 (or less). Areas of laboratory work that are normally confined to later years in an undergraduate programme – such as presentation skills, oral communication, devising their own experiment – these were possible with the large numbers with the assistance of the tutors. Additionally, the involvement of the tutors to the extent described above in the assessment of the students also encouraged the tutors to re-examine their own understanding of basic concepts.

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Chemical Demonstration. An Integrated Methodology for Chemical Education.

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Summary. We present an experimental methodology aimed to re-concept and diversify the practical work, allowing students to learn science, understand its nature, methods and the science-technology-society relation. The topics of experimental activities are in agreement with the new Chemistry and Thermodynamics curricula of the University of Mexico.

Introduction

For more than 100 years, teachers have been encouraged to give practical work a central role in science education, but when questioned on the reasons for using practical work, most teachers claim that it assists and promotes both conceptual and procedural understandings. The latter argument is sometimes expressed in terms of “what you see and do for yourself, you understand” or “practical work provides concrete reinforcement of abstract ideas”. The cluster of cognitive arguments is directed towards understanding the nature of scientific inquiry (*i.e.,* “scientific method”) and learning about the design and conduct of experiments. In addition, some teachers assert that practical work gives students experience in problem solving and provides opportunities for creativity [1].

If we consider that Chemistry is a reflection of man’s effort to explain his world and to survive in it, then it is understandable that the teaching of chemistry to new generations of students should recognize and, to some extent, look after this problem-solving heritage. But unfortunately, the adventure of teaching chemistry is often reduced to passive lectures and “cookbook labs” that suppress student’s questions, exploration, and interest [2]. In addition, in countries like Mexico, we must consider, that many chemistry classrooms are poorly equipped and severely limit the laboratory experiences that teachers can provide.

On the other hand, the professors frequently consider laboratory work as an essential component of any science course, but students seem to experience some difficulties in the integration and correlation between the chemical concepts learned in lectures and the phenomena observed in the laboratory.

In virtue of the above, it is important for academic groups to work and generate discussions on the type of practical works that should be offered, taking into account that what students really value is the cognitive challenge that face they are faced with in a particular experimental work, which they can understand and carry out successfully.

For many years, the main objectives of science education were investigated in a non-integrated way in specialized literature. The conceptual learning and the construction of models, the problem solving and the experimental work were developed by different and non-related groups of researchers. Although these items have been worked in a parallel way, today’s tendency is to work them in an integrated manner with the purpose of avoiding misunderstandings or even contradictions in the learning process [3].

For experimental work, the research evidence does not support our belief that practical work: *(i)* assists students in acquiring and developing an understanding of scientific concepts, *(ii)* motivates students, *(iii)* promotes achievement of laboratory skills, *(iv)* gives students a solid and authentic view of science and scientific activity and also *(v)* encourages the so-called *“*scientific attitudes*”*.

In agreement with [1] we consider there are a number of reasons that explain this situation:

1. Practical work is too gross a term and too large a category.
2. Practical work is often poorly designed and poorly executed.
3. From a didactic standpoint, teachers do not always achieve results as intended in their plans.
4. Performance by the students does not always live up to the teacher's intentions or expectations.
5. Practical work frequently gives unexpected, inconsistent or inconclusive results, and sometimes no results at all.
6. Assessment methods which conclusions on the efficacy of practical work are often based or focused on the less significant aspects of the work, while ignoring valuable learning in other areas.

Table 1. Classification of the practical work proposed by Caamaño [4].

Practical work	*Description*
Experiences	Practical activities designed to obtain a familiarisation with the phenomena.
Illustrative experiments	Activities to exemplify principles, to verify laws or to improve the understanding of certain operative concepts.
Practical exercises	Laboratory activities specifically focused on developing practical abilities, strategies of investigation, cognitive abilities of communication or processes in a scientific context.
Experiments to compare hypothesis	Activities intended to determine the validity of a hypothesis established by the professor or the students.
Investigations	Experimental activities to give the students the opportunity to work like scientists or technologists in the resolution of problems.

In short, practical work is both over-used and under-used. It is over-used in the sense that teachers engage in practical work as a matter of course, expecting it to assist the attainment of all learning goals by itself. It is under-used in the sense that its real potential is rarely exploited to its fullest extend. Instead, much that we provide is misconceived, muddled and lacking real educational value.

In relation with reason 1 above, practical work is considered as a single category of activity, as though all practical work is the same. Furthermore, researchers usually draw a distinction between teacher's demonstration and "hands-on" work by students, but not always between "hands-on" exercises (often using worksheets) and holistic investigations (under varying degrees of student control), nor between those activities with a specific and clearly defined and articulated purpose and those which are simply an opportunity to experience a phenomenon, view an event or "to see what happens when…".

To give an answer to this problem [4] suggests a diversification of the practical work in the manner tabulated in Table 1.

As professors of the Faculty of Chemistry, UNAM, we are concerned by the situation of the experimental aspect of chemical education. We consider that the practical work is a column in scientific education and not only a support, and that is it the only way to experience many of the phenomena and facts that science approaches. In addition it enforces the intellectual abilities which are particular and indispensable for the professional development. With these ideas in mind, we decided to work in the elaboration of experimental proposals that allow us to re-con-ept and diversify practical work, but also to permit students to learn science, understand its nature, methods and the science-technology-society relation.

There are many reasons to use this type of chemical demonstrations in our classrooms, they:

- engage students with chemistry itself,
- allow teachers to provide experiments that are difficult to do in a common school laboratory,
- require minimal equipment and reagents and
- produce minimal waste.

The specific experiments that we have selected and adapted respond to the first and second type in the Caamaño classification and they are in agreement with the new curricula of Chemistry and Thermodynamics in high school and college levels in Mexico.

The dynamic of presentation promotes that the students also develop experimental skills such as observation, variable identification, formulation of hypothesis, *etc.* We have selected ten experiments that deal with: the manifestations of chemical changes, surface tension, solutions and their classification based on their concentration, metal activity, chemical reaction, redox reactions and experiments that result in examples of analogies for the construction of scientific models.

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Modification of an expository laboratory for 1st year undergraduate chemistry

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Summary. This paper reports on the development of a general undergraduate chemistry module that has been designed to promote student engagement, development of laboratory skills, independence and creative problem solving. It will detail the new implementations to a previous expository laboratory including pre-labs tasks, “multiple task experiments”, outlined learning outcomes, trained tutors and new assessment methods. The paper will detail the effect of these developments on student confidence and performance.

Background and Aims

Laboratory work is seen as an integral and valuable part of chemistry programmes. The aims of practical work have been well discussed in literature [1, 2], with Garratt’s list of aims, as summarised in Table 1, reflective of a general consensus. However in many lab courses these aims are not achieved, particularly those on the right hand side of Table 1.

Johnstone and Al-Shuaili [1] categorises laboratory work into four main types namely, expository, inquiry, discovery, and Problem Based Laboratories (PBL). Each type is distinguished based on the “outcome, approach and procedure”. The outcome can be predetermined or undetermined, the approach can be deductive or inductive and the procedure can be given or designed by the student.

Table 1. Aims of practical work [3]

Provide opportunities to develop	*Provide experience of*
• Technical skill	• Designing the experiment
• Confidence in lab work	• The experimental basis of theory
• Observational skill	• Link between theory and practice
• Awareness of safety	• Consolidating subject knowledge
• Recording skill	• The process of science
• Data manipulation	
• Data interpretation	
• Presentational skills	
– Report writing	
– Oral communication	

The authors [1] noted that the expository laboratory was the most common type with the outcome pre-determined, the approach deductive and the procedure is given to the student. Thus the running of the laboratory is solely directed by the lab tutor or supervisor. This type of lab (often referred to as “recipe – labs“) often reduces the student activity to following a set of instructions with no possibility of students designing their own experiment or even doing additional experiments to check out a concept. In effect, many students carry out the laboratory activity without engaging with either the experimental concepts, good manipulative skills or even the aims of the task assigned.

The introductory chemistry laboratories of a first year undergraduate programme can be particularly difficult to set up and manage. In the authors’ University, particular problems include:

- large numbers of students (typically 180–200 per year);
- students prior knowledge of chemistry is varied (from very high marks in their final 2nd level examination to no knowledge at all);
- students prior experience of practical work is varied (from doing all mandatory experiments to no exposure to practical work);
- student interest in Chemistry is varied as the group combines students from 8 different undergraduate programmes.

As student numbers increased, the laboratory generally tended to be expository in nature resulting in poor engagement of the student with the laboratory activity. Students were given little opportunity in first year to develop confidence in their laboratory skills, planning or designing an experiment or even developing their presentation skills. All assessment was based on the written laboratory report.

Recently, a PBL module in Introductory General Chemistry was developed and successfully implemented with a small cohort of the first year students (approx. 25 students) [4].The evaluation of this module shows clearly that students demonstrated greater investigative skills, were more motivated and interested, engaged more with the material and developed more transferable skills than the students taking the traditional laboratories. The success of the PBL module gave the impetus to change the laboratory experience for the whole first year cohort.

The aim of this work was to change the laboratory experience for the students and to incorporate activities to address the aims of practical work as given in Table 1.

Methodology

As the laboratory was to change for all the students, it was decided to develop a totally new laboratory module. In addition to the issues of large numbers and varied chemical experience and knowledge, other issues that were considered included:

- The experiment itself – what were the learning outcomes for each experiment?
- Was it clear to the student what they should know after each task?
- Could we address the varied knowledge background – through a pre-lab and problem tasks?
- Assessment issues – was the lab report for each experiment appropriate?
- Data collection, observation skills, presentation skills – how could these be implemented?
- Links to lecture material.

The lectures that accompany this laboratory course are General Introductory Chemistry (main topics Atomic Theory, Bonding) and Physical Chemistry (Gas laws, Introduction to Thermodynamics and Kinetics). The laboratory course is one 3 hr block per week for 11 weeks.

The main changes introduced to the new laboratory involved the introduction of pre-lab tasks, "multiple task experiments", outlined learning outcomes, trained tutors and new assessment methods. Thus each experiment had its specific learning outcomes attached to each experimental task and a pre-lab exercise to prepare the students for the experimental tasks. The experiments are carried out individually and on small scale by all students. Additionally, rather than a laboratory report each week, each student was required to keep a laboratory notebook in which they record their observations and results as they proceed through the experiment. The assessment of the module was designed to encourage student engagement and assess all of the aims mentioned in Table 1. The assessment components of the module included the pre-lab task, maintenance of a lab notebook, oral presentations, skills marks, in-lab questioning, theoretical and practical examination and two lab reports. The monitoring of the assessment was carried out by assigned tutors.

The laboratory structure contained ”multiple task experiments”; this meant that each experiment was structured into a number of tasks (typically three), where the first two tasks are generally semi-structured in terms of procedure and had predetermined outcomes. The final task is a problem task that has a student generated procedure and a predetermined outcome.

As a typical example, the experiment in week 3 is “Qualitative identification through Solubility” with three of the associated learning outcomes as:
Students should be able to:

- Accurately observe and record their observations.
- Accurately record experimental data.
- Devise a logical experimental scheme for testing unknowns.

This particular experiment has three tasks requiring increasing understanding. Tasks 1 and 2 involved students carrying out anion identification tests; in task 1 students were required to react known chemical with each other, such as NaOH with KBr and justify the observation in relation to solubility rules. In task 2 students were required to develop positive tests for various anions. In task 3 they were given four unlabelled salt solutions and asked to label them correctly using only these four solutions. This task required students to use the information they had learned in the previous tasks.

The other experiments within the 1^{st} semester of this module were carried out in a similar fashion.

This new lab module is being evaluated using student surveys, results from the various assessment methods and student interviews. The survey questions pertain to several factors including the structure of the experiments, assessment and interaction with tutors, student preparedness, motivation and confidence and to student engagement with the practical and theoretical elements of the lab sessions. The tutors are also being interviewed and surveyed for evaluation.

Results and Implications

The module is currently being implemented in the 06/07 academic year with a heterogeneous group of students with varying chemistry backgrounds. Thus far one semester has been completed. Initial evaluation has indicated that the majority of students surveyed (n = 149) do like the individual experiments. 60 % of the students strongly agreed to the statement that the labs are challenging but doable. Only 15 % of the cohort disagreed with this statement. The majority of the students (84 %) also indicated that they learned from the specific experiments and that they saw a purpose to all of the experimental tasks. The non-2nd level chemistry students were in agreement to liking all the experiments and believed they learned from these with the exception of two; “What is a mole?”, and “Qualitative determination through solubility”. Interestingly though, these are the two experiments that they felt they learned most from.

There was mixed feedback in relation to the effectiveness of the pre-lab tasks in relation to preparing for and making students confident about the experiments before entering the lab; this is especially evident when comparing the non-2nd level chemistry students to those with a chemistry background. Only 44 % of those without a chemistry background felt confident in understanding the chemistry and about the practical tasks they were about to complete. This is in contrast to 62 % of those with a chemistry background.

Also noted, were mixed reviews regarding the use of multiple tasks in the experiments. Generally students indicated that the tasks encouraged them to complete the experiments and made them think about the chemistry involved and did agree that the initial tasks prepared them for the ’problem task’ at the end. Though the tasks encouraged the students to engage with the chemistry more than previously, this didn’t correspond to students liking the task structure. Only 30 % of the students strongly agreed to like the tasks. It was noted that the non-2nd level chemistry students indicated that they were less encouraged to engage with the tasks than those with previous chemistry (10 % difference).

Students have indicated that they enjoyed being able to make presentations and carry out a skills exam because it made them aware of the standard they needed to achieve. They also indicated that the questioning by the tutors encouraged them to think about the chemistry involved and also more confident and clearer about what they were doing once in the laboratory. There are some students finding the laboratories difficult however, this has being related to amount of preparation and not to previous chemistry experience. The laboratories are also highlighting areas of student weaknesses that were previously only anecdotally commented on using the traditional assessment.

A full review of results and implications will be made available in the presentation once the evaluation is completed at the end of the module (May ’07). This evaluation will take into consideration the students opinions, learning, engagement and effectiveness of this module in achieving the aims outlined.

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The Flash MX Supported Manual for Forensic Chemistry Students

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Summary. In 2005, the Laboratory for Forensic Chemistry at Jagiellonian University launched the project which covers the developing of multimedia techniques. A year later, an electronic manual for a laboratory class "The Application of Capillary Electrophoresis in the Inks Discrimination for Forensic Purposes" was ready and successfully applied in the teaching process. It was done by two students of the forensic chemistry specialization as their masters' project. The aim of this work is to present the structure of the final product and the multimedia elements which help students to understand such tough analytical method as the capillary electrophoresis.

Introduction

The Laboratory for Forensic Chemistry was established at the Faculty of Chemistry in Jagiellonian University in 2000. Its main goal, besides the research activity, is training undergraduate students of the forensic chemistry specialization. It is still the only one place in Poland, where chemistry students may join their passion to the analytical chemistry with enthusiasm of the CSI shows.

The laboratory classes, conducted together with experts from the Institute of Forensic Research (Kraków), are the main part of the forensic chemistry course. Unfortunately, there is still lack of books and other materials in Polish about the forensic chemistry investigation. Thus, it has been decided to start the project aimed on developing the multimedia materials which, added to the student's book, may fill this space. The exercise “The Application of Capillary Electrophoresis in the Inks Discrimination for Forensic Purposes” has been chosen as the first one to be digitalized, because of the complexity of the involved analytical technique.

The project was mainly done by two students of the forensic chemistry specialization: A. Strzelecki and M. Słoboda as their masters' project and was generously financed by the Chancellor Didactic Foundation “Ars Docendi” at the Jagiellonian University.

Structure and Elements

The multimedia presentation is divided in several chapters:

- *Introduction.*
- *Capillary electrophoresis.* This chapter includes the scheme of the instrument of the capillary electrophoresis, based on the system of hyperlinks. They leads to short descriptions of every essential part of the apparatus.
- *Physical and chemical background of capillary electrophoresis.* After the introduction, there are 8 animations (some interactive) explaining the electrokinetic phenomena and its application in the separation science.
- *The construction and working principles of the system for the electrophoretic separation.* Chapter three includes the huge interactive scheme of the PrinCE 550 M system, students work with during the exercise.
- *Techniques of capillary electrophoresis.* There are six main modes, the electrophoretic separations might be conducted by. All of them are clearly presented with several animations describing principles of the separation process.
- *Application of the capillary electrophoresis in forensic science.*
- *Description of the Exercise performance.* In the final chapter, the whole procedure, from its very beginning where the sampling takes place, to the measurement is presented in the series of films.

After each chapter, there is a quiz game to summarize the most important information and to offer a recapitulation to students.

A structure as well as all animations and quizzes were made in Flash MX 2004. This enabled students to be platform/system independent. The films included were made in the forensic laboratory and also compiled with Flash to avoid codec problems.

The e-book is planed to be added to the paper students' book on the CD. Moreover, the project could be easily put into the Internet and accessible for all students at home. However, because of some large files, a good quality Internet connection is recommended.

Finally, the application has the structure which can be quickly modified as it was built in layers.

The whole project includes:

- 16 animations
- 2 interactive schemes, offering the observation of the separation when we change some parameters
- 7 movies describing the sampling of ink dots from a questioned document and further preparation for the measurement
- 4 quizzes at the end of chapters

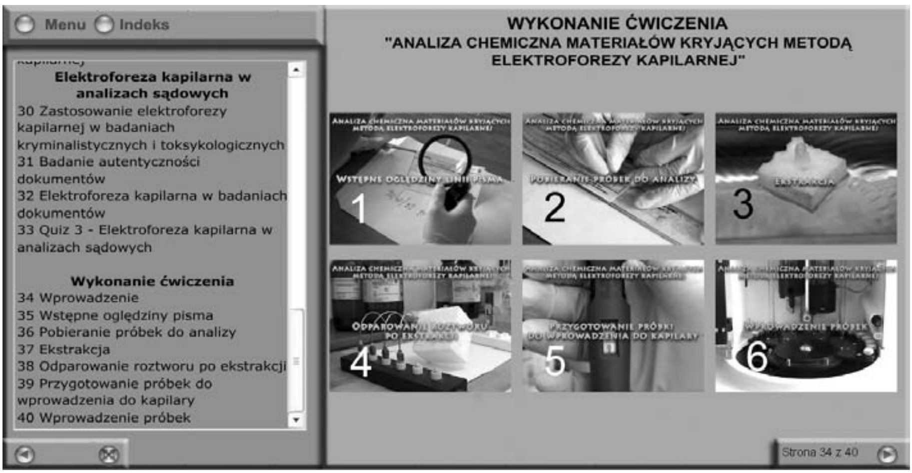

Fig. 1. Educational films offered by the application: (1) Preliminary inspection of writings, (2) Sampling, (3) Extraction, (4) Extraction evaporation, (5) Final preparation of the sample before injection onto the capillary, (6) Sample injection.

Evaluation and Conclusions

The presentation was used for the first time during the laboratory exercise “The Application of Capillary Electrophoresis in the Inks Discrimination for Forensic Purposes” and gratefully welcome by students. According to results of the evaluation questionnaire, the structure of the application is clear, all drawings, schemes and animations explain the topic in a plain manner. Students emphasized, that Quizzes helped them to prepare themselves to the final exam.

It should be stressed that this project was only the beginning of a long process. We are going to upgrade all exercises for students of the forensic chemistry specialization in the near future. By now, the beta version may be viewed in the Internet: *http://www.chemia.uj.edu.pl/~wozniaki/beta/index.swf*

How Could Chemistry Teachers Explain Tobacco Smoke Toxicity and Carcinogenicity to Students?

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Summary. Medical research has determined that chronic tobacco smoking is a major factor contributing to many health problems, particularly lung cancer, emphysema and cardiovascular disease. Chemistry teachers can significantly contribute to anti-smoking campaign by explaining the chemical composition of tobacco smoke and health risks to students. In this contribution we present information that could teachers support this effort and provide more detail inside from the chemist's point of view. We also share our experience with conducting laboratory experiment detecting some cigarette smoke components.

Introduction

Tobacco smoking is the act of burning the dried or cured leaves of the tobacco plant and inhaling the smoke for pleasure, self-medication, from habit and/or to satisfy addiction. The practice was common among Native Americans throughout North and South America, and was later introduced to the rest of the world.

As the use of tobacco became popular in Europe, some people became concerned about its possible ill effects on the health of its users. One of the first was King James I of Great Britain, in 1604, he wrote "A Counterblast to Tobacco" [1]. In 1912, American Dr. Isaac Adler strongly suggested for the first time that lung cancer is related to smoking [2]. In 1929, German Fritz Lickint published a formal statistical evidence of a lung cancer-tobacco link, based on a study showing that lung cancer sufferers were likely to be smokers [3]. Lickint also argued that tobacco use was the best way to explain the fact that lung cancer struck men four or five times more often than women (since women smoked much less that time) [3]. Still some people opposed and argued there is no connection between smoking and lung cancer. But later long term studies conducted by the National Institute of Health revealed the long lag time period for Lung Cancer manifestation to be approximately 20 years. Thus, the damage, a continuing smoker does to his/her lung, can take up to 20 years before its physical manifestation in lung cancer [11].

In 1954 the British Doctors Study (a study of some 40 thousand doctors over 20 years) confirmed the suggestion, based on which the government issued advice that smoking and lung cancer rates were related [4].

In the 1950s and 1960s there were over 7000 scientific articles that linked tobacco use with cancer and other diseases. This reports led to laws requiring warning labels on tobacco products and to restrictions on tobacco advertisements. From this time, manufacturers began adding filter tips to cigarettes to remove some of the tar and nicotine as they were smoked. “Safer”, “less potent” cigarette brands were also introduced, in spite the fact that the idea of a “safer” cigarette is a myth. Cigarettes that offer, “low tar and nicotine” simply cause the smoker to smoke more or to inhale more deeply to get the same level of nicotine. According to The Federal Government’s National Cancer Institute (NCI), light cigarettes provide no benefit to smoker’s health [5].

Smoking from the chemist and biochemist point of view

During incomplete combustion of dehydrated plant tissues in addition to CO_2 and H_2O numerous pyrolysis by-products are formed. These compounds form a gas and aerosol exhausts known as smoke, and tobacco combustion is not an exception.

When analyzed the cigarette smoke contains the usual combustion exhaust products CO_2, H_2O, but also many toxic or even carcinogenic by-products such a CO, aldehydes, formaldehyde, benzene, polycyclic aromatic hydrocarbons (PAHs) and their derivatives, HCN, hydrazine and many others (Table 1, *see below*) [6].

Another group of compounds includes volatile low molecular organic molecules that are already present in dry plant tissue before burning. They are evaporated when hot burning zone gets to contact with surrounding tobacco material. This is also the case of nicotine with boiling point 245 °C [7].

Dry tobacco plant contains between 0.3–5.0 % of the nicotine and the amount of 40–60 mg can be a lethal dose for adult human. Therefore, one cigarette can contains more than lethal dose of this alkaloid [8]. Fortunately, during cigarette burning majority of nicotine is decomposed, as a result only milligrams are released to the smoke and adsorbed in smoker’s respiratory system.

Although the amount of nicotine inhaled with tobacco smoke is quite small (most of the substance is destroyed by the heat) it is still sufficient to cause physical and/or psychological addiction. Nicotine acts as an agonist that binds to nicotinic acetylcholine receptors in the brain and temporary stimulates the neural activity. Nevertheless, the initial simulative period ends as the nicotinic receptors concentration raises in response to higher stimulation, and smoker starts to need certain nicotine level to reach even normal receptor activity. This neuronal brain alteration persists for months after administration ceases. The makes quitting without substitution at this stage very difficult.

The currently available literature indicates that nicotine, on its own, does not promote the development of cancer in healthy tissue and has no mutagenic properties. Its teratogenic properties have not yet been adequately researched [9]. The likelihood of birth defects caused by nicotine is believed to be very small or nonexistent.

Thus not the nicotine, but rather the polycyclic aromatic hydrocarbons (particularly benzo[*a*]pyrene) are the most carcinogenic components of tar and tobacco smoke. The mechanism of its carcinogenity is well-known: enzymatic oxidation by cytochromes P450 produces epoxide derivatives, which covalently bind to DNA. Such DNA modification usually results in cell dead or permanent DNA mutation. If the cell cannot repair its DNA damage prior to undergoing mitotic division, the daughter cells carry a greater risk becoming tumorgenic. DNA damage is one of the causes of cancer, because if the poison damages the programmed cell death system severely enough (usually requiring more than one mutation), damaged cells cannot kill themselves and begin to divide uncontrollably. This process results in the formation of tumors that have the potential of becoming cancerous [11].

Smoking from the teacher's point of view

Majority of adult smokers started their smoking habit as adolescents or even as a child. There are about 10–45 % of regularly smoking adolescents in European and America countries [10].

Although adults would like to quit smoking, they are usually unsuccessful because they are already strongly addicted to nicotine. Therefore, if we prevent children and adolescents from smoking by proper explaining the negative effects, we will reduce numbers of future adult smokers as well. This task is sometimes very difficult for parents, especially when they are smokers, but teachers could substitute their role. Chemistry teachers are especially suitable advisors not just

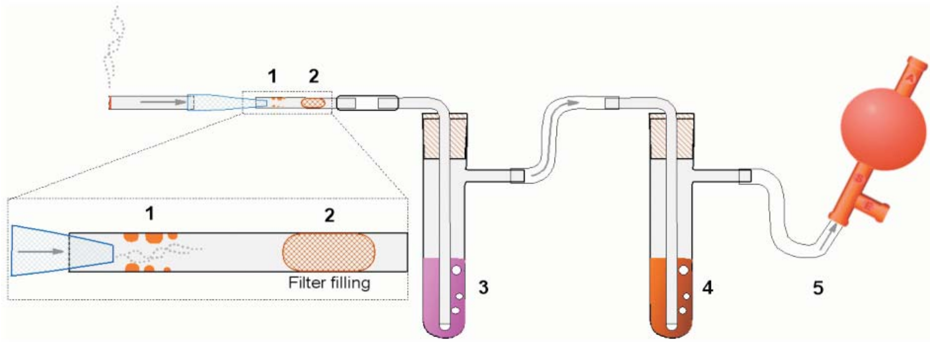

Figure 1. Scheme of the assembled apparatus for cigarette smoke analysis. Low volatile condensate (1), cigarette filter filling (2), first and second gas trap (3 and 4) and the three-way rubber safety bulb (5).

for explaining seamy face of the smoking, but also showing its the danger via demonstration of various chemicals present in tobacco smoke. The following paragraph describes chemical experiments suitable for such purpose in chemistry classes.

Experimental part

We use test tubes with side outlet as gas traps for compounds in cigarette smoke and three-way rubber safety bulb (usually utilized for pipetting) to create negative air pressure forcing the smoke to flow through the apparatus (Fig. 1).

The majority of low volatile compounds condensates after passing through pipette tip (blue). This dark-brown condensate consists of tar and water droplets (part 1 in Figure 1). Than the remaining gas and aerosol exhausts pass through the cigarette filter filling, students can notice that the filter is brown and completely saturated before even half of the cigarette is burned!

Well soluble compounds (HCN, formaldehyde, NO, NO_2, …) are almost completely adsorbed in the first trap, therefore we suggest following arrangement of the experiment (Table 1).

Aldehydes content in a cigarette smoke reaches such level that could be detected by the standard qualitative test for aldehydes. As a first trap we recommend Schiff reagent providing bright violet color in presence of formaldehyde and/or other aldehydes (Table 1, Ia). More sensitive but less specific is the 2,4-dinitrophenylhydrazine reagent providing a yellow or red crystalline precipitate of the hydrazone products (Table 1, IIa).

Nitrogen oxides can be detected using the "Brown Ring Test". NO_2 are trapped in the saturated $FeSO_4$ solution (Table 1, IIIa). When the tube is unplugged from the apparatus, concentrated sulphuric acid (96 %) is carefully poured down inside the tube. The acid sinks below the aqueous solution, after a short period an intensive brownish violet ring is formed at the inter-phase.

CO_2 test could be performed to detect the usual combustion product (Table 1, IVa).

In the second trap we can detect other reducing compounds (primary and secondary alcohols and amides, remaining aldehydes, hydrazine, *etc.*). They could be detected by reduction of neutral (Table 1, Ib) or acidified 1 % solution of $KMnO_4$ (Table 1, IIb).

For more experimental details see our poster presentation. *Warning! Toxic and carcinogenic chemicals are released during this experiment. In order to take safety precautions experiment must be performed in a well ventilated room or in a fume chamber!*

Table 1. Suggested reagent combinations

	Reagent in first gas trap	Positive response	Compounds detected
Ia.	Schiff reagent	*violet solution*	formaldehyde, aldehydes
IIa.	Brady's reagent (2,4-dinitrophenylhydrazine)	*yellow or red precipitate*	aldehydes, ketones
IIIa.	saturated $FeSO_4$ sol. + concentrated H_2SO_4	*brownish violet ring formed when H_2SO_4 added*	NO, NO_2, HNO_3
IVa.	$Ca(OH)_2$ solution	white precipitate	CO_2

	Reagent in second gas trap	Positive response	Compounds detected
Ib.	1% solution of $KMnO_4$	*brown precipitate*	pri. and sec. alcohols and amides, remaining aldehydes hydrazine etc.
IIb.	1% solution of $KMnO_4$ + 10% H_2SO_4	*discolored solution*	

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Electrochemistry and Redox Reactions in Chemistry Education

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Summary. Electrochemistry is defined as the study of the interchange of chemical and electrical energy that occurs through oxidation-reduction (redox) reactions, in which electrons are transferred from a reducing agent to an oxidizing agent. Electrochemistry is the most important interfaces between chemistry and everyday life (batteries in car, radio, mobile phone, *etc.* are depending on electrochemical reactions) in spite of this there is not very favorite part of chemistry among the students. In this paper some spectacular and interesting experiments are presented, that are suitable for primary and secondary schools students and they can be made by most students in any laboratory or most classrooms.

Introduction

Electrochemistry is not very favorite part of chemistry among the students in spite of this there are the most important interfaces between chemistry and everyday life (batteries in car, radio, mobile phone, *etc.* are depending on electrochemical reactions). Students at different levels have common misconceptions in electrochemistry. Similarly, concepts are often poorly presented to students, who then typically just memorize the concepts without gaining a meaningful understanding [1].

In this work some experiments have been introduced which presented spontaneous and nonspontaneous redox reactions taking place especially in electrochemical cells (voltaic and electrolytic cell) and their use in practice.

An electrochemical cell is a system consisting of two electrodes that dip into an electrolyte (two half-cells) that are electrically connected and in which a chemical reaction either uses or generates electric current. A voltaic cell is an electrochemical cell in which a spontaneous reaction generates an electric current. An electrolytic cell is an electrochemical cell in which is an electric current used to drive a nonspontaneous reaction (called electrolysis). A half-cell is the portion of an electrochemical cell in which half-reaction takes place. Whether a cell operates as a voltaic or an electrolytic the electrode at which reduction occurs is called cathode, and the electrode at which oxidation occurs is called the anode.

Spontaneous redox reactions

When Zn metal is added to an aqueous solution of $CuSO_4$, Cu^{2+} ions are converted to Cu, the copper is reduced and appears as a black coating on the zinc and Zn atoms enter the solution as Zn^{2+} ions. In time the blue colour of the $CuSO_4$ solution disappears:

$$\mathrm{Zn}(s) + \mathrm{Cu}^{2+}(aq) \leftrightarrows \mathrm{Zn}^{2+}(aq) + \mathrm{Cu}(s)$$

When a piece of Cu wire is placed in an aqueous $AgNO_3$ solution, Cu atoms enter the solution as Cu^{2+} ions and Ag^{+} ions are converted to Ag. The solution obtains the characteristic blue colour due the hydrated Cu^{2+} ions:

$$\mathrm{Cu}(s) + 2\,\mathrm{Ag}^{+}(aq) \leftrightarrows \mathrm{Cu}^{2+}(aq) + 2\,\mathrm{Ag}(s)$$

To determine the direction of spontaneity of a reaction we need to know only standard electrode potential (also known as standard reduction potential) $E°$. The more positive the value, the greater the driving force for the reduction half-reaction:

$E°(Zn^{2+}/Zn) = -0.76$ V $\qquad E°(Cu^{2+}/Cu) = 0.34$ V $\qquad E°(Ag^{+}/Ag) = 0.80$ V

Because of standard electrode potential of copper electrode is greater than that of the zinc electrode; copper ion is more easily reduced than zinc ion, but not more than silver ion. The same spontaneous reaction will take place in the cells zinc-copper (consisting of zinc metal-zinc ion and copper metal-copper ion half-cells) and copper-silver (consisting of copper metal-copper ion and silver metal-silver ion half-cells) which are written:

$\mathrm{Zn}(s)|\mathrm{Zn}^{2+}(aq)||\mathrm{Cu}^{2+}(aq)|\mathrm{Cu}(s) \qquad \mathrm{Cu}(s)|\mathrm{Cu}^{2+}(aq)||\mathrm{Ag}^{+}(aq)|\mathrm{Ag}(s)$

and cell EMF is calculated as follows

$$E°(\text{cell}) = E°(\text{cathode}) - E°(\text{anode})$$

For zinc-copper cell is $E°(\text{cell}) = 0.34\text{ V} - (-0.76\text{ V}) = 1.1$ V, and for copper-silver cell is $E°(\text{cell}) = 0.80\text{ V} - 0.34\text{ V} = 0.46$ V.

Electrolysis

In contrast to spontaneous redox reactions, which result in the conversion of chemical energy into electrical energy, electrolysis is process in which electrical energy is used to cause a non-spontaneous chemical reaction to occur.

The chemical reaction between hydrogen and oxygen producing water is spontaneous and can take place in a hydrogen-oxygen fuel cell too. The water decomposition to oxygen and hydrogen is non-spontaneous reaction and take place in electrolytic cell.

Water does not conduct an electric current in its pure form. An electrolyte (ionic substance, *e.g.* Na_2SO_4) must be dissolved into the water for electrolysis to occur. Sodium sulfate will dissociate in water to its ions

$$Na_2SO_4 \leftrightarrows 2\,Na^+ + SO_4^{2-}$$

Two half-reactions can take place at the cathode:

$$2\,H_2O\,(l) + 2\,e^- \leftrightarrows H_2(g) + 2\,OH^-(aq) \qquad E° = -0.83\text{ V}$$
$$Na^+(aq) + e^- \leftrightarrows Na(s) \qquad E° = -2.71\text{ V}$$

Two half-reactions can also occur at the anode:

$$S_2O_8^{2-}\,(aq) + 2\,e^- \leftrightarrows 2\,SO_4^{2-} \qquad E^0 = +2.01\text{ V}$$
$$O_2\,(g) + 4\,H^+ + 4\,e^- \leftrightarrows 2\,H_2O \qquad E^0 = +1.23\text{ V}$$

Because of standard electrode potentials described above it is easier to reduce H_2O than Na^+ ions at the cathode and it is easier to oxidize H_2O than SO_4^{2-} at the anode [2]. The electrode half-reactions during the electrolysis of water are as follows:

- anode (+) $6\,H_2O\,(l) \leftrightarrows 4\,H_3O^+\,(aq) + O_2\,(g) + 4\,e^-$
- cathode (–) $4\,H_2O\,(l) + 4\,e^- \leftrightarrows 4\,OH^-(aq) + 2\,H_2\,(g)$
- overall $2\,H_2O\,(l) \leftrightarrows O_2\,(g) + 2\,H_2\,(g)$

During the electrolysis of water the region around the anode becomes acidic, the region around the cathode basic.

Procedure: Two syringes containing a dilute aqueous solution of sodium sulfate with Bromthymol Blue indicator are immersed into a sodium sulfate solution which is placed in Petri dish. Each of them has a platinum electrode connected to a power supply. When electricity passes through the system, oxidation occurs at the anode (oxygen gas is produced) and reduction at the cathode (hydrogen gas and hydroxide ions are produced and the solution turns blue).

Protection iron from corrosion

Corrosion can be defined as the degradation of a material due to a reaction with its environment. Most metals corrosion is electrochemical in nature. Corrosion involves oxidation of the metal. This spontaneous process has great economic impact (enormous damage to buildings, bridges, ships and cars).

Cathodic protection is a process in which the metal that is to be protected from corrosion becomes the cathode in the electrochemical (voltaic or electrolytic) cell.

Procedure: Three test-tubes contain a solution of 0.1 mol dm^{-3} HCl, 3% H_2O_2, and 0.1 mol dm^{-3} KSCN in ratio 1:1:1. The first test-tube contains an iron wire. The solution in the test-tube turns a reddish-brown colour, and the intensity of the colour increases over time. The reddish-brown colouration is due to the formation of $[Fe(SCN)]^{2+}$ to $[Fe(SCN)_6]^{3-}$ complexes. This indicates that the iron metal is being oxidized to the Fe^{3+} ion.

The second test-tube contains an iron wire wrapped around a piece of zinc metal (zinc-iron cell). The colour of the solution in the test-tube is unchanged and the reddish-brown colour does not appear because of iron becomes the cathode in the zinc-iron voltaic cell. Zinc is than oxidized in preference to iron.

- anode (–) $Zn(s) \leftrightarrows Zn^{2+}(aq) + 2\,e^-$
- cathode (+) $Fe^{2+}(aq) + 2\,e^- \leftrightarrows Fe(s)$

When the connection between the iron and the zinc metal is severed, the solution begins to turn reddish-brown.

In the third test-tube are immersed in the solution an iron wire and a zinc metal. The metals are connected to a power supply. When electricity passes through the system, oxidation occurs at zinc (anode) and reduction at iron (cathode). The hydrogen is formed at the iron's cathode. The electrodes half-reactions are as follows:

- anode (+) $Zn(s) \leftrightarrows Zn^{2+}(aq) + 2\,e^-$
- cathode (–) $2\,H^+(aq) + 2\,e^- \leftrightarrows H_2\,(g)$

Conclusion

In this contribution we focus on explaining some problems associated with understanding the basic knowledge from electrochemistry. The experiments described here are well-known and simple. They can be realized in any laboratory or most classrooms during the general chemistry lessons. The microelectrochemistry experiments [4], computer animations [5] and small-scale and low-cost galvanic cells [6] were published recently.

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The Effect of Problem Solving Approach in Laboratory on Students' Attitudes and Performances within Chemistry Education

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Summary. Laboratory applications realized in chemistry teaching should facilitate students' thinking about conceptual problems and improve their problem solving skills. In the extent of this study, 42 students that were attending Hacettepe University, Faculty of Education, and Department of Chemistry Education have tried to solve the presented problem situation by using problem solving laboratory approach. They have been administered Scientific Process Skill Test, Attitude Scale towards Chemistry and Attitude Scale towards Chemistry Laboratory before and after applications. Students have conducted experiments to solve their problem during 5 weeks.

Introduction

It seems clear that if the goal of chemistry instruction is to have students think about and solve conceptual problems as well as algorithmic problems then the approach to chemistry instruction must change [1]. Because, there is a gap between the algorithmic problem-solving abilities of chemistry students and their conceptual understanding of chemistry. This gap persists because many chemistry instructors allow students to hide their lack of conceptual understanding by accepting a correct numerical answer as an indication of true understanding on the part of student. Instruction that focuses on algorithmic problem solving implicitly misrepresents the nature of science to students. A life in science is not one where algorithms always can be applied to find the answer [2]. Because one of the aims of science education is to improve students' ability to think critically, reason logically and ultimately to solve problems [3, 4]. Teaching of problem solving as a part of every curriculum is especially important in science and mathematics [5]. Problem solving skills are one of the basic skills that are necessary for human's life. Because of coping with difficulties in every domain, one of the main targets of science school programs is related to develop this skill [6].

The aim of the study
The aim of this study was students' finding solutions to the problem situation *"How does the changing of the rate of salt and pH within soil affect plants' growing and how is this rate stabilized?"* by using problem solving laboratory approach and to determine the effect of this approach on students' performance and attitudes.

Method

Samples
The study has been conducted with 42 students that were attending Hacettepe University, Faculty of Education, and Department of Chemistry Education.

Data collection tools

1) Scientific Process Skill Test
The original of this test has been developed by Okey *et. al.* [7] and translated into Turkish by Geban *et. al.* [8]. It is consisted of questions measuring description of problems variables (12), constructing hypotheses, description (8), procedural explanation (6), designing of required examinations for solving problem (3), graphing and interpreting (4) abilities. Consistence of this test is a = 0.82 (KR 21).

2) Attitude Scale towards Chemistry
This scale has been developed by Şimşek [9] to assess students' attitudes towards chemistry course. It is consisted of 21 items and it is a five point likert type scale. The Alpha reliability coefficient of the scale has been found as 0.82.

3) Attitude towards Laboratory Scale
This scale has been developed by Morgil *et. al.* in order to determine the attitudes of the students towards laboratory. It is a Likert type scale. In the development stage of the scale, first a scale consisting of 33 item has been prepared and applied to 150 students. After the factor analysis, the number of items has been shortened to 18. After the reliability analysis, alfa reliability constant has been found as 0.79.

Applications

This study has been conducted in the extent of "Student Experiment within Chemistry Education” course and continued for 5 weeks. Firstly, students have been taught about problem solving laboratory approach in shortly. Before applications, data collection tools have been administered as pre-test. Then students have been divided into groups of 3–4. The application process of the study has been conducted according to the following steps [10]. In the first step, student groups have been presented a problem situation *"How does the changing of the rate of salt and pH within soil affect plants' growing and how is this rate stabilized?"*. In the second stage, groups have tried to simplify the problem situation and identify situations that will examine or not. Then student groups have divided problem situation into steps and sub problems. Finally they have determined problem clearly. In the third stage, student groups have written technical and theoretical questions which are necessary to solve the problem. Group members have tried to find solution ways to their own determined problem. For this aim, firstly they have benefited from library and Internet sources and collected data related to themselves problem from this information sources. Then they have suggested solution ways to solve their own problem. As a group, they have discussed about suggested solution ways and then selected one of these ways to test. Since solution ways have been required to do experiment, student groups have presented their own solution way as an experiment suggestion. Expected result from their own experiment was their hypothese to solve problem. In the fourth stage, student groups have conducted their own experiments in the laboratory. Groups who obtained expected results from their own experiment have expressed their own results. In the last stage, student groups who did not obtain results appropriate to their own hypothese after experiment, have repeated application. After application, students have been administered the same scales and test as a post-test. The final grades of course "Student Experiments in Chemistry Education” have been evaluated as performance.

Results

The pre- and post test results of scales and test used in this study have been compared with paired-samples *t*-test to determine the effect of problem solving laboratory approach on students' attitudes towards chemistry and laboratory and their scientific process skill. The results have been displayed in Table 1.

Tab. 1 Paired-samples *t*-test results related to pre- and post test results of *Scientific Process Skill Test*, *Attitude Scale towards Chemistry* and *Attitude Scale towards Chemistry Laboratory* (n = 42).

		$\overline{x}$	*s*	*T*	*p*
Chemistry Attitude	Pretest	2.87	0.7150	– 6.286	0.000
	Posttest	3.57			
Chemistry Laboratory Attitude	Pretest	3.23	0.3733	– 5.676	0.000
	Posttest	3.55			
Scientific Process Skill	Pretest	60.60	16.6446	– 2.233	0.031
	Posttest	66.33			

When pre- and post test results of administered tests have been examined, a significant difference has been found in favor of post-tests ($p < 0.05$). Students' attitudes towards chemistry and chemistry laboratory and their scientific process skills have increased after problem solving laboratory application.

Tab. 2 The regression results related to the relationship between *Scientific Process Skill Test*, *Attitude Scale towards Chemistry*, *Attitude Scale towards Chemistry Laboratory* and student performance. Dependent Variable: Performance; $R = 0.556$; $R^2 = 0.309$; $F = 5.669$; $p = 0.003$. Predictors: (Constant); Chemistry Attitude; Chemistry Laboratory Attitude; Scientific Process Skill.

Model	Coefficients			*t*	Sig.	Correlations		
	Unstandardized		Standardized			Zero-order	Partial	Part
	B	Std. Error	Beta					
(Constant)	– 11.412	20.630		– 0.553	0.583			
Chemistry Attitude	1.295	2.491	0.078	0.520	0.606	0.289	0.084	0.070
Chemistry Laboratory Attitude	16.600	5.245	0.444	3.165	0.003	0.449	0.457	0.427
Scientific Process Skill	0.301	0.151	0.291	1.994	0.053	0.299	0.308	0.269

It has been found that significant and average relationship between all of the predictor variables (attitude towards chemistry, attitude towards chemistry laboratory and scientific process skill) and student performance grades ($R = 0.556$; $R^2 = 0.309$, $p < 0.005$). These three variables have explained 31 % of total variance. According to standardized regression coefficient (Beta), relative significant rank of predictor variables on performance was Attitude towards chemistry laboratory, Scientific process skill, Attitude towards chemistry. When *t*-test results related to significance of regression coefficient have been examined, it has been seen that only Attitude towards chemistry laboratory variable is a significant predictor on performance and scientific process skill and attitude towards chemistry variables have not significant effect on performance.

Discussion

The problem solving laboratory approach has been developed to give students practice in experimental design while still meeting the objectives of a traditional laboratory program and using of this method has restored laboratory work to its proper pre-eminent position in chemistry curriculum [11]. So in this study students have tried to find solutions to presented problem situation by using this approach. They have conducted experiments to verify their own suggested hypothese for solving problem. Laboratories are the ideal place to integrate and apply theoretical notions in a real-world context. It permits students to verify hypotheses and allows students' errors, interactive learning, and scientific creativity without threatening the so-important marks [12]. It is a truth that laboratory studies are necessary part of science courses in general and chemistry courses in particular. Laboratory applications should facilitate students' thinking about conceptual problems and improve problem solving skills.

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Inquiry Based Experiment Suggestions and Their Effect on Student Success and Gains in Chemistry Applications

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Summary. In chemistry applications, one of the factors that effect student performance is students' making new experiment suggestions by inquiring conducted experiment. In the extent of this study, 42 students that were attending Hacettepe University, Faculty of Education, and Department of Chemistry Education have conducted 6 inquiry based chemistry experiments by using inquiry based laboratory approach. They have been administered Attitude Scale towards Chemistry and Attitude Scale towards Chemistry Laboratory and Anxiety Orientation-Motivation Questionnaire before and after applications. The analyses suggest that inquiry based chemistry laboratory applications provide different kinds of learning opportunities and interact with students' development of inquiry skills.

Introduction

Laboratory activities have central role in the science curriculum, and science educators have suggested that many benefits accrue from engaging students in science laboratory activities. More specifically, they suggested that, when properly developed, inquiry-centered laboratories have the potential to enhance students' meaningful learning, conceptual understanding, and their understanding of the nature of science [1]. Science educators [2–7] assert that the preferred pedagogical method for teaching science effectively is an inquiry-based instructional approach. According to Hsin-Kai and Chou-En [8], intellectual skills, such as selecting and controlling variables, planning procedures, and interpreting patterns of evidence, are required for students to construct explanations and to engage in inquiry-based learning. Although studies on inquiry learning have recognized the importance of developing students' inquiry skills [11].

The aim of the study

The aim of this study was pre-service students' suggesting an experiment for 1) Exothermic and Endothermic Reactions, 2) pH and pOH, 3) Corrosion of metals, 4) Boiling Point and Steam Pressure, 5) Denaturation of Proteins and 6) Absorption topics by using inquiry based chemistry laboratory approach and to determine the effect of this approach on students' performance, attitudes and anxieties.

Method

The sampling of this study has been conducted with 42 students that were attending Hacettepe University, Faculty of Education, and Department of Chemistry Education.

Data Collection Tools

Attitude Scale towards Chemistry (ASTC)

This scale has been developed by Şimşek [9] to assess students' attitudes towards chemistry course. It is a five point Likert-type scale and it is consisted of 21 items. The Alpha reliability coefficient of the scale has been found as 0.82.

Attitude Scale towards Chemistry Laboratory (ASTCL)

This scale has been developed by Morgil *et al.* in order to determine the attitudes of the students towards laboratory. It is a Likert type scale. In the development stage of the scale, first a scale consisting of 33 items has been prepared and applied to 150 students. After the factor analysis, the number of items has been shortened to 18. Alfa reliability constant has been found as 0.79.

Anxiety Orientation- Motivation Questionnaire (AO-MQ)

The Anxiety Scale was developed by Morgil *et al.* in order to evaluate students' anxiety. This scale consists of 16 items and is Likert type. A sampling of 165 individuals participated in the scale development process. The analysis results displayed the reliability of the scale as 0.81.

Applications

This study has been applied in the extent of "Student Experiment within Chemistry Education" course and continued for 6 weeks. Before applications, data collection tools have been administered as pretest. Then Brainstorming has been conducted about Inquiry Based Learning by students. Brief Information about Inquiry Based Learning has been given by the researcher to students. Then students have been divided into groups of 3–4. In the inquiry based chemistry applications, 1) Exothermic and Endothermic Reactions, 2) pH and pOH, 3) Corrosion of metals, 4) Boiling point and steam pressure, 5) Denaturation of

Proteins and 6) Absorption topics have been selected and simple experiments that explain these topics have been conducted. While students were conducting experiments, they have realized inquiry-based applications. In applications which are guided by researchers, questions from simple to complex have been directed to the students after each experiment. At the same time, students have been requested to prepare questions about the topic. Thus, the students' abilities of asking questions have been examined in the extent of this study. The inquiry question for each topic has been selected between questions. Each team converted this selected inquiry question into problem statement. Then student teams have been prepared applications which are devoted to solve the problem statement. Student teams have been divided the problem statement into steps or subquestions and have been prepared all theoretical information and questions, which are necessary to solve the problem. Students have suggested solution ways to solve problem. In this phase, students have benefited written and online sources for their research and collected data related to their problems from this information sources. Student teams have been requested to present their solution way as an experiment suggestion. In this phase student teams have conducted their experiments in the chemistry laboratory. Teams who obtained expected results from their experiment have expressed their results. All steps in the preparation of inquiry based chemistry experiments have been videotaped. In the inquiry process, films have been showed to students by researcher and inquiry questions related to each of experiment have been discussed with students. Finally the students have presented one report, which contain every steps of application during inquiry based chemistry laboratory. Researcher has evaluated this students` report. After application, students have been administered the same data collection tools as a posttest. The final grades of course "Student Experiments within Chemistry Education" have been evaluated as student performance.

Results

The paired samples t-test analysis was used for the pre and posttest results of the data collection tools within the study to determine the effect of inquiry based learning in chemistry laboratory on students' attitudes towards chemistry and chemistry laboratory and their anxieties. The results are shown in Table 1.

Table 1. Paired-samples *t*-test related to pre- and posttest results of ASTC, ASTCL and AO-MQ (n = 40, p = 0.000)

		$\bar{x}$	s	t
Attitude towards Chemistry	Pretest	2.87	0.7150	– 6.286
	Posttest	3.57		
Attitude towards Chemistry Laboratory	Pretest	3.23	0.3733	– 5.676
	Posttest	3.55		
Anxiety - Orientation Motivation Questionnaire	Pretest	2.20	0.3881	4.327
	Posttest	1.94		

Table 2. The regression results related to the relationship between ASTC, ASTCL and AO-MQ and Student Performance. ANOVA: dependent Variable – student performance; predictors – (constant), ASTC, ASTCL and AO-MQ

Model	df	*F*	Sig.
1 Regression	3	6.243	0.001
Residual	38		
Total	41		

When pre- and posttest results of administered tests have been examined, a significant difference has been found in posttests (p < 0.05). While students' attitudes towards chemistry and chemistry laboratory increased, their anxieties decreased after inquiry based chemistry laboratory application.

It has been found that significant and average relationship between all of the predictor variables and student performance grades (R = 0.575, R^2 = 0.330, p < 0.05). These three variables have explained 33 % of total variance. When *t*-test results related to significance of regression coefficient have been examined, it has been seen that only Attitude towards chemistry laboratory variable is a significant predictor on performance, but attitude towards chemistry and anxiety-orientation variables have not significant effect on performance.

Discussion

Explanatory activities could be a core of inquiry learning. The phases of inquiry interacted with students' development of inquiry skills. Furthermore, the teacher's timely and ongoing scaffolds played a critical role when students engaged in explanatory activities. As students gained more experience in doing inquiry, they took more responsibilities for their own learning and the teacher took on more the role of collaborator [8]. Converting from cookbook type activities to inquiry-based labs and changing lectures from the presentation of facts to inquiries into phenomena will encourage student reasoning and lead to higher quality learning [12]. The inquiry-based learning approach provided the means to focus students' learning on the application of knowledge through problem solving, away from the more traditional approach of focusing on the acquisition of knowledge. The findings suggest a need to revisit the problem specifications to ensure that all are relevant and applicable as a means to increase student interest. The approach appeared to provide reasonable support for independent learning among the students [13].

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Effects of Project Oriented Laboratory Course on Students' Anxiety and Performance

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Summary. While learning chemistry, laboratories play an important role. With the help of practical implementations, students learn the subjects, interpret the data, and develop their evaluating, designing an experiment and practical skills. However, since there are some deficiencies related to this case, researches have begun to conduct some implementations like APCELL (The Australian Physical Chemistry Enhanced Laboratory Learning Project) [1, 2]. In the extent of this study, 42 students who will be chemistry teacher in the near future attending Hacettepe University, Faculty of Education, and Department of Chemistry Education have prepared laboratory projects. Each student has worked independently. Firstly students have chosen a topic and then they have prepared an experiment proposal in the extent of project based learning model. Each stages of students' work have been videotaped. Prior to the implementations, students have filled scientific processes skills and logical thinking tests and anxiety questionnaire as pre test. Afterwards, in three weeks' time, students have prepared their individual laboratory projects and conducted their experiments. Following to the experiments, the measurement tools which students filled as pre test have been administered as post test. At the end of the semester, students' course grades have been evaluated as performance scores. Data analysis has displayed that as a result of the implementations students' anxiety significantly has decreased and their scientific processes skills and logical thinking skills have developed significantly. Conducted regression analysis has displayed that the implementations have been the significant predictor of the performance.

Introduction

The laboratory practice in science education enables students to communicate between the theoretical knowledge and its application through providing experimentation, observation and the required equipment. The student reports resulting from experiments are of utmost importance since they teach students to *"recognize and value the reliable, logical and scientific knowledge through observation and experiments*" and to *"evaluate the experiments, proofs and conclusions accurately".* The laboratory practice within the graduate education aims to improve students' commenting skills, however, in fact they do not tend to question what students have learnt. As Barrie *et al.* [1] expressed in their studies, laboratory practice is an activity that should be finished at once. In other words, students are taught something, but what and how much a student learns is not considered. This lack could only be noticed when the learnt knowledge is required to be used in practice. Since 1999, with the support of The Committee for University Teaching and Staff Development (CUTSD), a project called Australian Physical Chemistry Enhanced Laboratory Learning (APCELL) has been conducted. With the help of the APCELL project, solutions are sought for this problem and it is enabled to publicize these solutions. One of the primary objectives of the APCELL Project is to disseminate widely the results, outcomes and practical developments in physical chemistry laboratory exercises that are based upon student-focused pedagogical tenets. The informal interviews that was made with many academicians at the beginning of this project highlighted a widespread recognition amongst academics that students studying physical chemistry were not learning in the laboratory as well as they should or could. One of the most important objectives of the APCELL project is to organize laboratory practice beneficially, in such a way to increase physico-chemistry students' motivation and improve teaching. Laboratory Work is considered to be of great importance in the chemistry curriculum, yet research suggested that it may not achieve the desired learning objectives. Students can often see the laboratory exercise as simply a task to be completed as quickly as possible, and this attitude can defeat any attempts to use the experience as a teaching and learning tool. There are many good reasons for that. These reasons are discussed in detail within the scope of the APCELL project [1].

In terms of chemistry applications, Okebukola [5] put forward that the laboratory practice enables students to gain experience in (a) making real observations and definitions regarding chemical events, (b) developing special skills, (c) recognizing problems related to chemistry and finding solutions for them, (d) developing their logical thinking skills, (e) improving their self-confidence, (f) double checking on previously known principles and facts. Looking at other studies related to laboratory practice in chemistry education, it is observed that some researchers carried the project-based learning approach to the experiments developed at laboratories. There are some factors that contribute to the success of the above-mentioned chemistry laboratory practices. Bowen [2], in his study, developed a tool in order to assess students' levels of anxiety at the college chemistry lab and he examined this tool's validity. The developed tool revealed the relationship between the chemistry lab anxiety and using equipment and tools, collecting data, working with other students and using time effectively. The study also involved the utilization of this tool in didactic experiments, which aim to increase the level of learning. Parallel to anxiety, it was observed that students' logical thinking skills and scientific process skills were also effective on the conclusion.

The Purpose of the Study

In this study, the effects of project-based learning model on the lab anxieties, scientific processing skills and logical thinking skills of student teachers of chemistry were examined. By comparing and contrasting the pre and posttest results, it was analyzed whether the utilized teaching model was effective on their lab anxieties, scientific processing skills and logical thinking.

Sampling

The sampling of the study were 42 Year 4 students from Hacettepe University, Faculty of Education, Department of Chemistry Education at the 2005–2006 Spring Semester.

Findings

Student teachers of chemistry were asked to design individually chemical experiments related to any topic in chemistry, where the project-based learning model is used. The anxiety survey [4], scientific processing skill test [6] and the logical thinking survey, which was developed by Tobin and Copie [7] and implemented in Turkish by Geban, Aşkar and Özkan [3] were all used as pre- and posttests before and after the student teachers completed their project-based lab practice. Finally, student teachers carried their experiments to the electronic environment and prepared presentations. At this step, students were given the photos taken by the research supervisor. Therefore, detailed information and data were acquired about student teachers' experiments related to the topics they had chosen. The design and actualization steps of the experiments were supervised through these processes; corrections were made where necessary; and possible accidents were prevented by providing safety regulations. The experiment presentations were handed out to all student teachers, so that they could use them as detailed experiment designs in their future professional lives. Moreover, students' final grades at the end of the course were taken as their performances. All project-based lab experiments were published on *www.kimyaegitimi.com*, the website of the main author, as well as *http://www.kimegi.hacettepe.edu.tr*, which belongs to Hacettepe University, Faculty of Education, Department of Chemistry Education as ICT(Information and Communication Technology)-assisted applications for the common use of all students.

Findings and Conclusion

Tab. 1 Dependent Variable T-Test results (n = 42)

	Mean	Std. Deviation	Std. Error Mean
Scientific Processing Skill Pretest	21.7857	6.0386	0.9318
Scientific Processing Skill Posttest	23.6190	3.4778	0.5366
Anxiety Pretest	2.1146	0.5346	0.0825
Anxiety Posttest	1.9568	0.5338	0.0824
Logical Thinking Pretest	11.2857	3.3878	0.5200
Logical Thinking Pretest	12.7857	2.7800	0.4291

Paired Differences	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Scientific Processing Skill Pretest × Scientific Processing Skill Posttest	– 1.8333	5.4590	0.8423	– 2.176	41	0.035
Anxiety Pretest × Anxiety Posttest	0.1577	0.4276	0.0660	2.391	41	0.021
Logical Thinking Pretest × Logical Thinking Pretest	– 1.5000	4.0680	0.6277	– 2.390	41	0.022

The statistical evaluations showed that the used teaching model had significant effects on students' lab anxieties, scientific processing skills and logical thinking skills. The differences between all pre and posttest results were found to be significant favoring the posttests. The individual lab practices, which were done by using project-based method are thought to have enabled students to develop their own special skills through observation on chemical events and contributed to their scientific processing skills. Additionally, these lab practices have positive effects on students' improving their logical thinking skills in terms of finding ways of solution. The administered pre and posttests concluded that all these positive features also decreased the level of students' lab anxieties.

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Computer Supported Electrochemistry

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Summary. The paper deals with the computer supported electrochemical experiments. Several common electrochemical processes were monitored by means of the most popular Czech school computer measuring system called *ISES*. The contribution comprises the processes particularly related to the galvanic cells. Three of them (Daniell cell, Iron-Nickel alkaline accumulator and Lead-acid accumulator) are presented in the paper. The processes that our work is focused on are: electric potential production, running down the galvanic cells and recharging the accumulators. All the experiments presented herein will be inserted into the electronic database of the school computer supported chemical experiments as a part of the school virtual laboratory of chemistry.

Introduction

One of the advantages of computer experimenting is an ability to measure of a physical quantity changes in time. There are many processes in education of chemistry that could be monitored continually. And also there are many long-lasting experiments that need to record data for a couple of minutes, hours or days. This is one of the reasons why they can be performed by means of computers. However computer is not only a “performer” of an experiment. It is also able to control an experiment, build and change experimental conditions and record and archive experimental data as well. In order to perform such experiments there is a necessity of specific equipment often called *measuring system* that usually gathers a computer, individual measuring instruments (*modules*, meters) and an appropriate software [1].

In our work we decided to create an electronic database of computer supported experiments which will cover the different chemical processes monitored by different *measuring systems* and different *modules* (meters). The experiments will particularly be focused on pH (potentiometry), conductivity (conductimetry), temperature, pressure, oxygen content measurements, electric current and electric potential measurements. Some experiments from the last category mentioned above are presented in the paper as a suggestion of a continual monitoring of the electric potential changes in time.

Experimental part

In the following text some processes related to electrochemistry, especially to galvanic cells are presented. We used *ISES Professional* as a measuring equipment (*measuring system*) and a *V-meter* as a measuring *module* [2–4].

The first galvanic cell that we present is the *Daniell cell*. As known this galvanic cell can be described by the following scheme:

$$Zn \mid ZnSO_4\ (aq) \parallel CuSO_4\ (aq) \mid Cu$$

If the concentration of the solutions ($ZnSO_4$ and $CuSO_4$) is 1 mol dm^{-3} the electromotive voltage (EMV) of the cell should be 1.1 V, which is the difference between the electrode potentials of both of the electrodes. An example of the *Daniell cell* EMV measurement is shown in the Fig. 1. As depicted in this thirty-second-lasting experiment the cell produces an EMV about 1.1 V. If one of the electrodes is placed out of its electrolyte the EMV production is interrupted and the EMV line (Fig. 1) is broken. The similar experiments can be done with another galvanic systems.

Fig. 2 and 3 show a behaviour of an EMV measurement of the *Iron-Nickel alkali accumulator*:

$$Fe \mid KOH \mid Ni(OH)_3 \mid Ni$$

and the *Lead-acid accumulator*:

$$Pb \mid PbSO_4 \mid H_2SO_4,\ 20\text{–}30\% \mid PbO_3 \mid Pb$$

It is also possible to measure the running-down processes of the galvanic cells. If we let the cell run connected to the electric circuit with the ISES (or we even connect e.g. a little bulb or a diode to the electric circuit together with the cell) and we have enough time to monitor the process, we can get the curve on how the EMV of the galvanic cell is running down (Fig. 5, 6).

The galvanic cells that can be recharged again after the running-down are called secondary galvanic cells or accumulators. In the *Lead-acid accumulator* the concentration of the electrolyte (H_2SO_4) is decreasing during the running-down process. That is why we can monitor how the EMV of the accumulator is decreasing by step-by-step dilution of the electrolyte with water (Fig. 7).

It could be interesting for students if two or even three galvanic cells are connected together in-line within the same electric circuit as presented in Fig. 8. The EMV produced by such a system was then over 4 V.

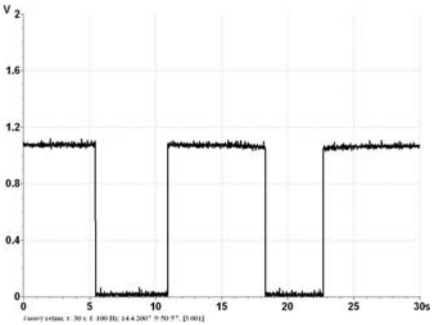

Figure 1. EMV of the *Daniell cell*. Two interruptions of the 1.1 V line show the withdrawing of one of the electrodes out of its electrolyte for a couple of seconds during the measurement.

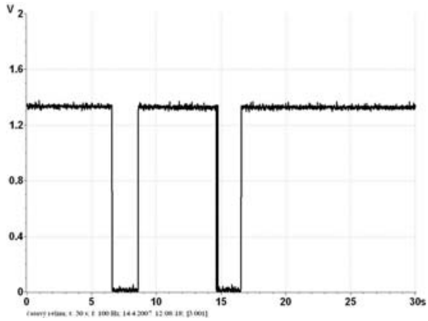

Figure 2. EMV of the *Fe-Ni alkali accumulator*. The interruptions of the line in about 1.35 V show the withdrawing of one of the electrodes out of the electrolyte (KOH) for a couple of seconds during the measurement.

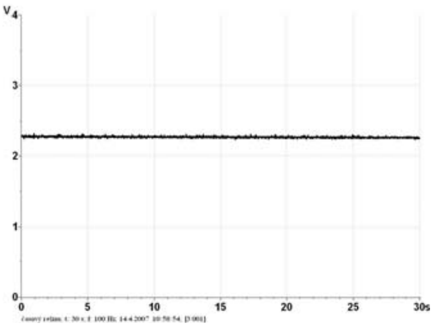

Figure 3. EMV of the *Pb-acid accumulator*.

The measurement was not interrupted by the withdrawing of the electrodes out of the electrolyte (H_2SO_4).

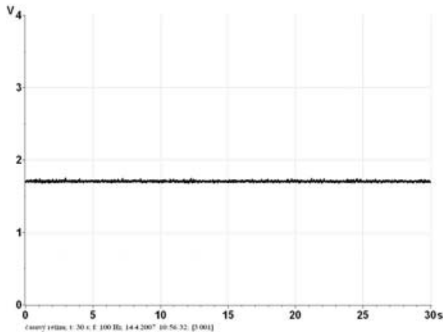

Figure 4. EMV of the run-down *Pb-acid accumulator*

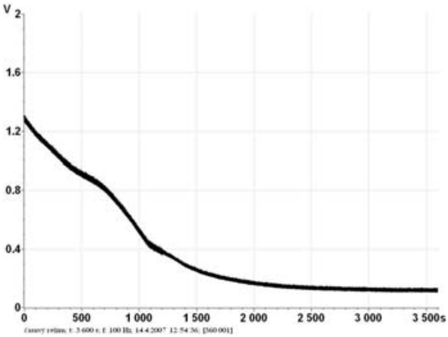

Figure 5. Running-down process of the *Fe-Ni alkali accumulator*.

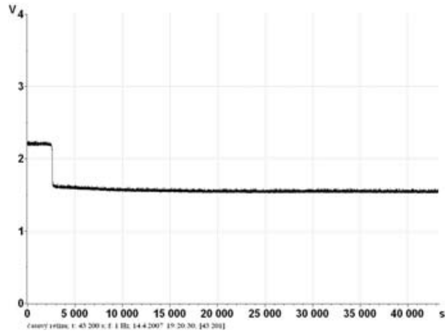

Figure 6. Running-down process of the *Pb-acid accumulator*.

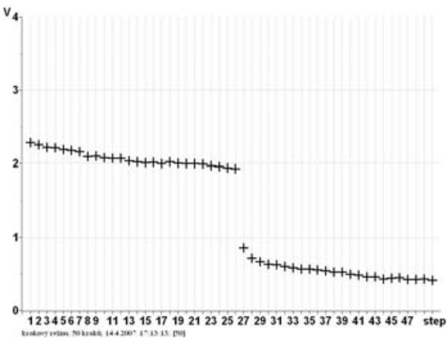

Figure 7. Decreasing of the *Lead-acid accumulator* EMV caused by a step-by--step electrolyte dilution. Every step means a 2 cm^3 addition of water from a burette in order to dilute the electrolyte (H_2SO_4).

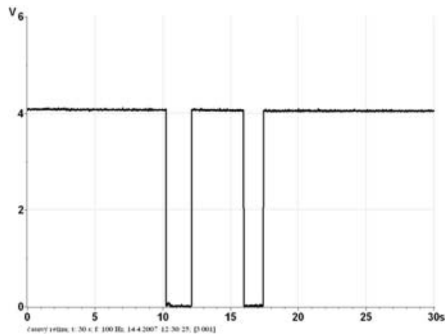

Figure 8. *Daniell cell*, *Pb-acid accumulator* and *Fe-Ni alkali accumulator* connected in-line within the same electric circuit. The interruptions of the line show the withdrawing of one of the electrodes out of the electrolyte.

Conclusion

Performing of the chemical experiments by means of computers can be one of possible ways on how to approach the work of students to the work of scientists and how to increase the students' interest in chemistry. The experiments presented in the paper are just a suggestion of where the continual measurements of different physical quantities can be applied.

The experiments will be inserted into the electronic database of computer aided chemical experiments that will be published on the web as a part of the virtual laboratory for chemistry education.

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A Comprehensive Approach To the Experiments Using the Multifunctional Data Logger Device

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Summary. The contribution is focused on the employment of multifunctional measuring data logger devices in high school education. The experimenting becomes more effective as it provides direct visualisation and immediate feedback. We have prepared several experiments centred on physical chemistry and general chemistry using the multifunctional data logger Infraline Graphic. This paper presents experiments focused on dependence of pH on increasing concentration of carbon dioxide, acid-base titration of phosphoric acid, and determination of heat capacity of calorimeter.

Introduction

"The nature of work is changing and skills required from employees and managers are changing. Examples of this change are an increasing knowledge intensity in products, an increasing proportion of the workforce in the service sector, changing work organisations that demand new skills, and the role of enterprises as training providers … new pedagogical issues arise around ways to encourage people to develop the specific skills to use ICTs in the learning process – such as the selection of relevant information, its analysis and its subsequent transformation into knowledge and skill … Europe needs an adequate throughput of mathematics and scientific specialists in order to maintain its competitiveness … The need for schools and training institutions to relate to the world of work is widely acknowledged. In the area of training, work placements are valuable in enhancing employability and in offering an insight into the world of work." [1] The mentioned objectives of Lisbon meeting at March 2000 require close connection between education and work. In order to be employable, the graduating students should be able to work with multifunctional devices, which are commonly used in real laboratory practice. Moreover in the Czech Republic the Ministry of Education, Youth and Sport comes up with so called Framework Educational Programme, which is supposed to be valid since the academic year 2007/2008. The Framework Educational Programme (FEP) officially fuses the school subjects into several thematic sections, such as Language and Communication, Man and Nature, Man and Society, Art and Culture and others; the chemistry, physics,

biology and geography are contained in the section Man and Nature. The FEP put emphasis on the cross-curricular relations, the understanding of implications, skill mastering etc. There has been a broad discussion about the programme discussing the pros and cons, but one definitely positive feature is a relatively freedom, that is given to schools, because they can realize their own school educational programme coming out of FEP. On the other hand there are also problems arising from implementing of FEP. One of them is an absence of any educational materials and methods supporting the new way of seeing the primary (secondary, high) school education. This feature is superimposed in science, because contemporary science branches use a lot of measuring instruments.

Measuring instruments at high schools in the Czech Republic

In our opinion, the utilization of measuring devices fulfills both requirements: the connection to work practice (Lisbon council, 2000, FEP) and cross-curricular relations. If the experiment is carried out using the device which allows connecting different sensors, the instrument can be used in chemistry, physics, biology, and mathematics. The experimenting enables simultaneous theoretical and practical illustration of taught themes. In addition to that, the direct visualization of a studied problem along with immediate feedback allows students to focus on a taught phenomenon. The heard and seen information provides better understanding and that is why we suppose that using scientific measurement devices could have a high impact in education. However, only a few schools in the Czech Republic are equipped with these devices, so they cannot demonstrate to students the techniques which are common in today's laboratory practice. Although the utilization of experiments supported and/or provided by PC in the Czech Republic is not a newcomer [2, 3], there is a lot of obstacles complicating this tendency, such as dimension, weight, know-how, money. One of the instruments available at the Czech market, which is designed to fulfill the teachers' requirements, like exact and comfortable measurements, mobility, easy and user-friendly control, easy and cheap maintenance, robustness, reasonable size, possibility to make experiments with or without PC and modularity, is Infraline Graphic by Pierron Education (Fig. 1).

The results describing Infraline Graphic testing, experiments' development and experiments' evaluation have been presented [4, 5]; the theoretical introduction, experimental experience, description of support software DidexPro and worksheets for teachers are summarized in [6].

Figure 1. Infraline Graphic

Figure 2. pH dependence on CO_2 content

Experiments

The experiments were put up using the literature [7], but the implementation was adjusted for Infraline Graphic device. One of the easiest experiments modest for chemicals and preparation is a ***study of pH dependence on carbon dioxide concentration.*** During the continuous measurement the students breathe out the air into the water, while the pH electrode is indexing the actual pH value (Fig. 2). The pH value of water falls down from 6.6 to 4.4 within three minutes as the carbon dioxide is absorbed in water. The carbonic acid partly dissociates which influences the pH. The experiment is easy, reproducable and takes up to 5 minutes. The experiment can be carried out by students in laboratory class as well as a demonstration experiment.

Measuring devices are well suited for demonstration and explanation of ***titration process***. Students can immediately see the response of their action on PC screen and no further data elaboration is needed. Acid-base titration of hydrochloric acid simultaneously monitored by potentiometric and conductometric sensor was described in [6]. Students observe two phenomena at once: a change of pH and conductivity. With one click they can make a first (or second) derivation of the curve to determine the equivalence point. ***The titration of weak phosphoric acid*** with potentiometric equivalence point detection is another example of didactic titration illustration. H_3PO_4 is a weak acid that dissociates into three degrees. Students can see two equivalence points during the titration and they can determine the precise volume of titrant by analyzing the first derivation of the curve (Fig. 3). Afterwards, pK_a of phosphoric acid can be read from the curve, which means half titrant consumption to the equivalence point. The results can be compared to the theoretical ones (pK_{a1} = 2.12; pK_{a2} = 7.20; [8]). In this experimental implementation the constant volume of titrant is added by micropipette in ten second interval. The experiment is well reproducable, two types of chemicals are used and even with the calibration of electrode and final analysis it takes time of 15 minutes.

The third attractive experiment easily controlled and visualised through the computer, which we present, is ***a determination of heat capacity of calorimeter***. The experiment is carried out with two temperature sensors that measure the temperature in hot and cold water. Students observe the changes of temperature till the final equilibration (Fig. 4). The values of initial temperatures and the thermal variation are put into calorimetric equation and the heat capacity of calorimeter can be figured out.

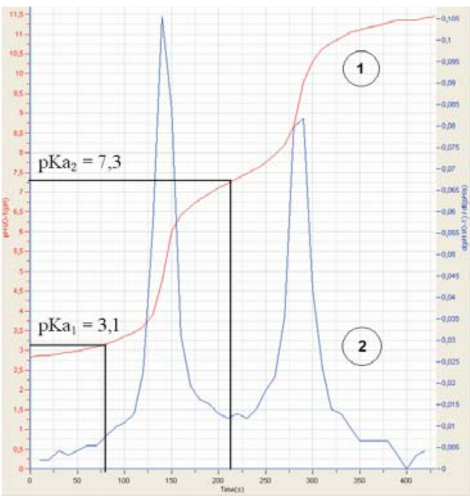

Figure 3. Titration curve H_3PO_4
(1) potentiometric detection, and
(2) deterivation.

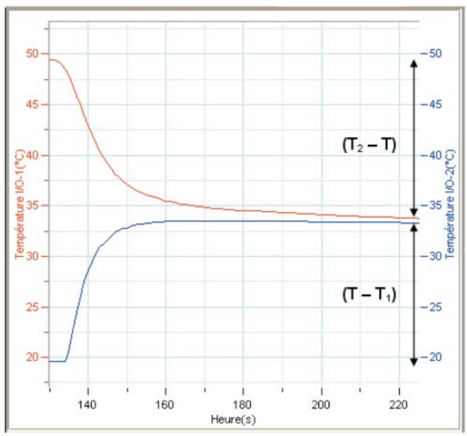

Figure 4. Temperature stabilization.

Conclusions

All experiments were processed into worksheets that are available in teacher and student version; the teacher version contains solution to included tasks.

The multifunctional didactic measuring instruments present suitable equipment for high school laboratory, because they simulate the real laboratory practice. The devices can be used in laboratory or as an instrumental demonstration during the lesson. The results acquired with Infraline Graphic are satisfactory and they correspond to the theoretical ones. Within the context FEP the measuring devices offer useful and convenient equipment for science subjects (chemistry, physics and biology), because they encourage the intersubject relations, context comprehension and laboratory/evaluation skill. Thinking in wider objectives of Lisbon meeting (2000) the students who learn to work with electronic devices during their studies should be easily employable in all countries of European Union or all over the world.

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Present Conception of Laboratory Activities in Chemistry Education

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Summary. Progressive tendency in didactics of chemistry is focused in two main aspects of chemistry education: using the scientific method and critical thinking and emphasis context of daily life. One of the ways to integrate both of these aspects into chemistry education is a properly designed chemistry experiment. Such an experiment is suitable for every level of education system and has its place also in the lifelong and distance education. We are concerned with usage of ICT and Internet in chemistry education particularly in relation to a chemistry experiment. Knowing a science experimental work is not a typical domain of e-learning, there are presented some interesting examples in this paper to show the wide possibilities of using chemistry experiments in blended or on-line learning, educational or hobby chemistry courses.

Introduction

Chemistry education as well as every science education is always a combination of the theoretical thinking with the exploration of the natural patterns and their verification by means of the experimental laboratory work, no matter what stage of the educational system is considered.

The Framework Educational Programmes for primary and secondary education (FEP) are the curricular documents created for the development of the key competencies in every school subject. A part of FEP relating to the science educational field *Man and Nature* (including chemistry) emphasizes the formulation of a science problem and its solving through observation, experimentation and measurement, data processing, modelling of the natural processes, making predictions based on the learned laws of these processes, and use of mathematics and modern technologies [1].

Most of the objectives set out it the *Man and Nature* educational field can be realized within the frame of the pupil's own experimental work. However, many of our chemistry teachers face up several practical obstructions impeding the realization of the modern chemistry education described above. Most frequent obstructions are: lack of time for the regular experimental work, lack of funds for the chemicals and tools purchase, insufficiently equipped or even missing laboratories, and the safety regulations restricting the pupils work with the chemicals.

We are concerned in searching for such form of chemistry experiment, which would reflect both the objectives set in the FEP and the limitations of the primary and secondary school education routine.

Demands on an innovative chemistry experiment

Summarizing the educational objectives, we can lay following demands on the chemistry experiment: it explores a system complex enough to allow creating several hypotheses, but not so much complex that the hypotheses verification is impossible; it meets other sciences, their knowledge and methods, and also the situations of daily life; it can be set as a problem task open to the heuristic approach.

The demands reflecting the restrictions of school practice are: simple equipment and available chemicals void of dangerous properties, and sufficient motivation effect.

Experiments with natural substances and readily available materials

We suppose that the experimentation with the natural substances and readily available materials in itself contributes to meeting the demands set above. Food, plants or household equipment are very well available, safe and inexpensive "chemicals", using them means a strong motivation due to their connection with daily life, and they can be explored also from the biology or physics point of view. Natural materials such as food or plants are of uncertain composition (for pupils), which allows creating a number of hypotheses. In this case pupils understand the need of hypotheses verification naturally – it leads them to the scientific method of thinking and research. However, the uncertain composition of the used materials brings one disadvantage: the presence of many other substances can complicate even a well-known and simple chemical reaction.

Working with natural and readily available materials can be integrated first of all into the education of biochemistry and chemistry of natural substances (proteins, fats, sugars, enzymes, dyes, *etc.*), but it can also upgrade the education of general and physical chemistry (acid-base theory, pH indicators, catalysis, electrochemistry), and both organic and inorganic chemistry. [2, 3]

Many of "traditional" chemistry experiments can be modified by substitution of the respective pure chemical substance by its natural source, simplification of laboratory procedures (an electric kettle or a microwave instead of a laboratory burner [2]) and using other off-hand tools.

Of course it is necessary to test each new experiment thoroughly with a detailed documentation. Some materials decay and the desired chemical components can be decomposed after a short time. Also the principles of the observed chemical reactions should be carefully examined, verified and confronted with a scientific literature. [2, 4]

Utilization of the innovative chemistry experiment

Chemistry experiments modified in a way described above are so safe and modest, that they are suitable for school science education, especially for schools without chemistry laboratories, for varied science hobby-activities such as summer camps or hobby courses and even for a "kitchen realization" within the distance education courses.

The "home chemistry experiment" can be implemented into the routine chemistry education in form of homework or extended activity for interested pupils. Younger children are often insecure and miss the presence of the teacher. They have to be led with a proper work sheet and the experiment cannot be too complicated. On the contrary, older students regard highly the possibility of their own planning. [3, 5]

Chemistry experiments in the distance courses

In most cases, the distance courses in science education are based on the work with text, information and theoretical thinking, because the practical distance courses are hardly feasible in general. But recently the development of information and communication technologies and the increasing Internet availability enable the e-learning courses based on the learner's own experimental work. These courses cannot cover systematically the scope of school chemistry education, but they can support the face-to-face learning on every type of school.

"Education in organic and practical chemistry" is a distance chemistry course in Moodle project of Charles University in Prague, Faculty of Science, designed for the undergraduate students of didactics of chemistry. It involves some problem tasks for the knowledge fixation and as an inspiration for their own teaching practice. [6]

"Current conception of the experimental education of chemistry at primary and secondary schools" is a chemistry course of lifelong education in the JPD3 ESF and Prague municipal council project. It is designed for the chemistry teachers and it is realized at the Department of Teaching and Didactics of Chemistry, Faculty of Science, Charles University in Prague. The e-learning support of this course provides many tens of chemistry experiments instructions including the result photos. [2]

"Course in practical Alchemy" [3] is a chemistry e-learning course designed for the wide range of non-chemists. It is based on the home chemistry experiments carried out by the learners, it leads the learners to the better understanding of the selected topics and raise their interest in chemistry and science. The course is fully realized via Internet (on the URL: *www.prskavec.mysteria.cz*) and the discussion forum and e-mail are used as communication tools. [5]

Conclusion

Our aim is to provide an all-round and high-quality preparation for our students, to develop their science literacy and to prepare them for the real life situations. We endeavour to achieve this by the natural combination of theoretical knowledge and experimental skills, using both classic and modern facilities and proper methods and forms of education. [6]

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Students' Interpretations and Gains From Different Animations on H-Bonding

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Summary. The present study is a preliminary attempt to compare different animations that can be used to explain the formation of Hydrogen-bonding. Five animations, each of which displayed distinctive features on Hydrogen-bonding were selected from the web. Fifteen 10^{th} grade students evaluated and interpreted each of these animations using a questionnaire that required them to explain the formation of H-bonding based on their observations. Students' initial and final conceptualizations on H-bonding were determined by four open-ended items on the formation and features of H-bonding. The results indicated that animations could add to students' conceptualization of H-bonding and each animation could provide a unique contribution based on its distinctive features. The results also showed that the degree of overlap between intended and observed interpretations ranged between 2–18 % for the definition of H-bonding, 0–13 % for the strength and stability of H-bonds, and 8–18 % for the number of H-bonds that can form between two molecules.

Introduction

Computer animations are considered to be effective tools that support visualization and learning of chemical phenomena at microscopic level [1–3]. Although world wide web provides chemistry teachers with several animated displays, selection of an animation that satisfies both the students' needs and teachers' expectations can be particularly important when it is used to demonstrate basic concepts at microscopic level. The present study examines student evaluations and gains from five web-based animations on H-bonding in order to determine their relative contribution in helping students visualize and understand the underlying conceptual base. H-bonding is the selected conceptual base, due to its importance in explaining several chemical phenomena, and its strong reliance on visual representations.

Method

Fifteen 10^{th} grade (age range: 15–16 years) students worked individually on five different animations on H-bonding in the computer laboratory. The work session lasted for 50 minutes during which the students could interact with their friends and receive teacher assistance whenever they needed. Students' initial and final conceptualizations on H-bonding were determined by four open-ended items that required the students to 1) define H-bonding, 2) state molecules that form H-bonding, 3) show molecular representation of H-bonding, and 4) comment on the strength of H-bonding. During the work session, the students filled out a questionnaire that required them to specify what they observed in each animation in terms of 1) the description of H-bonding, 2) number of H-bonds that could form between two molecules, 3) the strength of H-bonds, and 4) the stability of H-bonds. The last four items of the questionnaire required students to compare the animations in terms of their effectiveness and comprehensibility, and provide suggestions for improving each animation. Data was used to analyze 1) changes in students' understanding of H-bonding; 2) students' evaluation of each animation in terms of effectiveness and comprehensibility; 3) the degree of overlap between intended and observed interpretations.

Results and Conclusions

When changes in students' conceptualization of H-bonding was analyzed using pre and post test scores, t-test analysis revealed significant gains (form $M = 5.6$ to $M = 6.5$) indicating that the students could benefit from the animated displays about H-bonding. Students' evaluation of each animation in terms of effectiveness and comprehensibility revealed information on why students considered an animation on H-bonding to be effective or ineffective. The animation that was found to be the least effective by 47 % of the students was perceived to be very simple, very short, unclear, difficult to understand, symbolic, 2-dimentional and limited in scope (only H_2O was considered). The animation that was found to be most effective was chosen because it was perceived to provide clear and step-by-step explanations. The data was also examined to understand the degree of overlap between how the teacher expected their students to interpret each animation and how the students actually interpreted them in terms of 1) how H-bonding is defined, 2) the strength and stability of H-bonds, and 3) the number of H-bonds that could form between two molecules. The degree of overlap between intended and observed interpretations ranged between 2–18 % for the definition of H-bonding, 0–13 % for the strength and stability of H-bonds, and 8–18 % for the number of H-bonds that can form between two molecules. The results indicated that animations helped students refine their own mental models using dominant visual features displayed in each distinct animation. Results also suggested that it was more useful for students to observe different animations and differentiate between them instead of focusing on just one animation.

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The Interactive Voting System and the Interactive Display Board in Teaching Elements of Chemistry at the Academic Level

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Summary. Contrary to other teachers, the teachers of natural sciences tend to be better at getting acquainted with technological novelties. In order to facilitate their work, the Department of Chemical Education at Adam Mickiewicz University (AMU) Faculty of Chemistry in Poznań has been involved in designing computer software facilitating teaching chemistry at all educational levels and, since 2005, it has been working out a strategy of teaching natural sciences using an interactive display board and an interactive voting system.

Introduction

The Department of Chemical Education at Adam Mickiewicz University's (here and after referred to as AMU) Faculty of Chemistry in Poznań has been carrying out research on introducing the interactive didactic surroundings comprising independent devices, which may be configured differently as to provide new opportunities for organizing lectures, classes, presentations and training. Among such devices, we can find for instance:

- An interactive display board which facilitates effective learning by building up experience, and backing up such skills as making reflective observations, putting forward abstract hypotheses, or conducting experiments. Additionally, the board has been examined as far as its use in junior high schools, secondary schools, and universities and colleges is concerned. This examination has been taking place at AMU Department of Chemical Education since 2005 [1].
- Voting and assessment systems, i.e. cordless devices for various types of interaction, such as assessments, attendance and knowledge check-ups, votings, opinion polls, tests and questionnaires.

Though there are many producers of such survey systems, most of these systems tend to work similarly. Respondents vote or answer questions using remotes, by pressing a button correspondent to the answer they chose. The results are immediately accessible and may be displayed either on a computer screen, an interactive display board, or a broadcast screen. Additionally, the results are saved on one of the computer's hard drives, with a possibility of being presented later as either charts or numerical data, depending on the software provided by the producer.

The *Infrared* system provides a modern method of data transmission utilizing infrared radiation, which allows for conducting quick and precise opinion polls or votings among participants of a given meeting. The system can be used wherever the users are required to participate actively in a given activity by venturing opinions or casting votes. It is based on the coordinated cooperation of a set of remotes, infrared radiation receivers and a head computer.

The remote contains a numerical keyboard equipped with ten buttons corresponding to various answers, as well as with two diodes, a green one and a red one, which inform the user that the cast vote has been registered by the head computer. This allows the user to make sure that their vote has been cast properly. The signal is aired by a built-in transmitter in the remote and sent to the main computer.

Infrared has been introduced to some research on teaching efficiency in Finland [2] and Australia [3]. As an effect of interaction between teachers and learners, the electronic voting system has contributed to the improvement of educational conditions and teaching results.

AMU Department of Chemical Education, together with Teacher Training and Consulting Center in Szczecin, are currently carrying out research on the use of Hitachi's latest interactive boards (giving tests, conducting surveys and votings) in teaching students, as well as in training teachers. The VerdICT survey system comprises:

- grey student remotes with number buttons,
- a blue instructor remote,
- an infrared port,
- 10 meters long serial cable,
- serial/USB converter,
- VerdICT software.

Each participant of a lecture, conference or training, answers individually to questions asked by the speaker. The questions are of different types, for instance some may only be answered once, whereas others can be answered until the proper answer is found. All answers are registered and categorized. First, the signal is sent, by the means of infrared radiation, to the receiver connected to the computer. Each time one of the remotes sends a signal with data to the receiver, a correspondent, coloured circle changes its color from red to green, thus informing the user that their answer has been successfully sent to the receiver. While the answer is being sent, an icon with a raised thumb up appears on the screen. Each of the pilots has its unique ID to which a given user's answers are linked on the answer chart. The instructor is able to display such information as the user's name, surname, nickname, reference number, and the remote's number. It is up to the instructor what they will display on the answer chart, for instance they may display the answers that the users chose or the bare confirmations of giving those answers. After the set time-limit is up, the instructor can display the correct answer to a given question, together with the percentage of correct answers, by pressing a respective button on the remote.

Some of the benefits of using VerdICT in education are:

- the use of high-end technology which improves both teaching and polling attractiveness,
- the creation of an active, learning-friendly environment in which new ideas can be exchanged actively,
- the ability to prepare various tests and votings,
- the ability to test the degree to which students can understand lectures,
- the incorporation of real-time knowledge check-ups,
- the possibility of providing immediate feedback on a given lesson or pressentation,
- the replacement of traditional, written tests and questionnaires with their convenient, multimedia counterparts,
- the rise of students' interest in classes due to the system's multimedia form,
- the possibility of adjusting lecture content to students' demands ,
- the ability to formulate statistic summaries [4].

More didactic research on the efficiency of VerdICT is carried out (the piloting research was conducted in the academic year 2005/2006 [5]). The aim of this research is to answer the following questions:

- Can the use of VerdICT contribute to improving students' cognitive activity and developing their skills?
- Can the use of VerdICT result in the improvement of students' motivation for learning?

- How can VerdICT's educational efficiency be compared to traditional tests and multimedia tests taken in computer rooms?
- To what extent can VerdICT increase the number of correctly resolved problems?

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Developing Experimental Abilities. Computer Aided Teaching For Chemistry Students

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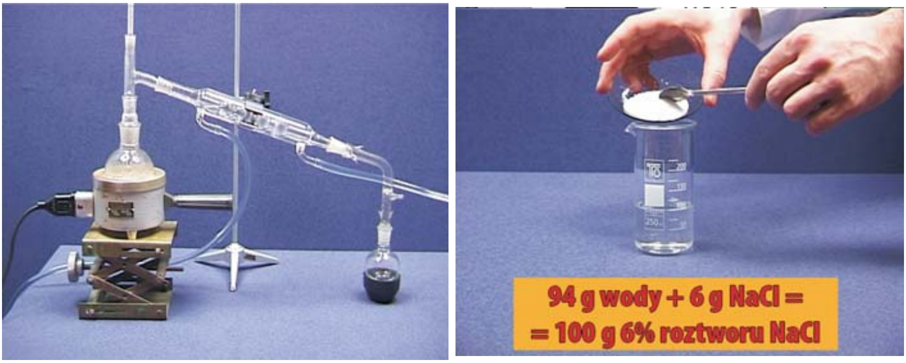
Summary. Research technology is often discussed in the literature on experimenting. Subjective aspect of experimenting allows perceiving the experiment not only as the implementation of specific strategy but also as an area which requires certain abilities and talent. The authors present the application of a new method of teaching laboratory skills to students of the Faculty of Chemistry training as Chemistry and Natural Science teachers. In addition to this, the results of research into the efficacy of educational videos presenting laboratory techniques as well as their application to chemical experiments are presented in this paper.

In order to carry out chemistry experiments in the lab students must be familiar with laboratory equipment in the context of its correct application and use.

The software *Basic laboratory techniques in chemistry experiment* is to assist students of Chemistry and Natural Science as well as those teachers who are not experienced in experimental work and are expected to carry out laboratory classes [1,2].

The software consists of an informational part and a control block. The informational part contains basic information on certain techniques of laboratory work as well as didactic films illustrating correct application of laboratory equipment. Numerous activities have been described in the software. They include activities involved in weighing, precipitating, exudation and decantation, calcination, heating, melting substances, distillation, extraction, preparing solution of various concentrations, collecting gasses, titration, glass processing, making holes in corks, sublimation, crystallization, crushing substances, evaporating solutions of certain substances, separating mixtures and exudation in laboratory conditions [3,4]. A set of videos was also prepared in order to present interesting chemical experiments in which particular laboratory work techniques are used. For each video presenting a particular technique there is a video showing the experiment in which the technique was used.



(a) (b)

Figure 1. Frames form videos presenting the principles of (a) simple distillation, as well as (b) preparing solutions of chemical substances of particular percentage concentration

(a) (b)

Figure 2. Frames from video presenting interesting chemistry experiments related to certain laboratory techniques *e.g.* (a) separation of homogenic mixture through distillation, (b) changing the concentration of solutions resulting from crystallization of the diluted substance.

The videos contain carefully selected commentaries which accompany the image. In some videos the comment is limited and only draws the student's attention to important details. In others, extensive commentaries accompany the images which include elements of problem solving. For instance, students are expected to choose the equipment necessary to carry out the experiment [5]. The software provides the students with a set of rules of safe laboratory work as well as with some advice on how to behave in the event of emergency situations. Additionally, the principles of handling hazardous substances are provided as well as the manner of handling toxic waste [6,7]. In the control block, there is an educational quiz made in the form of a multiple choice test. At each stage the users are allowed to check their knowledge [8,9].

The analysis of research results

A survey was carried out among students of the Faculty of Chemistry in order to determine the efficacy of the set of videos presenting basic techniques of laboratory work. The analysis of the results points to the fact that third year control group students working with conventional descriptions of laboratory techniques showed the increase of knowledge specified within four taxonomic categories of educational aids was as follows: category A – memorizing information – 24 %, category B – understanding information– 19 %, category C – the application of information to typical situations – 21.5 % and in category D – the application of information to problem situations – 22 %. In the experimental group of third year students working with educational video presenting basic techniques of laboratory work the respective results were: A – 36.5 %, B – 30 %, C – 36.5 % and D – 39.5 % (Fig. 3).

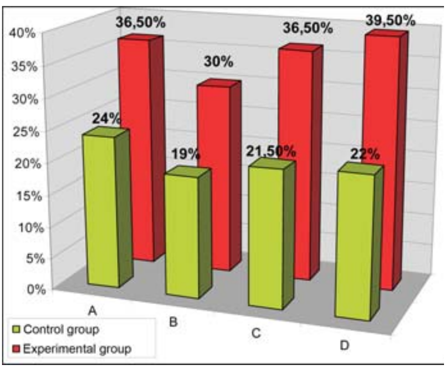


Figure 3. The results of research into knowledge increase amongst third year students obtained in four categories of taxonomic educational aims.

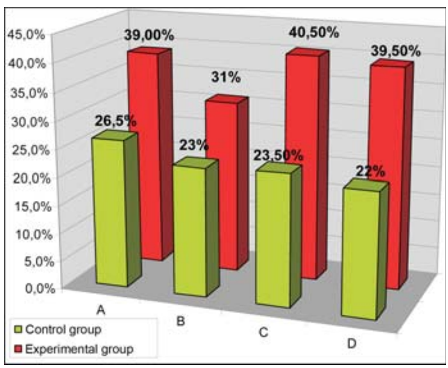


Figure 4. The results of research into knowledge increase amongst fourth year students obtained in four categories of taxonomic educational aims.

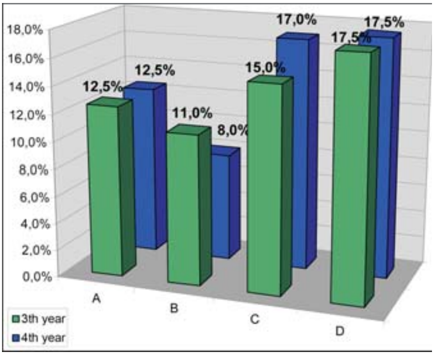


Figure 5. The increase of knowledge – third and fourth year students – obtained for each of the taxonomic categories of educational aims.

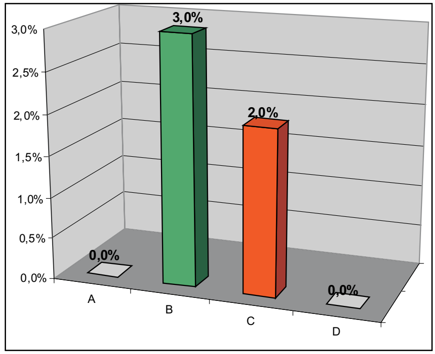


Figure 6. Differences amongst the increase of knowledge between third and fourth year students obtained for each of the taxonomic categories of educational aims.

Furthermore, the analysis of the obtained results points to the fact that the fourth year control group students revealed the following increase of knowledge in all of the taxonomic categories; category A – memorizing – 26.5 %, category B – understanding – 23 %, category C – the application of knowledge in typical situations – 23.5 %, and category D – the application of knowledge in problem situation – 22 %. In the experimental group consisting of the fourth year students the results were respectively: A – 39 %, B – 31 %, C – 40.5 %, and D – 39.5 % (Fig. 4).

Therefore, educational efficacy of the set of videos used in the research carried out for third year students amounted to: 12.5 % in category A – memorizing information, 11 % in category B – understanding information, 15 % in category C – the application of information in typical situations and 17.5 % in category D – the application of information in problem situation (Fig. 5).

Educational efficacy of the set of videos in the research carried out for fourth year students amounted to: 12.5% in category A – memorizing, 8 % in category B – understanding, 17 % in category C – the application of knowledge in typical situations, and 17.5% in category D – the application of knowledge in problem situations (Fig. 5) [10].

Subsequently, the results obtained by third year students were compared with those obtained by their fourth year colleagues. It was found that in category

A – memorizing information as well as category D – the application of information in problem situations, educational efficacy of the set of videos was identical for both groups of students. On the other hand, with respect to category B – understanding information the efficacy was 3 % higher in the group of third year students, whereas in category C – the application of information in typical situations the efficacy was 2 % higher in the group of third year students (Fig. 6).

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E-learning in Continuously Learning – I*teach Project

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Summary. New methodology of continuous education offers the opportunity to acquire new skills as well as general social skills in a flexible and synchronic manner. It also allows to learn and develop newly acquired knowledge by combining it with additional information in a manner that is much better adjusted to the possibilities of organizing the learner's own educational process. The I*Teach project is a multi-level one. On one hand, we attempt to examine how ICT skills can influence developing emotional skills; on the other, it offers teachers the opportunity to continue their own education.

Introduction

Continuous learning is nowadays absolutely essential. It answers the needs of the labour market. A conviction that an educated employee will maintain their high qualifications and knowledge regardless of the changing work environment has become obsolete. The ever-changing labour market, the structure of manufacturing and even the characteristics of some professions enforce continuous learning [1].

Modern information and communication technologies change our awareness and thus they change societies. This leads to changes of the economy and alters the needs related to its functioning – the technology, the structure of work force as well as the needs of employees.

Nowadays not only the labour factors but also knowledge constitute the basis of contemporary economy. Hence the broadly used term "knowledge based society" and "knowledge based economy" [2].

The rapidly developing technologies and knowledge call for continuous employee training. Therefore the concept of "just-in-time" training refers to the ability to acquire skills and knowledge exactly when the need of training appears [3].

It is currently believed that continuous training is the means to build knowledge-based economy which was clearly defined in the Lisbon strategy as well as in the strategy of the Ministry of Education on the development of continuous learning which must be completed by 2009 [4]. The European Commission worked out the definition which says that *"continuous learning* *includes any life-long educational activity whose aim is to improve knowledge, skills and competences of individuals, citizens, societies and professionals"* [5].

According to the definition of the European Council resolution of 2002, *"continuous learning should be applied from pre-school education until late-retirement age and it should include formal learning in educational institutions as well as skills and abilities acquired informally,* i.e. *beyond the educational system. It should also include incidental learning which is realized in a natural manner".* It should refer to any life-long and employment-oriented learning activity aiming to develop knowledge, competence and skills of individuals, citizens and societies. An individual should be the main reference point considered as a subject of learning which is to stress the importance of true equality of opportunities and quality of the learning process [6].

It is only possible to unite all the educational processes when continuous learning is implemented.

The European Commission suggests undertaking actions which are to support the concept of continuous learning. They include promoting the idea of life-long learning among employers and employees. The barriers which hinder taking up or continuing courses which may be removed by involving the so called social partners in the development of life-long education on the level of formal education [7].

ICT in teaching

Broad sets of tasks may be done by more users via the specialized programming tools, which allow structuring, analyzing and presenting tasks as well as analyzing, processing and structuring solutions to these tasks. As the systems are connected to the resources, it is possible to carry out effective exercises. The application of technology supports problem teaching. Learners using IT tools may structure their knowledge, draw up and analyze numeric data, create database, collect information. Electronic mail, discussion lists, forums and other online applications facilitate communication and cooperation with the world outside the classroom. Numerous websites offer access to museums, libraries and laboratories in, which remote research may be carried out.

E-learning is a universal term defining the area of online teaching, which includes online learning, web based training and technology delivered instruction. E-learning involves employing (electronic) technology for creating, distributing and delivery of data, information, training and knowledge in order to increase the efficacy of work and organized activities. This notion is currently related to including the Internet technology and teaching/ learning via the Internet or Internet assisted [8].

In addition to this, e-learning is a medium that offers people and organizations an arena in, which they may compete and thus stay at the frontline of the rapidly changing global economy. People and organizations involved are thus offered an opportunity to keep pace with the rapidly changing world by means of the Internet.

One must remember, however, that e-learning is about learning and therefore any interpretation, which focuses on technology instead on the process of learning must be avoided. E-learning needs to focus on people as it has been created for them. The greatest hope of e-learning lies in the vast changes in teaching, which do not relate to the changes of teaching per se, but to the methods of teaching.

The European Commission defines e-learning as employment of new multimedia technology and the Internet in order to increase the quality of teaching resulting from accessibility of resources and services as well as through a remote data exchange and cooperation.

I*Teach Innovative Teacher

The EU Leonardo da Vinci Project Leonardo I*Teach Innovative Teacher are a multilevel international research program. Participant in a project are: Bulgaria, Germany, Holland, Italy, Lithuania, Poland and Romania.

A number of surveys in the domain of the labour market identify as crucial and essential for the knowledge-based economy the ICT-skills and the so-called “soft skills”, such as information and knowledge articulation and presentation, information search, gathering, evaluation, and effective use, project working, team working, problem solving, and skills for life-long learning. These soft skills can be considered to be an essential part of the ICT skills of every citizen and worker, and in this respect we can speak about enhanced ICT-skills. The Innovative Teacher project (I*Teach) develops such practical methodology, approaches and tools targeted at day-to-day utilization by the teacher trainers and teachers of these enhanced ICT skills in their work [9].

The target groups of the I*Teach project are:

- teacher trainers in ICT from universities and teacher training institutions
- teachers and trainers in ICT-related subjects from vocational schools, specialised secondary schools, training organisations and departments.

The end users of the projects are the vocational students/trainees in ICT subjects/courses. Potential users of the project results are teacher trainers and teachers in other subjects willing to apply ICTs in their subject domains, and potential beneficiaries – their students and trainees [9].

The expected main project results are:

- developed Methodological Handbook, tools and instruments for enhanced ICT skills teaching;
- developed teacher training sample curriculum for applying the developed methodology;
- trained teacher trainers and teachers to apply the developed methodologies;
- an online multilingual content repository open to the European educational communities of practitioners, containing a variety of the Handbook-model developed learning materials;
- established virtual training centres in participating countries, working sustainable beyond the project life-time, providing training and consultancy in ICT-teaching and maintenance and upgrade of the online repository [9].

Virtual training centers have been created in many countries which participate in the project. It has been assumed that Moodle will become the platform on which the participants will work. The courses prepared within the project allowed teachers to be presented with selected ICT tools and the basics of e-learning. Moodle constitutes a very flexible platform which makes it possible to prepare training courses. In addition to this, no particular programming skills are required to create such courses. Only basic ICT skills are essential to prepare a course. E-learning as a new form of education is very well visible in schools. In order for e-learning to mark its presence in schools, teachers must undergo a very well prepared training. The new form of education offers enormous opportunities to both students and teachers. It works very well within formal training, self-learning as well as continuous learning. Due to the fact that the school prepares graduates to function in the economic life of their countries, its methods must be so adjusted that graduates could flexibly react to the changing needs of labour market.

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ECTN (The European Chemistry Thematic Network): Promoting Cooperation, Harmony, Synergy, and Innovation Throughout the EC

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Summary. The lecture will briefly describe the aims of ECTN and outline some past achievements and current projects before going on to describe our work on 'Developing Independent Learners in Chemistry' in more detail. As we move from the elitist approach of the past, to the mass higher education system that will be needed to support a future knowledge-based economy, it is becoming increasingly important that students accept more responsibility for their own learning. The lecture will consider why this is currently not happening, and suggest steps that might be taken to encourage students to develop a greater independence in their approach to learning. Some recent work on the use of 'Learning Logs' to encourage students to reflect on their learning, to recognise what progress they are making with their studies, to pinpoint gaps or weaknesses in their knowledge and skills and to identify steps that they themselves need to take to make good such deficiencies will be described.

ECTN [1]

Thematic networks were innovations of the EC's Socrates-Erasmus programme that sought to provide a forum for the analysis and study of the state of development of education and training in Europe in order to encourage and improve its quality on a European dimension. The Chemistry network has been particularly successful and over the past decade has been instrumental in developing and promoting a range of innovations relating to the teaching dimension of university activity. ECTN has been concerned not only with mapping and enhancing higher education and identifying good practice but also in fostering collaboration and cooperation throughout Europe and promoting the development and production of European models. This has been achieved by supporting a range of multinational working groups dealing with areas of specific interest and importance. ECTN has supported some thirty such groups dealing with a range of issues throughout its history; time will permit mention of only a few. The development and validation of a Eurobachelor degree to meet the requirements of the Bologna Agreement for primary cycle degrees throughout Europe represents an outstanding example of both innovation and cooperation in European Higher

Education. On-going work is concerned with extending this process to also cover second and third cycle degrees and a EuroMaster has now also been developed. Another major product over the past few years has been the development of the EChemTest, a multilingual internet-based set of chemistry tests. A third achievement of ECTN has been the development of Residential Summer Schools for newly appointed University Chemistry Teaching Staff to enable good practice to be introduced by experienced teachers and also to provide the opportunity for young lecturers to share experiences with contemporaries throughout the EC. The first Summer School, attended by 24 new lecturers was held in Malta in June 2005; the second is scheduled for June 2007, again in Malta, and will be attended by 30 new lecturers. ECTN is a developing and vibrant organisation that now has 150 member institutions representing 30 countries throughout the EC. New groups dealing with 'Employability', 'Chemistry and Chemical Technology' and 'Innovative Approaches to Teaching Chemistry' have recently been created to address areas of current importance. The remainder of the lecture will deal with the work of the ECTN group on 'Developing Independent Learners in Chemistry', formed in May 2005.

Developing Independent Learners in Chemistry

Widening access in search of the knowledge-based economy, as envisaged by the 'Lisbon Agenda', is resulting in less time being available to be spent on individual students by university lecturers. The challenge facing universities is how to maintain standards while reducing contact hours. This can surely only be achieved if students start to take more responsibility for their own learning.

Such independent learning will involve far more than the student merely controlling the time and place where an externally imposed programme is slavishly followed. It will surely also be necessary for the independent learner to exercise control in deciding what needs to be learned to achieve required goals, how to go about this learning and to continue to reflect on learning progress. To date, little effort has been made by universities to promote such an approach though few in academia or industry would argue that it wasn't a highly desirable outcome.

Teaching at post secondary level originally developed as an effective way to pass on information, knowledge and skills from those with them to others likely to want or need them. The system that developed was very much a mentor-apprentice culture, with the mentor identifying appropriate facts, skills and activities to be mastered before the apprentice could be considered fit to perform independently. The mentor decided what was to be learned, how it was to be learned and how learning was to be assessed. The process was therefore teacher controlled and little opportunity or encouragement existed, or we suspect still exists, for independence on the part of the learner. Assessment typically focussed on what the apprentice knew rather than what he or she could do with this knowledge.

While the old mentor-apprentice model might have been justified in universities in the past it surely depended on both highly motivated students and a high level of interaction between the students and their teachers. Recent moves to widen access to higher education have been accompanied by increasing student to staff ratios and a corresponding reduction in direct contact hours in many cases. This has led many to suggest that students must start to accept more responsibility for their own learning. Unfortunately, having been spoon fed throughout secondary education, contemporary undergraduates arrive at university probably unable and definitely unwilling to do just that. The vast majority of undergraduates currently accept little responsibility for their own learning and expect their teachers to tell them exactly what they should learn. Students often turn to past examination papers, 'the hidden curriculum', to decide what it is important to learn. While such an approach may prove helpful in passing exams, the resulting learning outcomes frequently show little resemblance to either the intended curriculum or the aims of the teacher. While students must clearly start to accept more responsibility for their own learning, merely telling them to do this is likely to achieve little. We must surely help them to become independent learners. Indeed given that retention is currently a major problem in many chemistry courses there is clearly a need to 'scaffold' new students while their confidence builds if drop out rates are not to increase even further. This suggests that we should concentrate our limited resources in helping students to become more independent in the early part of their course. As the course proceeds, confidence and independence should gradually develop and progressively less resources will be needed.

Students may well need to accept more responsibility for their own learning as we seek to widen participation in higher education with limited resources. There are clearly however many other advantages to becoming an independent learner. It is surely desirable and often essential in the world of work for individuals to reflect on their shortcomings and to initiate steps to overcome them if their careers are to develop. The widening of access to Higher Education has seen entry to many courses, including Chemistry, become much more heterogeneous in terms of prior knowledge, achievements and future aspirations. Therefore, in future, individual students may well need to decide how best to allocate their time and effort as they seek to master the different parts of their course. Diversity is also likely to rise with increasing student mobility across Europe, as envisaged in the 'Bologna Agreement'. Finally there is little doubt that independence is motivating and empowering, building confidence and ambition and encouraging further studies. Today, the importance of 'life long learning' and 'continuing professional development' is widely recognised. Such concepts are surely based on the premise that individuals will start to identify gaps in their own learning and take steps to rectify such gaps. The majority of students enrolled on primary degrees today however continue to assume an extremely passive role concerning their learning and expect to be told exactly what they need to do to succeed.

While there are few truly independent learners in primary degree courses there is little doubt that many graduates move on to become independent learners. Such independence is clearly essential to success in many areas of work and to promoting continuing professional development. All of us for example have become independent learners taking responsibility for our own learning, though it is difficult to recall exactly how this came about. The research PhD is surely a model that encourages and develops such independence and it seems likely that it was here that many of us moved from a teacher dependent, through a teacher supported, to an independent approach to our learning.

How then, can we as teachers, help to promote the metamorphosis of our passive, dependent students to the active and independent learners that we seek? Independent learning is likely to be promoted where students are intrinsically motivated to study open-ended problems and are permitted the time to assimilate new knowledge in a meaningful way. Students must be permitted time to reflect on their learning, encouraged to identify weaknesses and then supported while they seek to confront and overcome them. Helping students to identify areas where they lack confidence will surely be a good start so long as they can be encouraged to persevere rather than simply allowed to ignore such problems. Assessment is a problem with all aspects of learning. If independent learning is to be encouraged it must be recognised and rewarded through the assessment process.

Inquiry and problem based learning employing open ended projects as in the research PhD or the final year project in a primary cycle degree are non-traditional approaches that seem likely to promote the move to more independent learning; there is generally little alternative. However this may come at a price, as control of the curriculum may well have to give precedence to the demands of particular projects and problems. Some potentially evolutionary approaches that appear worth investigating within more traditional methods of teaching include peer group work, mentoring, metacognition, reflective diaries, concept maps, experiential learning, use of information sources including newspapers and the use of ICT. Even a techno-sceptic can surely accept that computers should have a key role to play in promoting independent learning. However care will be needed if we are not merely to convert learners from being teacher-dependent to becoming software-dependent.

'Learning Logs'.

Many present-day students are both highly teacher-dependent and challenge-averse, preferring to ignore or avoid any topic that they have difficulty in understanding. At the University of Ulster, to encourage students to identify their learning weaknesses and then to confront them rather than try to avoid them, students are required to keep a weekly diary in which they briefly record an outline of the new material covered, any first thoughts about this material, how it relates to other elements of their course, any difficulties they perceive and what steps they plan to take to address these difficulties. Although the use of 'reflective diaries' is well known, in the past, mature practitioners, particularly in the caring professions, have mainly used it. Here we are seeking to promote metacognition by encouraging often immature students to start to reflect on their learning, to recognise what progress they are making with their studies to identify gaps or weaknesses in their knowledge and skills that need to be overcome, and to identify steps to make good such deficiencies. The results of a questionnaire seeking students' opinions on the advantages and disadvantages of 'learning logs' will also be discussed.

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[1] Details of ECTN and its working groups can be found on the web site, www.ectn.net

Chemistry Education – Computers – ICT

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Summary. The article presents examples of the following multimedia tools: digitalized chemical experiments possibly supplemented with flexible texts, teaching created in PowerPoint, flexible programs, preparation of various school educational programs, distance education, ICT preparation of teachers.

Introduction

Use of computers in the process of acquiring the chemistry subject matter has become a pedagogical phenomenon in the field of education since the second half of 20th century. Importance of this approach was emphasized by an application of information and communication technologies principles that facilitated the use of computer networks (*e.g.* to realize distance education), the Internet, *etc.* On that account such an approach has become one of the principles of the subject matter acquisition methodology as it makes it possible to create teaching methods that can be highly interactive and flexible, methods that enable the process of the subject matter acquisition to be individualized and differenced in abilities, structure of knowledge and aspiration goals of individual students as well as teaching styles, computerization of schools, *etc.*, to be respected. This approach has been applied at the Faculty of Science of Charles University in Prague for more than ten years (*see* examples below).

1. Digitalization of Chemical Experiments

An important point in acquiring the subject matter in chemistry is the use of a chemical experiment that, apart from other things, reduces the complexity of problems solved. In order to remove problems connected with practical performance of experiments (*e.g.* great demands on time and funds, safety at work) we have decided to digitalize them [1]. A digitalized record allows to repeat the experiment anytime, to “pause” it and then “let it go”, enlarge it, *etc.* As in most cases students are not able to evaluate empirical data derived from chemical

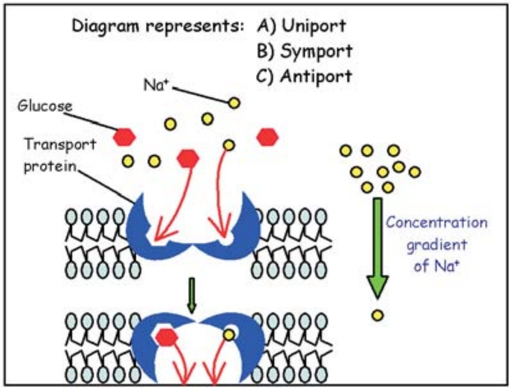

Figure 1. Example of animation: Comprehension Question – Transport by the cell membrane: It is a closed test item. The student after seeing the animation should be able to choose the right answer of three alternatives. On this slide there were created several dynamic animations. The course of the animation is shown in the figure 1. The glucose and the sodium ions are moving in the binding sites of the transport protein. The sodium ions and molecule of glucose are transferred across the cell membrane which causes modification of conformation of this transport protein.

experiments, we have supplemented the screened experiments with an adequate ”flexible text” that makes it possible to create several variants of different complexity leading to expressing the observed action by a chemical equation.

2. Teaching Created in PowerPoint.

PowerPoint is an intelligible and easy to handle tool facilitating creation of dynamic presentations of the subject matter whose dynamism can make the teaching process more effective [2]. In the figure 1 there is demonstrated an example of one question from the presentation “The Cell – Test”. In the process of creation PowerPoint presentations we drew from variety of biochemical and bilogical books [3, 4].

3. Flexible Programs

The term “flexible program” means a digitalized subject matter created for a given thematic whole [3–6]. A flexible program embraces and integrates a number of didactic tools, *e.g.* traditional textbook, chemical experiments on CDs, check tasks of various complexity, chemical hypertext dictionary, tools for the management of the process of the subject matter acquisition, motivation elements, possibility to search for further information via electronic browsers, *etc.* Figure 2 shows a result of an unsuccessful solution of a partial problem – the notation of a chemical equation of the iron – sulphur reaction. Mistakes in the solution are highlighted in red and in order to remove them students can click for help with the correction of a given mistake. The situation is accompanied by an animated clipart in gif format to help increase motivation.

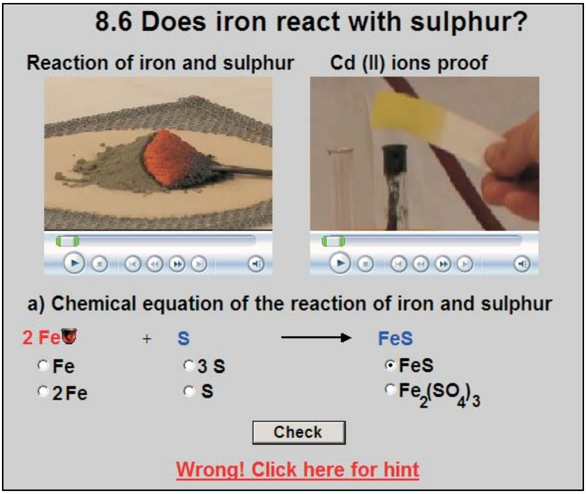

Figure 2. Incorrect result of a more complex solution of a given problem.
In a more complex solution pupils are asked to fill in the equations of a given reactions.

4. Preparation of School Educational Programs (SEPs)

Educational environment, *i.e.* external and internal conditions, under which the process of acquisition of the subject matter is realized, changes quickly. The fact is a base for skeleton educational programs (SkEP) expecting that the content of the curriculum will be continuously changed and, thus, various "teaching texts" (SEPs) for acquisition of one and the same subject matter created. Various SEPs can be prepared via modification of flexible programs by changing web sites in editing programs or directly in the source code (HTML). The simplest way of modification is an omission of certain parts of the program; less complicated changes are connected with *e.g.* modifications of learning tasks formulations. More complex changes are carried out when new structural elements are being incorporated into the program, such as new chemical models of substances or video records of other experiments [5–7] and, to draw a parallel, also an original part of the flexible program – its video-experiments part.

5. Distance Education – Preparation of the Gifted at Chemistry

The above stated multimedia tools are used for lifelong education of learners (students and teachers). The following is an example of the use of the "Chemical reactions and the everyday chemistry" course in the LMS LearningSpace within the scope of a project called "Talent" intended for education of students gifted at chemistry [8]. The chemistry course is divided into four parts. The first part consists of six lessons, in the second part students write seminar papers. The third part is devoted to on-line viva-voce of seminar papers, the fourth part is to be attended in person. The course includes video-experiments in order to decrease the complexity of solved problems. In order to increase motivation, the learning tasks incorporate demonstrations of certain important chemical regularities that are the basis on which the everyday chemistry phenomena are explained. Similar learning tasks are also the basis for seminar papers and students are allowed to use documents developed in HTML, PowerPoint, video-experiment, 3D graphic applications, *etc.,* for both their viva voce and presentations.

6. Preparation of Teachers to Use of ICT

For the use of ICT to be efficient it is necessary to enlarge the methodological set up of teachers, both in pre-gradual and lifelong education. Themes like *e.g.* distance education, E-learning, use of freeware programs, digitalization of empirical actions, creation and modification of flexible programs, *etc.* [8] are part and parcel of lectures and seminars. While determining the focus of the contents of lectures and seminars, we started with a preliminary test to evaluate teachers' ability to use ICT in their pedagogical practice. Its results established that about 42 % of teachers were not able to modify a flexible program and so create various SEPs; similarly, 70 % of teachers were not able to organize distance learning via E-learning, 55 % of teachers do not use freeware programs in practice, *etc.* So it became obvious that increasing a number of lessons devoted to ICT is a necessity.

7. Results and Conclusions

The results of employment of an approach such as this to the acquisition of the subject matter have unambiguously proved high effectiveness of the use of computers and ICT in the process of acquisition of the subject matter. Demands on time needed for acquisition of projected knowledge and skills decreased by 40–65 %; effectiveness of retention of knowledge increased by 30–60 %; learners' ability to explain principles of observed chemical actions increased by about 45–60 %; and pupils' interest in chemistry and the subject of its study *etc.* substantially increased, too. The above stated proportions of fruitfulness differ according to the nature of multimedia tools used. For the future we particularly consider the extension of distance education in chemistry both for the purposes of preparation of teachers and pupils.

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Interactive Whiteboard in Teaching Chemistry

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Summary. Within the confines of master's thesis has realized cycle of lessons of chemistry with interactive whiteboard. Due to software this board lessons were interesting and dynamic. Pupils could see animations and films, solve tasks using electronic pen, palette of color and play to interactive games.

Introduction

Interactive whiteboard (Fig. 1) enables connection traditional lessons with multimedia presentation. This instrument looks like big board and interacts with computer and multimedia projector. An electronic pen is used to write on the board, it has functions computer mouse [1]. Electronic unit receives coordinates pen to board and send them through a cable or infrared connection to the computer which has special software [2]. Depending on place of site a cursor, mode of work and action evoked felt-tip pen take place an event and changes are visible on the whiteboard.

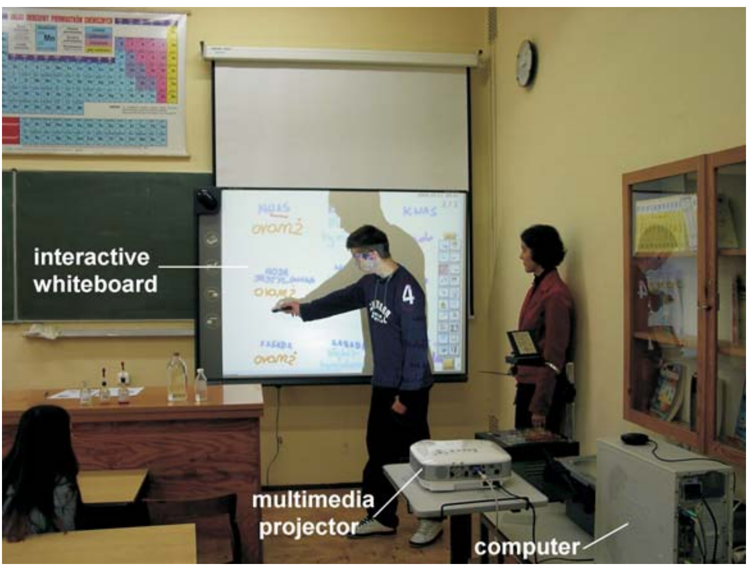


Figure 1. Interactive whiteboard

Before beginning of work with interactive board it is necessary to execute calibration to prevent divergences between a cursor which is display on a board and coordinates pen. Software this board makes it possible to choose mode of work [3]:

- Interactive display – to operate the PC and open files such as Microsoft Office documents (Word, Excel, PowerPoint) and image or movie files.
- Teleconference – to connect computers to the network and share the same screen on board
- External Video device – to display movie clips on StarBoard when DV is connected to your computer
- Interactive whiteboard – to use whiteboard functions. You can choose from a wide range of templates in the library and colourful pen types.

It is possible to import different types of files:

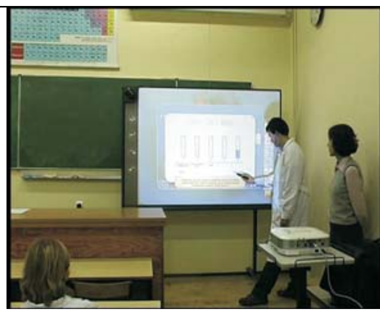
- icons and photos (.bmp, .png, .jpg, .jpeg)
- film files (all display by Windows Media Player)
- Microsoft Office documents (Word (.doc, .rtf, .txt), Excel (.xls), PowerPoint (.ppt))
- Portable Document (.pdf).

Within the confines of master's thesis in Department of Chemical Education Faculty of Chemistry Adam Mickiewicz University in Poznañ has realized cycle of lessons of chemistry with interactive StarBoard. On lessons participated pupils from schools in Wielkopolska. Purpose of master's thesis was elaboration of script of lessons with use of interactive board. Before studies teacher has prepared PowerPoint file with definitions, illustrations, reactions and tasks. It present below example of script in which pay attention on use of tools of board for realization of didactic purpose.

During lesson it use with CD-ROM "Ciekawa chemia" ("Interesting chemistry").

Pupils have evaluated lesson as interesting, because all of them could take active participation in different actions. Models of alcohol display on board have helped pupils to write down structures these compounds. After executed experiment, their observation and conclusions could write down on interactive board. They used board's tools: pen, palette of colour and eraser. Movies have been allowed to familiarize with experiments, which were not possible to execute into laboratory in given moment. Pupils approach to the interactive board with

Table 1. Script of lesson, subject: “What compound is created during fermentation of fruit juice?”

▪ Display subject on interactive whiteboard ▪ Discussion of alcoholic fermentation ▪ Discussion of structure of alcohol (animations from CD-ROM) Pupils write on board names and structures these compounds	
▪ Discussion of physical and chemical properties of methyl alcohol ▪ Experiment: research into properties of ethyl alcohol (pupils check up state, odour, reaction and flammability) ▪ Writing on interactive board observation and conclusions from experiment	
▪ Display movie which presents experiment about characteristic reaction of alcohol (detection alcohol with the aid of potassium dichromate; movie from CD-ROM) ▪ Discussion of influence ethyl alcohol on human body ▪ Display animations presents structure ethylene glycol and glycerol (animations from CD-ROM)	
▪ Solving of tasks from CD-ROM ▪ Interactive game – Memory (pupils plays on board using electronic pen, they must adjust name to structure of alcohol.	

pleasure and solved tasks from CD-ROM. Teacher has displayed all former charts with pupil's notes in order to repeat knowledge to the end of lesson.

All charts with pupil's notes and tasks have been recorded on disk of computer. It is possible to return for such script in optional time in order to modify its elements.

Cycle of lessons carried within the confines of master's thesis was recorded by digital camera then ready movies have been subjected digital processing with comment of lector. Prepared material is available on compact disk for teachers who are interested teaching with interactive board.

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Adapted Remote Learning: Live Video-Streaming *Versus* Podcasting, A Practical Approach

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Summary. Live streaming of lectures can overcome the requirement to meet at a specific date in a defined place without loosing interactivity. The rather new technique Podcasting allows students to review knowledge after the lecture more efficiently.

Introduction

Despite modern methodology for classroom teaching, location and time are still limiting factors in academic teaching.

A student has to visit a lecture at a defined time in a certain hall to acquire the presented knowledge. Knowledge transfer is therefore a singular event. Even in the context of international post-graduate training programs, people have still to arrange exact dates and places to interchange news and knowledge.

In the following, we would like to present two methods to meet the needs of the above drawn scenarios, which can be realized with a minimum of technical equipment.

Overcoming distances: Live Video Streaming

Research groups from the universities at Saarbrücken/Germany, Metz, Nancy, Strasbourg/France and Esch-sur-Alzette/Luxembourg form the International Research Training Group (IRT) 532 [1]. The members are group leaders (professors), permanent staff, doctorants and post-docs. An ambitious educational program designed especially for the doctorants and post-docs accompanies the interdisciplinary scientific program and consists of three main components:

- workshops, in which the members of one participating research group introduce their daily laboratory work to the colleagues within the IRT
- seminars, in which the doctorants present their latest results to the members of the group, and
- lectures, in which the group leaders introduce their research topic to the IRT.

The workshops require the presence of all participants because of its experimental approach. The seminars aim at supervising the ongoing of the individual research and training of presentation skills. Therefore, physical presence is of great importance in these events. However, the lectures are class teaching with following feedback. The lectures are typically scheduled every 2−3 months for 1−2 hours each and would not justify the travel of 10−20 participants between the member laboratories.

Figure 1. Screenshot from the streaming of one of the latest lectures of IRT 532 at Saarbrücken.

Therefore we set up a live Internet streaming scenario in collaboration with the computing centre and video studio at the Saarland university. The lectures are given in front of the Saarbrücken students in a video production studio. The studio is equipped with white board, video beamer, wireless microphones, video camera, a professional audio/video control room and features excellent acoustic and illumination properties. The analog video and audio signals are synchronized, encoded as windows media stream on a Pentium IV computer running Windows Media Encoder and sent on demand *via* the video server of the computing centre to individual computers at the partner laboratories. The on-line watching students need a windows media player compatible client on any operating system to watch the stream; the computer presentation file has been provided on a server prior to the lecture for print out, so that the students can follow the lecture and take notes simultaneously. To enable feedback of the students, questions and annotations from the outside participants are posed by text chat and alternatively by e-mail and read to the lecturer by the moderator. To enable this degree of interactivity, the audience in the studio and at the screens in the partner laboratories have to watch the same content at the same time: they are interconnected at the same time in different places.

Overcoming time and location: Podcasting

Podcasting is a relatively new technique of making audio and video material available over the Internet. The term is composed of terms derived from the portable multimedia device "*iPod"* from Apple® and "*broadcast*" for radio/tv shows and thus could be named "*portable shows on demand*". The end user is subscribing to a podcast feed with a podcatcher (such as *e.g.* iTunes) and gets the latest episode automatically. However, he can listen/watch the episode on his preferred tool (desktop or portable computer, mp3 player, iPod) when and where it fits best to his needs.

One of the main problems with class teaching is the reviewing of the knowledge from ones own notes taken quickly during the lecture. With a podcast, the student can follow his own notes while listening (or watching) the lecturer again giving exactly the same explanation as he did in the lecture hall. Additionally, the podcast is enriched with presentations (pdf-files) and interactive animations of molecular structures in QuickTime format (produced with CrystalMaker). Since the black board writing is not given in the audio podcast, it should not substitute the physical presence of the student in the hall, but helps adopting the knowledge.

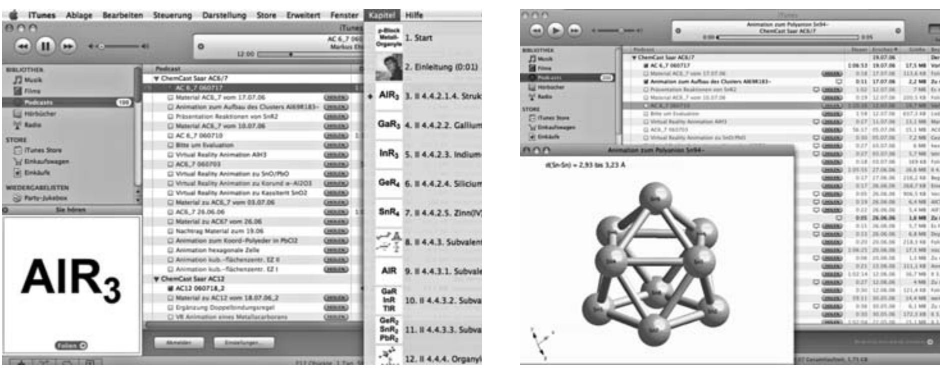

Figure 2. Screenshots from iTunes showing the podcast *ChemCast Saar AC6/7* and one episode in chapter view (left) and a separate window for interactive animations.

The technical requirements are relatively low using the iLife multimedia suite shipping with every new MacIntosh computer. The lectures are recorded with a iPod equipped with a mono microphone. After the lecture, the audio take is transferred to the computer *via* iTunes into GarageBand, optimizing sound, deleting idle time (*e.g.* black board writing/cleaning), sub-dividing the file into logical chapters, which can be accessed directly by the end user and enriched with pictorial images of the current slide or presentation. The episode is handed over to iWeb, where the feed is composed, translated into html and transferred to the server. The new episode can then be accessed either via a podcatcher, a RSS feed reader or directly on the homepage of the podcast on various platforms [2].

Conclusion

From our experience, streaming is recommended for occasionally occurring lectures where special knowledge is delivered. Enhanced podcasts are very helpful in supporting the reviewing of notes from regular lectures in basic or advanced graduate courses.

Both means have become available broadly with lower cost and less need for expertise due to cheaper hardware, more user friendly programs and availability of broad band connections especially to private end users thus considerably lowering technical obstacles. This easier performance of transmitting multimedia content over the internet in both methods helps making teaching more efficient because of time saving (less travels) and more intensive reviewing of lectures.

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Student's Multimedia Presentation as a Part of Chemistry Teacher's Training: A Practical Approach

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Summary. Article describes a useful approach to educational video films recorded by students in the chemical laboratory for the purpose of including them in multimedia presentations. Practical aspects of recording and processing video sequences are discussed.

Introduction

Student's multimedia presentations are one of the forms of introducing ITC to the education of chemistry students at the college level. As long as preparing such presentations involves using such elements as text, still graphics (photographs, drawings, schemes) or hyperlinks, it poses no particular problem for the average student. However, enriching the presentation with self-recorded video sequences showing the course of a chemical experiment is much more challenging task.

At our Department, since a couple of years, chemistry students attending a pedagogical course have been recording video films in the chemical laboratory in order to include them in their multimedia presentations of educational character [1, 2]. In this contribution we would like to share with our observations and conclusions gained from this activity.

Desirable features of educational chemistry film

Video sequences recorded in chemical laboratory constitute a very valuable element of multimedia presentations, since they make possible to demonstrate directly chemical processes and phenomena occurring on a macroscopic scale [3]. They are particularly useful in presentation of:

- the course of chemical changes, drawing attention to the most important points of interest (colour change, evolving of gas, temperature rise, *etc.*)
- correct performing of laboratory operations (heating, transferring liquids, filtering, collecting gases, *etc.*)
- assembling and functioning of laboratory glassware (*e.g.,* distillation apparatus)

- using the laboratory instruments (pH-meter, calorimeter, electrolyser, *etc.*)
- the properties of chemical substances, both static (such as colour, transparency, appearance) and dynamic (such as viscosity, elasticity, brittleness, malleability).

If the video film is to be a reliable source of scientific information, it must meet several important requirements, some of which are listed below:

1. Features of the recorded pictures must be as close to reality as possible. This is particularly important in reproducing the colours of substances, which often carry valuable information for the chemist-experimentalist.
2. The film must accentuate the events that carry the most important message for the viewer. This should be done by the appropriate operation of the camera: zooming in, changing focus, panning, *etc.* On the other hand, all the events being the subject of recording must be practiced and prepared in such a way as to maximise the desired effect.
3. A sequence of scenes must be planned carefully and realised according to the screenplay prepared beforehand, as to assure a clear and meaningful message.
4. During the film, at any point, the viewer should be able to identify all the substances shown on the screen. This is particularly important when the reagents are colourless solutions or white substances.
5. The film should be relatively short, so the corresponding computer file does not take too much space on a disk and does not overload the RAM memory.

Amateur video equipment and recording skills are not enough to fulfil these requirements. Below, we discuss the practical approach, developed in our laboratory, which helps to obtain video films suitable for including in student's multimedia presentations.

Video equipment and setup

Modern video cameras equipped with three independent charge-coupled devices (3CCD) and recording on digital magnetic tape (miniDV) or optic disk (DVD) have technical parameters appropriate for the recording video sequences of quality satisfactory for educational presentations. In our laboratory, we are currently using a Panasonic NV GS400-EG model, which provides a clear, well-resolved picture.

In a typical recording setup, the camera is placed on a tripod at the height of human eyes (about 1.6 m) and at about 2 m distance from the filmed objects. It is important to use a professional, sturdy tripod with a half-ball head to ensure stability and smooth motion of the camera. The recorded scenes are performed on a special laboratory table with the top finished with light-grey matt tiles, to provide suitable background.

Great care is taken to ensure appropriate lighting of the scene, since the appearance of the reagents, particularly coloured solutions, is very sensitive to the way they are lit. Up to now we have been using two 250 W halogen bulbs placed on 2 m stands, with the light dispersed with aluminised “umbrella” reflectors. However, we have found this lighting setup inadequate in some cases and we intend to change it to professional 1000 W studio lamps. An additional, small table lamp, equipped with a 100 W halogen bulb, is very helpful in recording scenes with coloured solution. Placed at the side of the flask with solution, it brightens the inside of the content and brings out the appropriate colour.

Usually, camera is operated with remote control by a student performing the experiment being recorded. Only for the scenes involving zooming in/out and panning, a help of the second student is required. Recording parameters, such as balance of white, shutter speed, zoom, focus, *etc.,* are controlled manually to ensure the optimum visual effect.

Making a video film

The first step in preparing a video film is to write a screenplay, describing in detail what actually happens on the screen. The example of such screenplay for a student’s film is presented in Table 1. The actual scenes, though, are rarely recorded in the same sequence as in the screenplay. Instead, a working schedule of scenes is prepared, that specifies how every particular scene will be set up and recorded. Scenes are taken according to this schedule. Usually, they are repeated several times and in several versions until the effect is satisfactory. The idea at this stage is to collect ample video material for the subsequent editing. It is important that all operations and events are practised beforehand to ensure the optimum effect during the actual recording.

Table 1. Exemplary screenplay for the film "Reaction of copper(II) ions with 1,2-diaminoethane".

Scene 1. *Normal plan.*	A flask containing a blue solution of copper(II) ions. Label: $[Cu(H_2O)_6]^{2+}(aq)$
Scene 2. *Normal plan.*	A flask with colourless 1,2-diaminoethane. Label: $H_2NCH_2CH_2NH_2(l)$
Scene 3. *Normal plan.*	Withrawing a portion of blue copper(II) solution from the flask.
Scene 4. *Zoom-in.*	An empty test tube placed in the rack. Adding blue solution of copper(II) ions from the pipette.
Scene 5. *Normal plan.*	Withdrawing a portion of 1,2-diaminoethane with a Pasteur pipette.
Scene 6. *Zoom in.*	Adding 1,2-diaminoethane to the test tube with blue solution of copper(II) ions. Colour changes to intense violet. A label appears: $[Cu(H_2O)_6]^{2+}(aq) + 2H_2NCH_2CH_2NH_2(l) \leftrightarrows$ $\leftrightarrows [Cu(H_2O)_2(H_2NCH_2CH_2NH_2)_2]^{2+}(aq) + 4\ H_2O(l)$ Test tube is taken out from the rack, shaken in front of it and put back again.
Commentary *Text visible during playing the film.*	Adding 1,2-diaminoethane to the blue solution of $[Cu(H_2O)_6]^{2+}$ ions results in substitution of four water molecules with two molecules of 1,2-diaminoethane. The resulting complex ion is of intense blue-violet colour.

Video scenes, recorded on a magnetic tape, are then transformed to the computer format. We have been using Pinnacle Studio Plus 10 software for this purpose, obtaining the video material in form of AVI files. Due to very large size of these files, it was necessary to compress them to MPEG1 format, though with the considerable loss of picture quality. At the moment we are experimenting with other compression formats to minimise the quality loss.

The next step involves selection of scenes, cutting them out and putting them together in the right order. At this stage, computer labels are added, identifying (where necessary) substances shown on the screen, giving the chemical equations for the presented reactions, *etc.* In the editing phase, it is advisable to use a computer of high computational speed and equipped with high-capacity hard disks, to ensure fast and effective processing of video files.

A commentary, explaining what is happening on the screen, is the final important element of the film. As yet, we have added the commentary as a short text visible during the projection of the film (Table 1). Since this is not satisfactory, we plan to arrange a simple audio studio to record narrations that would parallel video sequences.

Conclusions

Recording video films for chemistry educational presentations is quite a complex and challenging task for a student. It requires not only planning and running chemical experiments in such a way as to maximise the desired visual effect, but also skilful operation of video camera, as well as careful control of own movements in the recorded scenes. Preparing such a film, makes a student to focus on achieving the clear, scientifically correct and attractive message. This is of great value itself in the training process of prospective chemistry teachers.

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Interactive Internet Tools for Practicing the Correct Representation of Chemical Compounds by Means of Structural Formulae

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Introduction

An interactive Internet tool to assist learning the correct representation of chemical compounds by means of structural formulae was prepared by the Department of Chemical Education at Adam Mickiewicz University in Poznań. The tool helps to understand the principles of representation of chemical compounds' topology and to effectively employ cheminformatical tools. They are based on major didactic principles aiming at improving the efficacy of implementing educational tasks by activating and individualising the learner's work.

The representation by means of structural formulae constitutes one of a chemist's key tools. It improves the accordance of the topological message with the author's knowledge and facilitates scientific communication [1]. There are numerous computer formulae editors commonly used by chemists [2]. The application of the tools, however, may be hindered by several typical systematic mistakes committed by the users [3]. The identification of these mistakes as well as the correct choice of methods to eliminate them may prove to be useful for chemical education.

An interactive approach using Internet tools in the client-server system was used which not only increases the individualisation of the educational process and the tool's flexibility, but it also naturally increases its scope. The educational server *Chemistr* is available free of charge at *http://zdch.amu.edu.pl/chemistr*.

Structural formulae

In the 19th century chemists worked out the manners of describing chemical compounds. Since that time a chemical diagram has remained the most commonly used manner of describing compounds [4]. The diagram of chemical structure constitutes a simplified and abridged representation of a compound. It merely explains the topology of atoms within the compound (showing which atoms are bound by means of particular bond), while their topography (spatial placement) is most frequently treated very conventionally [5].

According to a mathematical approach, the structural diagram drawn by a chemist may be viewed as a mathematical graph. Graphs consist of nodes, which represent atoms on one hand and edges representing bonds on the other. In organic chemistry such graphs are frequently simplified by representing carbon as points where the lines intersect. The analogy between a structural diagram and a topologic graph constitutes the basis of the algorithm of processing of information about chemical structure.

Such a topologic graph is indeed very easy to understand even for those who are relatively poorly prepared as it is based upon the intellectual ability to interpret images.

The structural formulae editors

There are numerous computer editors available and all of them are commonly used by chemists. The editors of structural formulae are actually graphics editors. They are used to prepare and modify structural formulae of graphic elements, including the most important ones – the schemes of rings.

Their most prominent feature is that they are object-oriented. This issue needs to be brought to the learners' attention as it bears many serious consequences. The drawings of structural formulae consist of numerous objects whose most basic elements are: point, line, a block of letters and others. This allows a chemist to prepare structural formulae in a more efficient manner. Owing to this fact, it is possible to freely rotate the structures, to move them as well as to enlarge and reduce them to any size while keeping their proportions unchanged [6].

Ordinary structural formulae editors are equipped with specialized techniques making it possible to create such structural formulae as: techniques of analysis of bond multiplicity and valence of atoms. The numbers are frequently automatically written in text fields to the position of subscripts, which facilitates the introduction of molecular formulae or fragments of structures.

The more advanced structural formulae editors recognize the names of chemical compounds and thus even very complex spatial structures can be constructed automatically once their systematic name is introduced. Therefore while creating structural formulae one should follow certain principles so that the mechanisms could work effectively.

Typical problems encountered whilst editing structural formulae

The application of the above-mentioned tools, however, may cause several typical systematic mistakes committed by the users. Here are four general practical pieces of advice regarding the most characteristic mistakes, which may be committed by the users of structural editors:

- While drawing a formula, it is recommended to expand it by adding subsequent elements (bonds, rings) to the existing element. One must not move the element of the formula and just hope that they will be merged. The users frequently draw structures, which resemble the correct ones yet they are separated.
- Do not forget about connecting the elements. First, the framework of the bonds must be prepared so that all the lines representing bonds are connected, and only then the symbols of elements must be added at the points of bond connections – inserting the symbols before the formulae are created causes incorrect placement of bond next to the symbols.
- Each separate line represents one bond. A single line in the formula represents one bond only – even if two lines seem to create one bond visually, they must be treated as a representation of two bonds. One always needs to distinguish two lines and one double-line.
- The symbol must be inserted and not dragged. The letters from the fields outside the formula must not be dragged either. One must not place the subscript digits by moving the independently created text fields.

The role of interaction and active commentaries

An interactive Internet tool to support learning the correct representation of chemical compounds by means of structural formulae was prepared at the Department of Chemical Education at Adam Mickiewicz University in Poznań. The tools improve understanding of the principles of representation of a chemical compound topology and prepare students to use chemical information tools more effectively.

Similar tools have already been created to assist:

- Filling in stoichiometric equations with the application of molecular formulae [7],
- The construction of simple models of covalent molecules as well as getting familiar with the conventions of modeling [8],
- Doing tasks based on the schemes of action [9],
- Team work done whilst making mind maps and brainstorming [10].

Interactively provided commentaries on the user's actions fulfils an important role aiming at individualizing educational activities and decreasing the tensions experienced by the student while doing the task.

Internet tools for practicing the correct representation of chemical compounds by means of structural formulae

Chemistr is based on co-operation of database served by *mySQL*, *PHP*, *HTML* and *Java* with the module *ChemDraw ActiveX/Plugin* [11] or *JME Molecular Editor* [12]. The editor module placed on the website transfers the results of the user's work via public and hidden forms as a *SMILES* code to the database which subsequently returns the appropriately prepared comments based on the analysis of the specific *SMILES* code as well as on the general empirical analysis of the formula back to the recipient.

The tool based on major didactic principles aims at improving the efficacy of education by activating and individualizing the students' work [13].

An interactive approach using Internet tools in the client-server system does not only increase the individualization of the educational process but also the flexibility of the tool itself. At the same time, the scope of the tool is increased.

The educational service *Chemistr* is available free of charge at *http://zdch.amu.edu.pl/chemistr.*

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CAPA – New Development for Computer Aided Examination at University of West Hungary

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Summary. Our new computer program (CAPA) was used for General Chemistry midterm examination of first-year-students at University of West Hungary. The program-package consists of an *editor*, a *server* and a *client program*. The *editor program* of our **C**omputer **A**ided **P**ractice and **A**ssessment make possible filling up databases and building up test sheets. Students can access the activated test sheets via Internet connection by the help of *client program*. Dozens of candidates were passed simultaneously; their individual set questions were randomized by the *server program*. The English version of the program will be demonstrated the simple and practical way of computer aided examination.

Introduction

The computer aided assessments (CAAs) play increasingly important role in the teaching and learning process, because more and more information can be accessed Internet. Lots of traditional tests and quizzes are found on the chemistry course websites, which are only a digital version of some printed question series (*e.g.* [1, 2]). These web-based quizzes are not suitable either for the students' self-assessment or for examination, because of using only multiple choice questions on a fixed web page as a simple worksheet. They are well designed but not practice; or even the web-sites have been unchanged for some years [2].

On the other hand some new textbooks [3] contain an attached CD-ROM, which make the lessons complete with videos, animations and quizzes for self-assessment. The offered answers for the questions are randomized by computer on this interactive CD-ROM.

Furthermore most of CAAs, which are attached to the textbooks or can be found on websites, are definitely useful in those countries where the chemistry teaching are realized in English language. But they have much less importance anywhere else.

Our new Hungarian project was focused on developing a **C**omputer **A**ided **P**ractice and **A**ssessment *program-package* (CAPA), which can use up the computer-power to the highest degree, can run without language restrictions and the quizzes are not electronic reproductions of some printed test-sheets on the monitor.

Results in developing

The CAPA program-package can be used not only in chemistry quizzes, but very different assessments of sciences and arts, too. This program-package consists of three different functional parts (editor, server and client program), which are essential for the running [5].

The *server program* provides

- connection between the personal computers and server either during test-creation or assessments;
- selection and activation of test-sheets, which were prepared by the test creator program;
- recording of log files, which contain all important information about connection events, *e.g.* the students' assessment;
- randomized question series within the test-sheets, thereby all of the visualized quizzes of the same test-sheet will be different from each other.

These services of the server program can utilize the capability of both programming and the personal computers fully, as well as render possible automatic summarize of the results. The details of the assessment, *e.g.* the exact questions/answers of all candidates and the correct number of their hits, are fixed in the log file; that is why the server program makes possible an immediate marking.

If there are more answers fixed to a question in the database than those are visualized large number of generated variants of test sheets can be represented on the monitor. First of all different answers are offered to the same question or their order will be changed at least. Thereby it is not required large bank of questions for preventing of students' deception or irregularity.

The *editor program* is a powerful and easy to use system for both creating of question bank and test sheets. Lots of question types can be loaded up:

- multiple choice question;
- multiple response question;
- true/false decision;

- matching pairs;
- gap-fill exercise;
- value sizing-up;
- assertion-reason sentences and
- computer generated problem-solving.

The question bank can be increased continuously in the database. Not only text, but different formulas and images also can be loaded up. Anybody is able to learn the data-processing easily; it does not demand special computational knowledge. The editor program has a *question clone option* for duplicating a question with all fixed answers. This method can help in production very similar records in the database. It is useful for true and false answers, or for multiple response questions if you want change only some words.

The *client program* is used as a well arranged checking board by the students on their personal computer, which has a connection to the server. The users can choose different topics for their practice after login. The correctness of the checked answer is indicated on the monitor at once within the self-training-time. The same quizzes are also suitable for students' mid-term or summative tests, when only computerized marking is presented at the end of the examination, right answers are not displayed.

New approach for using computer power

Same databases can be used for either *multiple responsible* or *multiple choice questions*, depending on the number of indicated right answers to one question. It was calculated that hundreds and thousands of answer-variation can be presented to a question if 15 right and 15 wrong answers are fixed to that one, because of the random selection of the server.

Matching pairs is not a common type of printed assessments. But it is very useful for computer quizzes, since the teachers can load up easily the database, as well as the students can find most of the right pairs. This question type was found to be very useful for memorizing the name and formula of compounds, or checking the correct description of different definitions. Furthermore it is suitable in chemistry for finding of shape of molecules or crystal structure of substances, and even matching laboratory vessels to their images.

Value sizing-up is an easy to use and typical computerized question type; series of comparable properties have to fix in the database, with numbering of their place.

Preparation of *gap-fill exercise* demands great attention from the teacher, because all of the variations of the correct words, the synonyms have to be loaded up as well as unambiguous filling sentences have to be written. This type of box filling questions can be used for balancing chemical equations, too.

Results in using CAPA

Our Computer Aided Practice and Assessment program-package was utilized for self-training and mid-term assessment in 2006 fall semester. Three chapters of General and Inorganic Chemistry course – Atomic structure, Chemical Bonding and State of Materials – were prepared in three databases with 83, 64 and 36 records, respectively.

The test sheets of self-training were available for the students from anywhere if their computer has an internet connection to the server, while the mid-term assessment was organized for a large group of students in the presence of an invigilator. The candidates were allowed to take an exam from the very same test sheet at the same time, because their individual question sets were presented in different ways by the computer; so there was not any trouble if classmates were sitting close at hand.

After the self-training period of a month the freshmen students had to solve the fifty questions of the midterm examination within 30 minutes. The log files of the assessments, the exact questions and answers of all candidates as well as the correct number of their hits, were recorded by the server. It was found that the 193 students' quizzes were occurred on the monitor in very different variation. Both the order of the questions and the answers were various.

The result of the final examination was well prognosticable by the efficiency of the mid-term assessment (Table 1). Unfortunately 43 students did not get through the laboratory course and they did not get permission for the final examination. Other 64 candidates had to repeat the final examination because of their wrong results.

Table 1. The results of mid-term and final examination

result in %	0	< 20	20–30	30–40	40–50	50–60	60–70	70–80	> 80
mid-term	–	16	40	80	33	16	7	0	1
final exam	43	4	22	38	30	29	18	4	5

The enlarged version of the CAPA will be suitable not only for mid-term assessment, but for final examination, too. In spite of that this program-package was developed for Hungarian education it will be helpful for other European universities, because of the translation function of the program.

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Presentation as a Component of University Chemistry Education

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Summary. This contribution deals with the effects of IT presentations on the respective components of educational process within the tertiary level of chemistry education. On the basis of the research related to these issues, an attempt has been made to summarise possibilities and problems of teaching with the use of these presentations on the part of both teachers and students. Our aim is to find an optimal way of how to design presentations and how to use them in chemistry education.

Introduction

Recently there has been a considerable progress in ICT, which is followed by an increasing level of implementation of these technologies into schools and the educational process. However, the development and use of ICT in these areas is often realized in the atmosphere of enthusiasm and teachers are hardly ever interested in the effects of these new aids, educational tools and methods on the process of learning on the part of students, on the position of the teacher in the teaching process or on the real performance of the student. Our department is involved in creation of presentations in the program MS PowerPoint that are related to various areas of chemistry curricula. Our aim is to find an optimal way of how to design presentations and how to use them in chemistry education.

Presentation as part of university lectures

ICT presentations are quite common as part of university teaching. The method, which has had a long tradition at the university, is a lecture. Lecturing allows us to convey a large amount of information to a large audience at the same time. Disadvantages of lecture are mainly linked with its low degree of activity, practically zero feedback and, of course, with a decreasing attention of students. It can be assumed that the lecture supplemented with a presentation of slides is more attractive for the students and therefore presentations could serve as a tool to attract and maintain their attention. Further, it can be expected that by means of appropriately selected graphics and animations, comprehensibility of the lecture can be increased. It is assumed that all the above should find its expression in a better performance of students. However, it is necessary to verify in practice whether these assumptions are met and whether their positive features are not compensated by negative effects of the use of ICT presentations in the teaching process that are mentioned by a lot of authors.

ICT presentations in the teaching process – pros and cons

A wide use of presentations at universities originates mainly in the interest and enthusiasm of lecturers. Several reasons can be traced. Preparation of presentations is relatively amusing. It is necessary to solve the colour and font of lettering, transitions and animations of slides, *etc.* A completed presentation then serves to the lecturer as a basis for the lecture preparation. Slides contain the respective points and pictures, which facilitates the lecturer to maintain the sequence and does not allow him to leave out whatever is essential. Moreover, the completed presentation can be used in other courses, because it is not a problem to make smaller changes in the presentation. These are pros of the use of presentations as they occur in the reactions of specialists [1–3] and the assumptions, which formed the basis for the research [4–6] conducted in this area mainly in Great Britain and the USA. Now it is necessary to summarise the critical views. If the teacher immerses himself/herself into the preparation of presentation with enthusiasm, it can happen that he/she will spend a lot of time doing the activity that will not ensure the final effect. Some specialists therefore draw our attention to the fact that this can bring about a poorer content of the lecture, which is not the main concern of the teacher. Then, during the lecture, the teacher is led by the presentation, which, however, does not allow him/her to make excursions or develop a discussion. He/she is closed within a linear format of the slide sequence. In his/her speech, he/she is pressed to use the form of supplementary comments. The position of the lecturer has also changed. He/she is driven out from the centre of attention by the screen or interactive board with the presentation slides. The presenter himself/herself can thus be separated from the message and the students. Some authors also warn of a possibility to provide the students with handouts or the presentation itself in advance. It can, on the contrary, lead to a complete loss of attention caused by the feeling that all the necessary information has already been provided. Szabo and Hastings [6] researched, among others, the effectiveness of lectures supplemented only with PowerPoint and the lectures supplemented with PowerPoint where the students were provided with printed handouts. This research did not reveal any substantial difference in the performance of the students.

Let us study aspects related to *e. g.* the program MS PowerPoint as a presentation tool, which can affect the course of the lecture, the lecturer and also the students. Presentations are usually valued for their clarity, brevity, and structuring of curriculum, which makes the comprehension easier. However it is alongside necessary to realise that this leads to a simplified use of language. Craig and Amernic [2] refer here to a comparison with the language of SMS. A small space makes the presentation designer use catchphrases. Presentations often lack sentences at all. A system of presentation development leads to the development of information hierarchies and to the division of the curriculum into fragments. With the students, this can give rise to an inaccurate logic and desultory thoughts.

One of the presentation pros is mainly the option of curriculum visualisation, though, even here, a cautious approach is necessary. Improperly used graphics can, on the contrary, divert attention from the subject-matter. Bratsch and Cobern [4] studied, among others, the influence on storage and recollection of pictures that are not linked with the presented topic. For this case, they revealed worse results than with the text alone or the text linked to the picture through its meaning. In this light, it would be necessary to think about *e. g.* the use of much-favoured 'motivating' pictures such as *e. g.* various clip arts.

General chemistry in ICT presentations

Our department is involved in the creation of presentations related to the general chemistry curriculum. Our work is based on the assumption that chemistry as a whole faces the problem of low popularity among secondary school students. This, of course, finds its reflection in the low interest of these students to continue their studies of chemistry at the university.

One of the reasons is the course of general chemistry as a part of introductory curriculum of the subject chemistry. It is undoubtedly a very difficult and abstract curriculum. However to comprehend this curriculum is a prerequisite for a proper mastering of other parts of chemistry. It can be assumed that demandingness and low attractiveness of general chemistry is a significant contribution to unpopularity of chemistry as a whole.

For these reasons, our department strives to create presentations containing illustrative components (pictures, photos, models, graphs, tables, diagrams and simple animations). These graphical components should contribute to a better comprehension of curriculum and they should also be visually attractive to enhance the attractiveness of this markedly theoretical part of chemistry. From the experience of the teachers, who have already used our presentations in education, it is evident that a significant activation effect on the students is linked with the “effect of news”. If the students have already got used to the presentations, their interest and then also their attention are again weakened. Therefore we strive to supplement the presentations with both theoretical and practical tasks. These are problem-based tasks, the solution of which will forward the students' knowledge or comprehension in the respective part of curriculum. Apart from the activation of students, these tasks also motivate the students.

We are aware of the fact that all the advantages and disadvantages of using the presentations will, to a certain extent, also hold for seminars or tutorials that are usually attended by smaller groups of students and where the presentations supplemented with tasks are most often used. However, here the teacher may select from a larger number of methods, he/she may use other activation tools and he/she may appropriately combine the methods. And if he/she opts for the methods of lecture supplemented with the presentation, then some of its lacks can be eliminated. It is also necessary to add that the presentation can become a supplement of other methods and forms of work. At the same time it can be attractive as a tool for presentation of results from independent or group work of students on the tasks, projects or laboratory work.

As mentioned earlier, the first completed presentations related to the structure of substances [7] and redox processes [8], have already been delivered for the use of teachers. The experience from the use of these presentations has been reported by the teachers by means of questionnaires specifically designed for this purpose. From the up-to-now collected reactions, it can be judged that we set off in the right direction. Gradually we would like to process all general chemistry curricula in the same manner. Doing this, we will strive to take into consideration both the data collected from the questionnaires and also the above-mentioned research and experience of specialists.

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Interesting Chemistry – Multimedia Collection Of Tasks

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Summary. Computer as multimedia instrument plays important role in education of children. Within the confines of master work it had been created the program in Flash technology which to help has with didactic process. “Interesting chemistry – collection of tasks” is rich in content inclusive symbols, signs, pictures and schemes. Science with so prepared multimedia base is effective than hearing of lecture of teacher. Work with such program motivates knowledge of content included in book.

Introduction

It has been introduced a new technology by firm Macromedia in 1997 year, which allow to create interactive multimedia programs being based on vector graphics. At the beginning this technology was only taken advantage for creation WWW sites, but now it is there, where surprising, efficiency are wanted. For creation of presentation, in above-mentioned technology, serves software called Flash. It has introduced personal format of file about expansion SWF. For reading this type of file it is needed free software Macromedia Flash Player. Flash has become one of most important and most popular instrument which has found employment in creation of interactive programs, it has become certain standard. Last time cellular telephony begins using this technology, many games exists on cellular phones due to Flash.

As it has been written already earlier that Flash is a program for creation vector graphics *i.e.* it is not based on remembering colour and single pixel, but it uses mathematical accounts for as the most realistic modeling. Due to it images emerge about constant quality independently on scale in which file will be displayed. Flash creates files about smallest size in comparison for standard files JPG, GIF or BMP. We gain greatest control over appearance too and site of object on displayed image. This program creates typical effects for multimedia presentation, allows interactiveness with user, as well as on animating (movement along path, change of colour in definite moment). Introduction of element to movement problem several moments, you should only define initial and final site of object then Flash automatically will build indirect frames. Flash presentation can implicate musical cushion as well as sounds different kind taken advantage at click mouse or in other moment of operation of program. It is possible to use with files in format mp3, it causes that really, ultimate file has small size. Flash environment also contains language of programming called ActionScript, it is possible to create compound applications (interactive games) due to it [1].

Within the confines of master work it had been created the program in Flash technology which to help has with didactic process, it is called “Ciekawa chemia. Zbiór zadań. Cz. 1“ (“Interesting chemistry. Collection of tasks. Part 1”) [2]. This program is integral part of textbook “Ciekawa chemia. Część 1“ (“Interesting chemistry. Part 1”) of authorship of Hanna Gulińska. This educational program has been made in flash technology. In today’s times of development of electronics and computerization school-bookish knowledge does not suffice. Pupil becomes bored book reading only and loses motivation for far work, begins thinking about leisure and entertainment (for example playing on computer). It is possible to joint both these cases, book knowledge should be supported concrete examples and animations. Reading of book is greatest amenity when exists capability of verification of knowledge in the form of electronic test or computer games. It is possible to widen knowledge observing movie, which pictures effect of definite reaction. Computer as multimedia instrument plays important role in education of children. It is element helping, developing and knowledge complementary.

Work on computer with proper program is base for independent consideration of problem, is capability of deployment of imagination. Science with so prepared multimedia base is effective than hearing of lecture of teacher. Modern educational programs include contents which necessary read, hear and observe [3]. “Ciekawa chemia. Zbiór zadań. Cz. 1” (“Interesting chemistry. Collection of tasks. Part 1” is included for such programs. Program includes hundred interactive tasks which were created on base of textbook “Ciekawa chemia 1” (“Interesting chemistry 1”). CD includes:

- Tasks of multiple choice in which you should insert served elements to suitable places. These tasks include more elements to insert than it is fields of answers, so each element will not be taken advantage in task.
- Tasks with scheme in which you should analyze presented scheme and lend correct answer. For this type of task will be helpful content of textbook from given section.
- Account tasks relying on typically mathematical accounts and to fields of answers inscription of gotten result. You should round gotten results in these tasks to get maximum amount of point for it.

- Rebuses, relying on inscription proper words to fields of answers.
- Tasks with chemical reactions, relying on complement of fields of answers to such manner, in order to get correct exemplar of chemical reaction. It belongs to insert to empty (hollow) fields substrate or product of chemical reaction or implement equalling of chemical reaction by coefficients.
- Tasks with chemical animations relying on start-up of animation and analyzing its result, next you should lend correct answer inserting proper element or inscribing correct values

All tasks are constructed by this way, that after given answer and pressed checking button it is possible to look in correct solution of task (exists return to chart displaying given answers). Each task is pointed separately, so content of task should be read exactly and think over its solution.

Research have been carried due to which prove requirement of existence this type of tasks. Tasks pleased students, they could check their knowledge, and also graphic appearance was complimented.

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Possibilities in Applying Research-Based Teaching in Chemistry

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Summary. Universities all over the Europe have renewed their curricula to follow up the Bologna Declaration during past two years. This research is focused how the curriculum renewal has succeeded at the University of Helsinki. Level of chemistry knowledge and chemistry students' approaches to learning and studying were tested with first year students in the beginning of their university studies.

Universities all over the Europe have renewed their curricula to follow up the Bologna Declaration during past two years. The greatest change was to build up two cyclic degrees (3 + 2): Bachelor of Science (3 year) and Master of Science (2 year). During this renewal the workload and learning outcomes in chemistry were carefully specified both at degree level as well as at single course level.

Our research is focused how the curriculum renewal has succeeded at the University of Helsinki. What is the chemistry knowledge of our chemistry students in the beginning of their university studies? Do our curricula support research--based teaching? What kinds of approaches to learning and studying chemistry students apply and how these are related to academic achievement and learning outcomes? The chemistry knowledge of first year students was examined with *EChemTest* developed by ECTN Association and approaches to learning and studying with an electronic questionnaire developed by ETL project [1].

137 first year students were tested with *EChemTest level 2* and 65 % of the students passed the test. Factor analysis of chemistry students' approaches to learning and studying distributed students into 3 factors:

- Evidence seeking (F1) (deep approach)
- Organised studying (F2) (strategic approach)
- Deep understanding (F3) (deep approach)

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From Upper Secondary School to the Jagiellonian University

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Summary. Presentation is focused on a modern model of mutual collaboration between Jagiellonian University and upper secondary school. In this model, pupils have direct contact with university teachers through several actions, such as workshops in computer laboratory, participation in selected lectures dedicated for undergraduate students, participation in dedicated lectures in school, scientific camps.

The first recruitment to the biological-chemical class in the Upper Secondary School no. 6 in Cracow run under the aegis of the Department of Chemistry of the Jagiellonian University in Cracow took place in the school year 2004/2005. According to the regulations for such a class the chemistry teacher is also an employee of the Department of Chemistry of the Jagiellonian University in Cracow and the main subjects are taught according to a specially authored course which is designed in co-operation with scholars from the university at the beginning of each year.

According to the guidelines students participate in university lectures and computer workshops held both in the Department of Chemistry and in the school building. The main aim is to extend the interest of students in modern problems and university research and present the development prospects of biology, chemistry, biochemistry, biotechnology, pharmacy and medicine. Although the lectures are presented at a very high level, they are conducted in an easily absorbable and interesting manner. Throughout them young people develop and master the ability to individually construct notes and solve problems presented by the lecturer.

During computer workshops students familiarise themselves with new graphics software enabling them to draw chemical formulae or to model molecules; learn to search internet resources for information on an assigned subject. The multimedia projects developed by young people are presented and thoroughly analysed at the end of each class, and also verified with a view to eliminating possible shortcomings. Moreover, the workshops allow students to prepare better for the final examination by developing the ability to present a prepared topic.

The students of patron classes have an opportunity to take part in various extracurricular activities during which they add, verify, consolidate or extend their knowledge. Those classes – generally called consultation hours, are not obligatory and are meant for all students, those interested in chemistry, as well as those who have problems with this subject. The most popular with students are extra classes preparing for chemical contest. They operate separately for forms 1, 2 and 3. The leading teacher, discussing extended concepts, solves problem tasks with students.

Similarly to contest classes – olympiad classes operate on similar rules. The difference lies primarily in the type and level of difficulty of the tasks analysed with students and the problems which are in this case tackled based on academic books.

Another form of co-operation with students – an experiment class, attracts the attention of many students, also those from outside the biological-chemical profile. The basic level for students not interested in chemistry is convenient because of the insubstantial content, but leaves something to be desired owing to a limited number of experiments.

The experiment class in our school is based on experiments from various branches of chemistry, int. al. qualitative analysis of cations and anions, chemistry of complexes. The participating students have an opportunity to carry those experiments out individually or in small groups.

The role of chemical experiments in class and in extracurricular classes is of utmost importance. They allow an optimum transfer of both factual knowledge as well as skills. Moreover, they create a possibility of closer contact between the teacher and students. Providing a good illustration of the concepts discussed they are undoubtedly one of the more attractive forms of presenting facts. While carrying out, or observing experiments students do not only work with their sense of hearing, but also sight, often using their manual skills. They notice that the theory given by the teacher is not dry information to memorise. They realise that chemistry is not only words, but also phenomena, reactions and transformations taking place in our immediate surroundings, in ourselves.

It is experiments that shape the awareness of one's own abilities and skills by means of developing imagination, memory, abstract thinking and observance. It is worth emphasising that the experiments carried out by students influence their independence, curiosity, endurance as well as interests and creative initiative. Working with chemicals also teaches application of safety regulations. Even if students do not carry out experiments themselves, but only observe a presentation being made by the teacher, it is important to point out the factors directly influencing the process of reaction, and also to create a problem situation. Eventually, support or refute the formerly presented hypothesis.

Organising extracurricular classes one should primarily put emphasis on:

a) free participation (acquiring new participants it is worth utilising success motivation; the student participates in the class out of his/her free will, without the pressure of routine, school mark),
b) attractiveness (only classes attractive both in content and presentation can be expected to hold relatively steady participants, the participants are characterised by high level of emotional involvement in relaxed atmosphere, acceptance of effort and a dose of clear satisfaction.

In order to enrich the educational offer of classes under the aegis of the Department of Chemistry of the Jagiellonian University in Cracow, apart from the mentioned computer workshops and university lectures, the school organises scientific camps and educational trips aimed at:

- developing the awareness of the responsibility for protection of natural environment;
- correlating the study of natural subjects;
- shaping the ability to design and carry out a chemical experiment;
- presenting the manifold use of chemistry in everyday life;
- familiarisation with modern chemical equipment in modern specialist laboratories.

The usefulness of such classes can be explained by the need to develop the student's scientific behaviour, develop the habit of exploration and popularize an authentic creative anxiety, enabling students to meet the staff of the Department and familiarize themselves with the department labs; get accustomed to the specialist jargon, current research problems and the basics of chemical scholarly knowledge.

It is also worth noticing that the student of patron classes prepares – individually or in groups – the so-called semester papers both in Polish and English. Those papers, tackling a given chemical problem, can assume various forms, *e.g.:* an essay, a multimedia presentation, a poster, a drama.

Students – both in current and revision classes – learn to prepare their notes in the form of the so-called “mind maps”. Those are schemata allowing systematisation of information in small thematic blocks. Such a form of writing down facts allows storing – in clear graphical form – the most important concepts from various fields of science and noticing the correspondences between the stored information.

A mind map is especially useful before tests and examinations – during the revision of the subjects discussed in class. They can be created in class – during group work or as the whole class – supervised by the teacher.

The method of systematising information with the use of mind maps is especially useful if the student creates schemata individually, because he/she then marks concepts especially difficult to remember. The student, in order to acquire facts, can attach illustrations to the text information in the maps, which in turn facilitate matching facts and combining concepts.

When creating mind maps, the student practises systematisation and selection of information. Constructing them he/she can use books other than those used at school, thanks to which he/she expands their knowledge corresponding to the analysed problems. This in turn prepares him/her also to independence in acquiring the necessary information so useful for studying at university.

In our school 6 we organise many competitions for the whole school community. The topics of the competitions are chosen in such a way as to allow students to present their knowledge, their scientific interests practised outside school and additional skills they cannot present in class.

The photographic competition “Natural phenomena in the lens” did also attract plenty of attention among young people. The participants’ task was to portray in a photo a natural phenomenon or an experiment they carried out themselves. Together with the photograph they were supposed do hand in a short description of the observed phenomenon or conclusions from the experiment. The subject was random but it had to fall within geography, chemistry, biology and physics. The third contest category was the artistic category.

There are also papers being handed in our current competition – from the borderline between science and journalism: “In search of chemical absurdities in the media". The task the young people face is finding such a piece of pseudo-scientific information in everyday (*i.e.* non-specialist) press, the Internet, the radio or TV, which can unambiguously be considered "rubbish". Additionally, the participant is expected to explain what the given "rubbish" consists in and provide a correct description. We assume here that in search of explanation the students reach for specialist literature, that is, they educate themselves, sometimes at a very high scholarly level.

Elements of work with a scientific text are also used in ordinary classes, which is especially important in the times of the contemporary final exam. We try to encourage students to read a text presented to them, think critically and creatively and draw conclusions – not being afraid to do so, first of all.

Meeting university staff is very important for us – teachers. They allow transfer, between universities and schools, of information about the requirements set before candidates and students. The remarks and advice given by university lecturers are taken into account in our didactic work.

Chemistry Self-efficacy: A Study of Gender and Major Differences Among College Students in Turkey

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Summary. This study aimed to investigate the differences of college students' chemistry self-efficacy beliefs by gender and by major area. The dependent variables were three dimensions of chemistry self-efficacy scale. The sample of the study consisted of 358 college students. Results of the two-way MANOVA indicated statistically significant main effect for gender and for major area but no significant interaction. Univariate ANOVA results indicated that while no significant difference was found by gender, there was a significant difference between majors and non-majors in terms of self-efficacy for cognitive skills and self-efficacy for everyday applications, with higher efficacy scores for major students.

Introduction

One of the essential elements of social cognitive theory, as proposed by Bandura [1], is perceived self-efficacy, which is defined as *"beliefs in one's capabilities to organize and execute courses of action required to produce given attainments"* [2, p.3]. Self-efficacy beliefs affect individual's behaviour, particularly their choice of action, effort and persistence to complete a task, and resilience in adverse events. For example, in schools, students with high self-efficacy tend to choose more challenging tasks, show more effort, and do not give up easily. This explains the reason of different academic performance of students even with the similar ability [3]. Indeed, researchers have confirmed the relationship between self-efficacy and student achievement [4–7].

In chemistry and other sciences, self-efficacy has been found to be a predictor of academic performance as well. Andrew [8], studying with college students, reported that self-efficacy beliefs significantly predict 24 % of academic performance in physical science and 18.5 % in bioscience. In high school students, a significant positive correlation between self-efficacy beliefs and achievement in science was found [9, 10]. Lau and Roeser [10] also indicated that female students have higher science grades and self-efficacy than male students. Britner and Pajares [11] also provided similar findings with middle school students. However, it should be noted that gender difference in self-efficacy does not show the same pattern. For example, Anderman and Young [12] reported higher science self-efficacy for male students than females. In addition to student achievement, perceived self-efficacy was also found to be related with self-regulation [13, 14], engagement [10, 15] and career choice [16, 17].

This study aimed to investigate whether there is a significant difference on college students' chemistry self-efficacy beliefs by gender and by major area.

Methodology

Sample

The sample of the study consisted of 358 first-year students attending chemistry class in a college (127 female, 231 male, and 138 major, 220 non-majors).

Instrumentation

Students' chemistry self-efficacy beliefs were measured by Chemistry Self-efficacy Scale developed by the researchers. This scale included 22 items on a 9-point rating scale, ranging from "very poorly" to "very well". The items were factor analyzed by using exploratory factor analysis with maximum likelihood estimation and three factors emerged with eigenvalues greater than 1. An oblique rotation was then undertaken to assist in the interpretation of the factors. The three factors were interpreted as relating to self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications. The overall percentage of variance extracted was 51 %. Further, reliability tests for each of the dimensions all exceeded the threshold of 0.80 for acceptance.

Data Analysis

Two-way (2 × 2) multivariate analysis of variance (MANOVA) was generated in which the dependent variables were three dimensions of chemistry self-efficacy scale. The independent variables were gender and major area.

Results and Discussion

Prior to MANOVA, descriptive statistics were examined. For the whole sample, the overall means were 6.18, 6.27, and 5.53 for self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications, respectively. Considering ratings on a nine-point scale, the mean scores were at the moderately-high end of the scale. In addition, descriptive statistics by gender and descriptive statistics by major were investigated. Results indicated that on average, females showed higher self-efficacy than males. Similarly, majors had higher self-efficacy than non-majors.

The MANOVA showed that no significant interaction effect was found between independent variables, *Wilks' lambda* = 0.98, F (3, 352) = 2.11. With a nonsignificant interaction effect, the main effects can be interpreted directly without adjustment. The combined efficacy measures were related to gender, *Wilks' lambda* = 0.99, F (3, 352) = 0.31, $p < 0.05$; and major area (*Wilks' lambda* = 0.97, F (3, 352) = 3.70, $p < 0.05$). The multivariate η^2 for gender was 0.003 and η^2 for major was 0.031, both indicating a small effect. Univariate analyses of variance on each dependent variable were performed as follow-up tests to the MANOVA. Using Bonferronni method, each ANOVA was tested at 0.02. Results indicated that while no significant difference was found by gender, there was a significant difference between majors and non-majors in terms of self-efficacy for cognitive skills ($F = 5.96$, $p < 0.02$, $\eta^2 = 0.02$) and self-efficacy for everyday applications ($F = 11.1$, $p < 0.02$, $\eta^2 = 0.03$). The efficacy scores for cognitive skills of major students ($M = 6.38$, $SD = 0.93$) were higher than that of non-major students ($M = 6.05$, $SD = 0.98$). Moreover, the efficacy scores for everyday applications of major students ($M = 5.89$, $SD = 1.21$) were higher than that of non-major students ($M = 5.30$, $SD = 1.34$).

The findings of significant difference in efficacy for cognitive skills and efficacy for everyday applications by major area concurred with Bandura's argument that as individuals gain more experience, their efficacy judgments are enhanced. Major students are expected to have more experience than non-majors. However, non-significant difference in self-efficacy for laboratory applications seemed surprising as majors had more lab applications than their counterparts. But it should be noted that these data were collected from first-year college students. Therefore, more noticeable difference would be expected if this study was repeated at the later years.

The lack of a significant statistical difference between male and female students of this study would seem to be supported by previous research. There is no consensus in differences of efficacy beliefs by gender. Further research, more explanatory ones, is warranted and would hopefully produce more consistent findings.

This study contributes to the chemistry self-efficacy literature by providing some analysis by gender and major area. However, considering the data were collected at a single point in time and from a single university, more research is needed in this area, particularly with random samples from different colleges and through different grade levels.

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Approach To Implementation of Science Curriculum, With a Special View to Chemistry

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Summary. The Czech education system is undergoing a big reform – mainly in conception of education. The new curriculum documents are based on key competencies, their connection to the educational content and application of the knowledge and skills in practical life. But this approach is very different from the current one. Our team suggested a way of realisation the reform – by supporting teachers and preparing materials correspondent with the main goals of reform. Consequently, we prepared seminars, workbooks and teacher's guides and a new curriculum-oriented subject for preservice teachers. The usefulness and accuracy of our attitude was verified by teachers in evaluation questionnaires.

The Czech education system, similarly as education systems in many other European countries, is undergoing a tremendous reform. According to Lisbon strategy, Europe's education and training systems need to adapt both to the demands of the knowledge society and to the need for an improved level and quality of employment [1]. It is not only the politician resolution, but conclusion based also on results from international assessments TIMSS 1995, TIMSS-R 1999, TIMSS – Video Study 1999 and PISA 2000 and 2003. Some important characteristics of Czech students and also whole Czech basic science education are shown below:

- Czech Science teaching can be characterised as "Talking about science content". Instruction time is focused on review, assessment, and development of canonical science knowledge, with relatively little time allocated for students to work independently on practical activities. The content of Czech science lessons is challenging, dense, and theoretical, and also is organized more often around acquiring facts and definitions (72 %) than making conceptual connections. The main source of the science content is teacher (60 %) [2].
- In all mentioned assessments the results of our students in science were above the international average [3–6]. But, in 1995 the Czech Republic was the country with the biggest difference between the results in the main

assessment (written test) and performance assessment [3, 7]. PISA assessments showed, that our students were very good in items which needed only pure demonstration of facts, but items which needed application of knowledge in new or unusual situations were problematic for them [5, 6]. In addition to this, we saw that our students were able to answer some applying or reasoning items only with the use of recalling (due to their large knowledge). So, the Czech students demonstrated both a large number of science knowledge and problems with using it.

- Science education is also influenced by the problem with reading literacy of the Czech students. About 25 % of them were at the lowest level of retrieving information, making and arguing for their own opinion was also a problem [5, 6].

The main trend occurring while creating new curriculum documents is incorporation of key competencies, their connection to the educational content and application of the knowledge and skills in practical life. Czech framework educational programmes (FEP) [8] are designed in order to balance the amount of knowledge gained by students at school with their abilities to apply such knowledge, use it practically and develop the necessary skills. Therefore the conception of education is based on key competencies which include competencies in the area of learning, problem solving, communication, social, interpersonal and civil competencies. The acquisition of such key competencies is important for personal development of the students and it should help them to act actively in the society and to assert themselves in personal and professional life. Other innovations in FEP are cross-curricular themes, such as Environmental education, Media education, Multicultural education, etc. The main value of these topics is interconnection of all (or almost all) school subjects and students´ life. The main change caused by FEP is in the interpretation of educational content. The core of the educational content is created by expected outcomes which establish the level of knowledge and skills which should be achieved by the students at the end of their studies. The other important part of the educational content is the subject matter that should be a mean for the students to achieve the expected outcome. The expected outcomes formulate what operations the student is able to do based on the acquisition of the subject matter, and the subject matter presents or specifies more deeply what knowledge the pupil is using for such operation.

Nowadays, teachers are trying to find ways how to realize this curriculum, because none of them was actually prepared for this type of education. Our team of five from Department of Chemistry and Didactics of Chemistry, Faculty of Education, Charles University in Prague holds the view that teachers are not able to manage all these changes alone and need support and help to teach in accordance with FEP. Due to this we decided to prepare seminars, teachers' guides and other educational materials, try them in practise and then ask teachers for evaluation of our attitude to the school reform.

Our first outcome was a teacher's guide [9] for the whole set of textbooks and workbooks for the basic school chemistry named "Basics of practical chemistry". There is an example of a part of a school curriculum (educational branch chemistry) included in this teacher's guide.

"Key competencies" and "cross-curricular themes" represent two topics which should help in preparation of young people for "real life". Therefore we think if we outline an every-day problem in an appropriate complex item (with more questions), we will both teach the knowledge and develop the key competencies. But in the Czech Republic there is a lack of such real life items. Teachers can use released items from TIMSS and PISA assessments but TIMSS items are more oriented to knowledge and PISA items are usually difficult and very unusual for our students. A partial solution can be the workbook "Practical chemistry and our life" [10], which contains complex items (but not as difficult and/or long as in PISA). By using this workbook the key competencies can be developed and some cross-curricular themes (*e.g.* Environmental education, Media education, Personal and social education) can be fulfilled.

Critical thinking and bindings between chemistry and real-life are supported very well in our book "Devil sign and other mysteries for young chemists" [11]. This book represents edutainment genre (a form of entertainment designed to educate) and covers the informal education area.

Our teacher's guide to including environmental education into chemistry is the most recent material for teachers [12]. This guide is special not only because of its content (methodical recommendations, items, suggestions of practical students activities with prepared worksheets), but also because of its form. It is a book supplemented with a CD, which contains the almost whole guide in .DOC format.

Beside the written educational materials, we offer five different FEP-directed seminars for (chemistry) teachers. In these seminars we clarify the processes related to the school reform, give them materials which can help the teachers with creating the school curriculum (in the area of chemistry) or answer their questions about the reform and FEP. One of those seminars concentrates on cross-curricular themes and possibilities of inclusion of these topics into school curriculum and teaching, as well. The newest seminar is dedicated specially to environmental education and its inclusion into chemistry. Almost 1270 teachers attended these seminars during last two years.

We also care about preservice teachers, we prepared a new elective subject "Theory and practice of school curriculum" and we innovated all didactic subjects, too.

For evaluation of the usefulness and accuracy of our attitude we used a questionnaire, which was completed by 555 teachers. The results are:

- Nearly 97 % teachers appreciated seminars related to school reform, FEP, changes in teaching etc.
- The 96,5 % teachers use or plan to use completely prepared materials for teaching (textbooks, workbooks, teacher's guide with items, *etc.*).
- The 95 % teachers want to use complex items in their teaching.

These results confirm our idea that Czech teachers are not prepared for teaching in intention of FEP and that they welcome any help, both in form of seminars and in form of teacher's guides, workbooks *etc.*

During this year, we would like to continue and prepare some new things and offer them to teachers, for example: new science items developing of key competencies, evaluation of key competencies in science education or development of chemical software for educational use.

We hope that all these materials will help in developing key competencies of our students and consequently the level and quality of their lives.

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Equipping Secondary School Teachers with the Tools for Inspiring the Next Generation of Young Chemists

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Summary. In many European countries, there is an urgent need to interest more gifted young people in studying chemistry [1]. Key factors influencing their choice are their secondary school teachers. The Comenius project CITIES will produce five teacher training modules which will help teachers to make their chemistry lessons more appealing by seeing the subject in the context of their daily lives. Besides basic information on European aspects of chemical industry and chemistry teaching, CITIES will offer course material with "hands on" experiments and a homepage that presents people and products, linking everyday benefits, the making of products and their chemical background in an interactive way.

Introduction

The European Parliament has set the objective that the EU shall be the leading economic area by 2010. Chemistry is the central (basic) science of key technologies such as biochemistry, molecular biology, biotechnology, material science etc. Without a sufficient number of qualified chemists, the chemical and related industries will be unable to fulfil their task in EU economic development. In the 90ies, most European countries experienced a decline in the number of science students, and with a generation of chemists retiring in the next years, there is still a need for more well-trained chemists [2]. Each job of a university graduate in a technical field entails an estimated average of 2.3 additional jobs – which would be lost if there are not enough appropriate graduates [3]. *"Taking into account the fact that the yearly number of school leavers will decrease in the coming years, Germany will not be able to meet the increasing demand for well trained/educated specialists if we do not manage to increase the number of students in the relevant fields"*, says Andreas Schleicher, OECD education expert in an interview with DER SPIEGEL. Especially SME's, which make up to 90 % of all chemistry related companies and employ nearly 50 % of all personnel in the sector, will suffer from this trend. On the other hand we know that in China and

India 700 000 young technical graduates leave the universities – twice as many as in Europe, and nine times the number of US graduates.

Chemistry is not "sexy" enough

Why is the fascinating world of the molecules – and chemists are those who can and make molecules dance – not appealing for so many young people? Here are some expert opinions [3]:

- *"It is most astonishingly the high 'technology content' of everyday life that decreases interest in technical studies: everybody can operate a mobile phone or an MP3 – but few have an idea how it works. Technology becomes self-understood, and at the same time a black box."* Volker Brenneke, Bildungsabteilung VDI.
- *"Studying technical subjects is still not yet sexy enough … Telling your fellow students that you study mechanical engineering and work on control engineering is not an impressive university party topic."* J.Fuchs, VDI
- *"Sadly enough, we do net get the ones who are gifted all-rounders – technical careers just lack splendour … Technical studies are not very appealing for many youngsters, because right at the beginning there is no link to the professional practice."* Frank Stefan Becker, University expert, Siemens.

Some of these arguments do not hold true for European countries in economic transition, where the traditional industries have declined, and new technologies have not yet fully developed. But they will develop, and they will need well-trained personnel as well.

Dieter Jahn, President of GDCh, stresses the importance of chemistry as a basis of professional excellence of medical doctors, engineers, biologists, but also as a subject in general education. This is why, he says, teachers have a challenging task and must be well equipped and well trained [4].

Secondary school teachers as key persons

When asked why they study chemistry, young people say that their chemistry teachers played a key role in their decision. Some of these teachers have studied chemistry many years ago, some have not studied chemistry at all, and many say that the time for experiments and the supply of appealing teaching material is scarce. They often struggle with a negative image of chemistry in their respective countries [5]. These colleagues need material and resources for giving their pupils an adequate training and a correct image of chemistry and its applications. In addition to the usual university science courses, future teachers as well as the secondary school teachers need training and continuing professional development courses which bridge the existing gap between their studies and everyday school life and the “real” industrial and applied research world. With this help, it is easier for them to awaken in their pupils more interest in and enthusiasm for studies in chemistry, its technologies and its applications.

Many initiatives have been started in the past years to answer this need [4]. The project CITIES, “Chemistry and Industry for Teachers in European Schools”, does not pretend to re-invent the wheel, but rather to focus on the needs of teachers based on a needs evaluation in several European countries [6] and offer a concise, practice-related set of training modules including information on existing material and initiatives.

CITIES – partnership and products

To answer the needs described above, CITIES found a home as an ideal COMENIUS project. It was launched by ten European partner institutions [7] who had co-operated in several previous projects, among them FACE (Forum for Advancing Chemical Education) [8] and started in November 2006. The training package it will produce consists of five modules and will be available on a homepage.

Module 1: Framework Europe. General basic information on EU policies (such as Lisbon strategy, Bologna declaration and follow-up), with special reference to the context of chemistry and chemical industry and on trends in the European development of an “educational space”.

Module 2: Chemistry changes everything. The scope and impact of the European chemical industry, its workers and employees and of chemistry based products on the European economy, on citizens' everyday life, on the environment, and on the labour market.

Module 3: Commerce and innovation – our future. Current and future development trends in the field of commercial application of chemical innovation, with particular regard to the European area (covering fields such as nano-technology, bio-technology, bio-analysis, sustainability of material and energy use, Green Chemistry, chemical engineering design etc.).

Module 4: Chemistry – bringing it alive. Modern, practically oriented, appealing methodologies of teaching chemistry to a broad spectrum of pupils from different abilities and interests, including those who are heading for a career in chemistry and those who will just be "users" of applications of chemistry and voters in elections (societal aspects). As an example, E-learning with chemical subjects, use of mind-maps, topics of everyday life such as *"A tin of ravioli – what is in it?"*. Additionally, communication by teachers in a transnational and international environment will be stressed

Module 5: Europe – the education and training arena. Different approaches to vocational and tertiary chemical education in Europe, with special attention to student work experience and to student mobility, taking into account the question of employability of the graduates in a global economy.

The presentation for Eurovariety Prague will report on first results of questionnaires given to teachers, and on selected examples of the module contents and design.

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Studies of Knowledge Standard in General Chemistry of the First Year Chemistry Students

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Summary. The research whose aim was testing the basic knowledge in general chemistry of the students prior to their chemical studies and post the first semester of general chemistry classes was carried out. Then these results were compared to those they achieved in the high school final exams in chemistry.

Introduction

For a few years it has been observed that the secondary school leavers who begin their chemical studies are worse and worse prepared. Their achievements after the first semester are also unsatisfactory. More than a third of students fail the exam in general chemistry. The classes in general chemistry are conducted in the first semester and their aim is to create possibilities for students to equalize the knowledge in general chemistry to complement it and to broaden in some aspects to some extent. Unfortunately, this aim is not achieved fully. This is the state about which the teachers of general chemistry have only intuitive knowledge. Therefore the attempt was made to carry out research which will provide reliable knowledge about students' elementary chemical knowledge acquired at secondary school and about improvement or lack of improvement of this knowledge when the classes of general chemistry are finished. The results of research will help to raise the standard of chemical education within the subject general chemistry.

Research

In the first stage general chemistry curriculum and teaching contents in the core curriculum “Chemistry for secondary school” were analyzed. Then the problems, whose knowledge will be tested, were chosen. The attempt was made to choose the most essential ones in general chemistry and whose knowledge is indispensable for further studies of chemistry.

Of the selected problems there were those related to the electron structure of atoms of elements, periodic table, chemical bonds, calculation related to the concepts of mole and molar volume of gases, electron balance of the redox reaction, reactions in aqueous solutions, concentration of solution, pH of aqueous solutions, theory of acids and bases, equilibrium constant, factors influencing the reaction rate. The next stage was elaboration of the test plan and suitable tasks. The set composed of 15 open and closed tasks was worked out. The same test was used twice to test knowledge of students who begin their classes in general chemistry. The test was used at the beginning of the first semester and when the classes were over.

Results and discussion

The average result of research in the first appointed time was 9 points (20 possible) in the second appointed time it was 11 points. The results of research carried out in the first term were compared with the achievements of the school final exam in chemistry.

This exam in its present form was introduced in 2005. According to the regulations it can be taken on the ordinary and advanced levels [1, 2]. The obtained results decide about becoming a student. The students are recruited to study in the Faculty of Chemistry, M.C. Sklodowska University in Lublin as well as in the chemistry faculties at other Polish universities based on the results of secondary school final exams.

The chemical tasks during these exams test knowledge and skills presented in “Examination Standards” which are described in detail in School Final Exams Directory [3]. They include three areas:

1. *Knowledge and understanding* – the pupil taking the exam knows, understands and uses terms, concepts and laws as well as explains processes and phenomena.
2. *Using information* – the pupil taking the exam uses and transforms information.
3. *Formation of information* – the pupil taking the exam solves problems, creates and interprets the information.

The students under investigations took the school final exams in chemistry in ordinary and advanced levels. There were compared the scores of the school final exam in chemistry of the students who acquired 15 and more points in research in the first term with those acquiring a small number of points (below 10) in this research [4]. In the first group, the average score in the ordinary level was 94 %

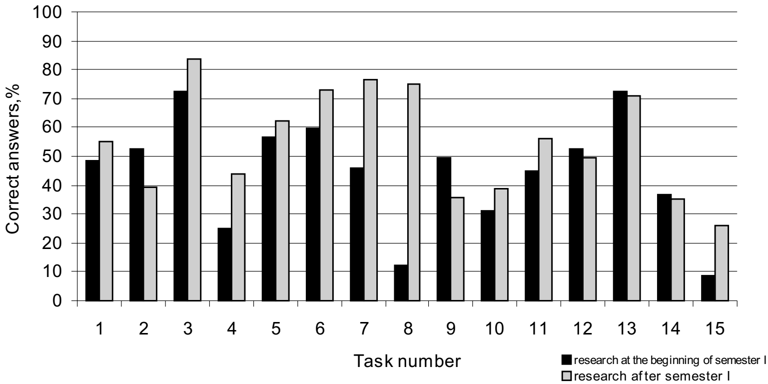

Figure 1. Comparison of the number of correct answers given to individual tasks in both research.

and in the advanced 83 %. In the second group the average score in the ordinary level was 71 % and in the advanced 41 %.

The analysis of the tasks was also made with respect to the number of correct responses. Figure 1 shows the number of correct answers to individual tasks given by the students in both terms. In the research carried out in the first term the most correct answers (over 70 %) were given to tasks 3 and 13. Task 3 tests the knowledge of pH of solutions of substances known in everyday life. Task 13 tests the skills of determining the element position in the periodic table from the electron configuration of the atoms of a given element. In the research, carried out in the second term the most correct (over 70 %) of answers were given to tasks 3 and 13 and additionally to tasks 6, 7, 8 that is related to adjusting the equations of redox reaction, Brönsted theory and calculation of pH. The poorest score was found for task 15 in both terms of research which concerned calculation of equilibrium constant.

The table 1 presents the chemical problems tested in individual tasks, grouped according to changes in students' knowledge which took place between the first and second terms of research.

Table 1. Chemical problems tested in individual tasks

Differences between the scores in both research	**Chemical problems**
Increment over 30 %	Theories of acids and bases, calculation of aqueous solutions pH (tasks 7 and 8).
Increment in the range 10–30 %	Electron balance of the redox reaction calculations, connected with the concepts of mole and molar, volume of gases, determination of solution acidicity, reactions in aqueous solutions, equilibrium constant (tasks: 3, 4, 6, 11, and 15)-
Increment below 10 %	Calculation of percent concentration, allotropic varieties, isotopes, discrimination of the bonds σ and π (tasks: 1, 5, and 10).
Lack of increment	Electron structure and element position in the periodic table, factors affecting reaction rate, kinds of bonds (tasks: 2, 9, 12, 13, and 14).

Conclusions

1. Comparing the average results of the research carried out at the beginning and the end of the first semester it can be concluded that basic knowledge and skills in general chemistry acquired at school are poor and the increment after the classes in the first semester is small.
2. The students, who obtained large number of points in the research, had also good score in chemistry school final exam both in ordinary and advanced levels. There are small differences between the scores achieved in the ordinary level and in the advanced level.
3. In the case of students who achieved a small number of points in the research, it can be stated that there are large differences between the average score in the ordinary level and that in the advanced level. It means that the exam differentiating the achievements of secondary school leavers is the advanced level one.
4. The lack of knowledge increment takes place in the two groups of tasks. The first one includes the tasks which were solved well in both terms of research. This can indicate that the students acquired good knowledge of these problems at secondary school and it is still kept on a good level (*e.q.* electron structure and position of an element in the periodic table). The other group includes the tasks which are characterized by a low score of correct answers in both terms of research. This, in turn, may mean that the problems presented in the tasks were not studied sufficiently at secondary school and still provide

some difficulties for students (*e.g.* types of bonds). This is clear advice for teachers conducting the classes in general chemistry that they should spend more time discussing these problems or they should change the method of dealing with them.

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Helping chemistry students to get into labour market

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Summary. Students of chemistry and fresh alumni have to take a decision: *"what I want do? Where I should look for a placement? which profession? which position? which branch?"* To help students of Faculty of Chemistry of Jagiellonian University we have prepared a pathway of advices: 1st year – short meeting and leaflet *"What to do during the study?"*; 3rd or 4th year – course *"Alumni on the labour market"*, visit to chemical industry; 5th year – meetings with older alumni who present their career pathway.

Introduction

Students have to take a decision: *what I want do when I finish the study? Where I should look for a placement? Which profession? Which position? Which branch? Where to look for work? As a laboratory worker or a sales representative? In the professions of chemistry, pharmacy, cosmetics, or outside of them? As a chemistry teacher, scientist, specialist press reporter, public service worker? In a large international company, medium enterprise, small family-based company, or on your own billing?* And this is not only the problem of Polish students – chemistry students of American universities were convinced during the ACS convention, that it is worthwhile to look further than the companies that have the word "chemical" in their name [1].

Counselling for students of chemistry

Chemistry is being studied by people who are genuinely interested by this branch of science (in minority) and the rest – those who are here by accident, because it was easy to get in (it happens in Poland), and those for whom chemistry is a stepping stone to further career in other areas. It's important that everyone has the right direction from the first year of studies.

During the **first freshmen meeting** – organization of classes, the student gets a variety of useful information, including where their department's career service office is located (the first career service based in a specific department in Poland). The worker of the service presents the unit's activity as well as gives out brochures made especially for them [2]. Within the brochure, other than basic information:

where and what can be done (dean's office, library, scholarships, health care and so on), how the system of university studies presents itself (*e.g.* a different than in high school grading system, different types of activity/classes) as well as a text entitled: *"How not to waste 5 years of studies?"*. There is also a place for notes which the students religiously use during this organization meeting, writing down meaningful observations and hints, following which they keep the pamphlet for a longer time instead of throwing it in the garbage as usual. Within the essay there are descriptions of basic courses and suggestion that:

- the first year is supposed to be dedicated to acquiring control over the mathematical skills, computer literacy, English, and most of all the transition from a school to an academic way of studying
- during the second year it is advisable to sign up and take part in some student organization, which is well-met by employers, master professional computer skills, and after the second year, on vacation, improve the language and acquire interpersonal skills with *e.g.* Campus America
- during the third year one has to think of a specialization, make important decisions in the organization of which one is a part of, *e.g.* create a project as well as study a second foreign language
- during the fourth year it is advisable to take part in possibly the widest variety of non-obligatory courses, and after that necessarily go to practical placement/internship.
- during the fifth year, concentrating on the thesis and its presentation, expanding communication skills, take part in an international student exchange, visit job fairs, and so on

The next student contact with the career service is usually during the **third year** of studies (in Poland, the chemistry students very rarely end their education at a bachelor level) when they start to look for a place of internship, which are unfortunately not obligatory for general/university education. These practices are found in the industry as well as R&D institutions and administration units (*e.g.* environmental protection) but not without problems.

During the **fourth year** (first year of MSc studies) the students may take part in a 15-hour course called *"Graduate on the job market"* (1.5 ECTS). This course includes short lectures as well as practical exercises, which concern the following subjects:

- Job market for chemist,
- Job market in Malopolska region, Poland and Europe
- Possible pathways of future career, self-assessment
- Requirements: key skills, subject skills, *etc.*
- Documents for employers: CV, letter of intention,
- Methods of recruitment: interview, tests, assessment centre,
- Negotiations (*e.g.* salary), *etc.*

They can also choose a course called *"Practical management"* (3 ECTS) led by Dr. Stefan Witkowski, with help from the General Motors management group and the chemical company PPG. During this course, they can acquaint themselves with the realities of work of a large company during a trip to the car factory (Opel) in Gliwice. For university students who previously rather had nothing in common with the industry, this is an exceptional experience. They observe a completely different work system, the necessity of regardless care for standards and procedures, stressed in the case of any malfunction and huge time pressure (a car leaves the line every 1 min 50 sec, one car costs around 55 000 PLN = = 14 000 EUR, every malfunction, like a scratch on the paintwork makes the assembly line stop), expectance of effective teamwork and a high capability of solving problems which are not accounted for in the manual. Following this tour, many of them declare a noticeable willingness or unwillingness to work in such an environment, which makes the making of later decisions simpler.

During the **fifth year** (second MSc) the students could have taken part in the course *"You didn't get a job offer – employ yourself"* joined with a contest for a business plan of your own company.

During the course, students meet with graduates of the same department of the same university, who are in possession of their own business activity and who are able to share their experience. The presented companies were:

- Production of educational materials for chemistry teaching at secondary schools
- Sales chemical appliances
- Production of high class chemical reagents
- Recycling

The contest required writing, in the form of around two pages, an elaboration of an idea for a self-owned business activity according to the outline spoken of at the workshops:

- Type of activity (production, sales, service…)
- Client (market segmentation)
- Time and place
- Development and activity costs
- Risk level, and so on

The grading criteria was: originality, preparation detail, reality. Students appreciate all of those kinds of counselling and help to get into labour market, what is showed in the evaluation questionnaires.

Career service

This quite complex and above all oriented for students of specific departments "student help system" is complemented with constant activity of the department career service [3], whose job is :

- cooperation with the employers of the Malopolskie Voivodship (gathering information about forms of recruitment, job offers, expectations for potential employees), organization of a cycle of meetings with employers (Degusa, Opel-Poland, PPG, fire-brigade, Pliva Kraków, Merck, ...), presentation of companies willing to recruit graduates of the Chemistry Department,
- acquiring information about possible practices in the country and abroad
- administering a website and an information board which includes, among others: job offers, information of internships, practices, courses, internet addresses, practical advice – how to write a CV and so on.
- Organizing an ”*informatorium*” gathering data about: companies, professions, post-graduate and doctorate studies within the country and abroad, job offers printed in magazines.

This way, graduates' of the Faculty of Chemistry Jagiellonian University chances on the job market essentially grow.

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"Doing Chemistry" in a New Context

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Summary. Studies on the difficulties in the conceptualisation of basic concepts of chemistry show that the way in which we are teaching chemistry in the classrooms is not giving results. In order to recover the explanatory capacity of chemistry, chemical practice *for all* (the intervention on particular phenomena by means of chemistry procedures and posing key questions) should be related to theory (the atomic theory and its entities and magnitudes), using the adequate language for it and according to educational purposes. In this paper, we are presenting and analysing a chemistry activity carried out at the Universitat Autònoma de Barcelona belonging to a programme (named "Ithaca") to introduce secondary students in "*doing science*".

Introduction

Chemistry teachers worldwide teach more or less the same things. But, for some authors [1] current chemistry programmes do not attend to young citizens' needs, interests and aspirations. Much is said about a lack in students' interpretation of experimental data and, consequently, reasoning strategies, social interactions and language do not cooperate in the construction of a scientific knowledge permitting to interpret phenomena.

Contributing with new ideas to enhance the quality of chemistry teaching is a challenge. Current didactics of science (DoS) emphasises the need to establish relations between experiencing, writing and thinking; the importance of attitudes; the new models of evaluation; the information and communication technologies; and a new model of School Scientific Activity (SSA) [2].

From these recommendations, we consider that University can propose secondary students open projects interesting for them and in which they can act as chemists; projects that help them think on what they do and what happens by means of scientific entities and a scientific language that develops through "classroom discourse". Thus, a process of "modelling" is developed along which all cognitive dimensions grow [3] and genuine school scientific activity is generated.

University can contribute to providing these situations to secondary students; these would permit them to successfully develop their capacities of scientific thought and would promote scientific vocations. Good results obtained up till now, coinciding with those of the Summer Academy at the University of Strathclyde (Summer Academy @ Strathclyde) confirm that an interesting path has been initiated and that the University should go on organising this kind of activities.

Aims and Framework

A school scientific activity is an activity in which experimentation, modelling and “regulating” discussion intertwine to promote a reconstruction of phenomena. The process that takes place when students “give meaning” to the facts that they observe, building increasingly complex relations and explanations, has received the name of “modelling” [4]. Our investigation focuses on the identification of the “modelling” process of chemical phenomena; for this, we organise “settings” for students to develop a “chemical activity” with a high degree of autonomy.

The activity that we propose and analyse in this communication has as aim introducing students in the “model of chemical change” by means of a workshop of two hours forming part of the 15-day-programme of project Ithaca, organised by the UAB for students in 3rd year of ESO (aged 15) from different Catalonian public schools. The proposal is based on obtaining salt from ingredients that can be found at home, but that should be previously identified; the ingredients should contribute the elements of salt and should be able to interact between them. We intend to generate “chemical criteria” to act according to the purposes of chemistry (transforming materials, controlling processes, identifying chemical changes…), rather than writing formulae without understanding them. The title of the activity is “Do not let us being deceived by the aspect of materials”; we wanted with it to draw the attention onto the identification of substances, which should take into account both their physical and chemical properties. We intend that students, through what they do, say, ask and respond, put in action different aspects of chemical change.

The new context of “scientific activity that University offers secondary students facilitates the modelling process. Our working hypothesis, which is also that of project Ithaca, is that, with all this, the best conditions are given for the introduction of the theoretical approaches of the disciplines: following Giere [5], the “theoretical models”. We presented the activity by means of a narrative, in order to contextualise the concepts to learn and the experiments that had been done in class [6]. The following problem was presented: A group of friends are isolated in a remote cabin surrounded by snow, and they need salt for the water-treatment system. Can they obtain it? To solve the problem, students needed to identify

Na_2CO_3 and HCl from among several flasks with different substances that were found in the cabin. They also manufactured an indicator with red cabbage. Once students identified the reagents, they had to obtain salt by making them react and adjusting the proportions so that the final pH was the adequate. Finally, the solution was evaporated in a bath of sand in order to collect the salt and carry it back home.

Once students discussed what they had done, they wrote a report. Due to the characteristics of the workshop and the little time available, we provided students with a set of vignettes that were mixed up and only in part reproduced the situation that they had lived (*e.g.,* the dialogues between friends were incomplete and some vignettes were empty for students to write or draw in them).

In our investigation, we analysed these reports and characterised the different interpretations that students do of the chemical activity that they had carried out. We are interested in identifying indications showing that students understand the main ideas suggested: salt can be obtained from other substances by means of a chemical change; in order to do this, they should use substances that contribute with the elements chlorine and sodium; substances have characteristic properties that permit to recognise them. Due to the modality of final report that we have chosen, we also deem interesting to identify the transformations that students introduce in the set of vignettes and the expressive quality of the final documents produced.

Methods and Samples

Data collected correspond to the reports elaborated by students (aged 14–15) that participated in the activity. In each workshop, we worked with a group constituted of 12 boys and 12 girls coming from different Catalonian schools that participated in project Ithaca of the UAB during 15 days of the months of June and July. Data analysis permitted to identify variables allowing the characterisation of reports; these variables were organised in a network.

Results

The activity has been carried out for three years; the first year, we worked with four groups, and the two following years, with 12 groups. The reports analysed are those corresponding to the third year of activity; they show that students are grasp the main ideas that we wanted to suggest to them and of organise the final reports in a creative way. From the different "paradigms" of the network, and from the analysis carried out up till now, we have been able to identify different typologies of reports:

- *Type A:* Students adapt to the frames contributing a few new ideas. Purposes are planned in the first frame and they refer to “obtaining sal”, without keeping in mind the title of the activity (paradigms 1, 5, 12).
- *Type B:* Similar to type A, but giving greater emphasis to the recognition of materials (paradigms 1, 5, 4, 11, 13).
- *Type C:* Students add relevant new information, use an academic style and provide scientific evidence: 2–2 or 2–1, 4, 9 or 11.
- *Type D:* Similar to type C, but using personal style: 2–2, 2–1, 6 or 10.

As it has already been said, the analysed reports came from 12 different student groups. We have found resemblances in the reports within one group; it seems that some students or group tutors gave suggestions or drew attention on details that have greater presence in the final documents.

We consider that the activity has had positive results and that students have learnt some chemistry; nevertheless, chemical change still does not have the presence that it should in students’ reports; students seem not to give importance to the difference between “mixing” and “reacting”. Some of them go on saying that salt is a mixture of sodium carbonate and hydrochloric acid, although they know that salt is something completely different. The message that we intended to communicate with the title of the activity “Let us not be deceived …” was not correctly interpreted by students.

Conclusions and Implications

The workshop is going to be repeated this summer, revolving around a different topic. We will insist on the difficulties of interpreting chemical change and the differences between substances through experimental evidence. Results confirm that the main chemical ideas: 1) a substance can be obtained from other substances through a chemical change, 2) we must use substances that contribute with the necessary elements and react, and 3) substances have characteristic properties that permit recognising them, are better understood if pupils can act in an autonomous way.

It seems to us that the proposal of preparing a report with ready-made images that students should reorganise is valid, since students used the images according to their own interests and with the ideas that they wanted to communicate.

Project Ithaca of the UAB has been very positively valued by students and their families, as well as by their teachers. We consider that our working hypothesis is adequate and that we should continue to develop it.

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ECTNA, A Major Actor in European Chemistry Education. Eurobachelor® / Euromaster Quality Labels and EChemTest Assessment Tool to Ease Students Mobility.

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Summary. The European Chemistry Thematic Network Association is composed of over 160 major European institutions from 30 countries. Among others, ECTNA has developed the Eurobachelor® / Euromaster labels, a quality label in chemistry, approved by EuCheMS; and the EChemTest, the European Chemistry Test, an evaluation tool dedicated to chemistry assessment.

Introduction

ECTN, is the European Chemistry Thematic Network, a network created in 1996 under the Socrates and Thematic Network frames, and composed of over 160 major European institutions from 30 countries. Supported by the European Commission funding and by its non-profit and self-sustained association ECTNA [1], and coordinated by Prof. Anthony Smith (CPE Lyon, France).

The ECTNA involves its members in various fields of chemistry education research in the context of the future European Higher Education Area. Two of them are of major interests: Eurobachelor® label / Euromaster Label and EChemTest and will be highlighted in this presentation. Other projects are visible online in the network section [2] but we are always seeking for new developments and cooperation across Europe, to guarantee the widest and most representative approach, to promote student mobility and industrial recognition. Professor Antonio Lagana (University of Perugia, Italy), is the actual President of the ECTN Association.

Eurobachelor® / Euromaster

One of the major activity developed by the ECTNA and approved by the EuCheMS, is the Eurobachelor® and Euromaster labels [3]. Accreditation, with quality labels in chemistry, are awarded to Universities following the Bologna process.

The current Label committee, in office until 2008, is composed of Prof. Raffaella Pagani, Chair, (University Complutense of Madrid, Spain), Prof. Terrence Mitchell, General Secretary, (University of Dortmund, Germany) and elected members from different country states.

With 29 labels awarded to 21 institutions from 11 countries during the pilot phase 2004–2006, we are now seeking to extend the partnership and cooperation with other national institutions. We recently reached an agreement with the three first national accreditation agencies, ASIIN in Germany [4], RS•C in the United Kingdom [5] and SCI in Italy [6].

EChemTest

Another important activity sustained by ECTNA, is using the information technology to develop the "EChemTest", an evaluation tool dedicated to student's mobility and chemistry knowledge assessment and evaluation [7–9]. Available in different European languages, the demonstrator version is accessible free of charge on the Internet; the second product is dedicated to certification process, to help candidates willing to prove their level of chemistry knowledge in the student or professional exchange context. To run this certification process, we are currently deploying this Internet-based plate-form in Test centres located in 8 different countries during a pilot phase. Most of the centres has already started their activities.

Working groups

Among others, ECTN has set working groups devoted to activities towards student's employability, to help new university teachers in chemistry, to work on innovative technology, *etc.*, providing education reports and studies at European level, oriented to the chemistry education in the context of the European higher education area. For any further details visit our websites or contact us.

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[2] ECTN Network: *www.ectn.net.*
[3] Eurobachelor® / Euromaster: *www.eurobachelor.eu* .
[4] ASIIN, Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik e.V., Germany: *www.asiin.de.*
[5] RSC, The Royal Society of Chemistry, United Kingdom: *www.rsc.org*.
[6] SCI, Sociéta' di Chimica Italiana, Italy: *www.soc.chim.it.*
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Determination of Variables Affecting Secondary School Chemistry Teachers' Technology Utilization Skills In Teaching Chemistry

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Summary. This study was planned in order to assess secondary level chemistry teachers' knowledge related to the utilization of technology and computer literacy. It was assumed that the determination of the variables affecting technology and computer utilization would contribute to taking the necessary precautions for possible problems. The training of teachers and administrators, who would play the primary role in applying technology in education, is as important as equipping the educational institutions with technology. Introducing technology to the faculty would never be enough for its utilization. Teachers have to be trained in learning activity organization skills by utilizing technology as well as the new teaching methods [1]. With this aim, secondary school chemistry teachers were administered the adequacy survey related to the utilization of computer and educational technologies, which was developed by [2]. In the evaluation of the results, it was determined that such variables as gender, experience and school types were effective on chemistry teachers' knowledge levels and some recommendations were made.

Introduction

Keeping up with the developing world could be possible by being aware of the technological developments and applying them in real life. This could be done through bringing up individuals, who would notice and understand the importance of technology in human and social life. Modern human beings could be defined as the individuals, who could utilize the technology of their times. The effective utilization of technology at schools is very essential; because, gaining new perspectives and developing commenting and discussion skills are skills that could be developed with the opportunities created by technology. The concept of technology utilization and computer literacy is an unlimited world where all course topics are involved. Effective and conscious utilization of technology in chemistry classes is almost an obligatory part of an efficient chemistry education. Determination of effective learning strategies for productive teaching of chemistry could be actualized by equipping chemistry teachers with technology utilization and computer literacy skills. There are many studies on assessing teachers' knowledge related to technology utilization and computer literacy [3]. Many studies had concluded that the negative attitudes developed in faculties, where technology utilization is the subject of training, affected student teachers' attitudes negatively [4–6].

The Purpose and Aim of the Study

This study aimed to determine the skills and attitudes of secondary level chemistry teachers regarding the utilization of technology.

Method

In this study, the descriptive method was used in order to determine the skills and attitudes of secondary level chemistry teachers regarding the utilization of technology.

Data Collection Tools

The survey form developed by [2], which questions the technology utilization skills and computer literacy of science teachers, was administered. The form was translated into Turkish and integrated for chemistry teachers by [7].

FINDINGS

The findings of the attitude and adequacy survey regarding the secondary school chemistry teachers' utilization of computer and educational technologies are displayed in Table 1 (Questions 9–18).

The significance of the gender was determined as a factor affecting secondary school chemistry teachers' attitudes towards utilizing technology. The average attitude scores of female teachers was found to be 40.35, whereas that of the male teachers was 36.09. Female teachers displayed a higher average than the male teachers' in terms of attitudes towards the utilization of technology. Looking at the significance of teachers' attitudes towards the utilization of technology and their years of experience, it was found out that teachers with 0–10 years of experience had higher average attitude scores than the ones with 11–20 years or 21–30 years of experience. Then, a possible significant relationship was sought between teachers' attitudes towards the utilization of technology and the school types they worked at. The average attitude scores of the chemistry teachers of Anatolian High Schools were higher than that of private school teachers. Similarly, the average attitude scores of the chemistry teachers of private schools were higher than that of regular high school teachers. Consequently, the average attitude

Table 1. Comparison of the average attitude scores in terms of school types

school	N	Mean	Std. Deviation
Private School	11	40.0000	0.0000
Anatolian High School	25	44.1200	0.8327
Private School	11	40.0000	0.0000
Regular High School	40	35.6500	2.4760
Anatolian High School	25	44.1200	0.8327
Regular High School	40	35.6500	2.4760

Table 2. The *t*-table regarding the comparison of average attitude scores in terms of school types: (1) Private School, (2) Anatolian High School, (3) Regular High School

	F	Sig.	*t*	d*f*	Sig. (2-tailed)
1 *vs.* 2	1.758	0.194	– 16.277	34	0.000
1 *vs.* 3	13.217	0.001	5.784	49	0.000
2 *vs.* 3	18.395	0.000	16.489	63	0.000

Table 3. Comparison of the average attitude scores in terms of years of experience

years	N	Mean	Std. Deviation
1–10	9	44.000	2.0000
11–20	54	38.019	4.0492
1–10	9	44.000	2.0000
21–30	13	40.000	3.8730

Table 4. The *t*-table the regarding Comparison of the average attitude scores in terms of years of experience: (1) 1–10 years, (2) 11–20 years, (3) 21–30 years

	F	Sig.	*t*	d*f*	Sig. (2-tailed)
1 *vs.* 2	34.602	0.000	4.323	61	0.000
1 *vs.* 3	6.224	0.021	2.833	20	0.010

Table 5. Comparison of the average attitude scores in terms of gender

years	N	Mean	Std. Deviation
female	53	40.35	4.3416
male	23	36.09	2.1087

Table 6. The *t*-table regarding the comparison of the average attitude scores in terms of gender

	F	Sig.	*t*	d*f*	Sig. (2-tailed)
male *vs.* female	16.346	0.000	4.482	74	0,000

scores of the chemistry teachers of Anatolian High Schools were higher than that of the regular high school teachers. The results of the statistical analysis, which was done in order to determine the level of technological tool utilization in classes, it was found out the attitude scores of the "novice" group was higher than that of the "intermediate" group. In other words, the chemistry teachers, who defined themselves as "novice" regarding technology utilization, were found to have more positive attitudes than the ones that defined themselves as "intermediate level". The chemistry teachers , who expressed that they were at "advanced level" regarding the utilization of technological tools, were detected to have more positive attitudes than their colleagues, who defined themselves as "novice" or "intermediate".

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Research-based development of courses in chemistry education for future chemistry teachers

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Summary. University education of future chemistry teachers includes both content and pedagogical content knowledge. At the University of Oldenburg a new design of a first module in chemistry education has been developed, accompanied by researching future chemistry teachers PCK. The new structure is aiming at connecting the students´ own content learning with the reflection of future teaching and learning situations.

Introduction

Lee Shulman declared in 1983 the research on teacher's cognition as a missing element within educational research and introduced the term "pedagogical content knowledge" (PCK). He defined PCK as an important part of teachers´ professional knowledge, next to curriculum knowledge, subject matter knowledge and other categories [1]. In the last 20 years, different researchers of chemistry education have applied the term PCK for chemistry, and different studies about chemistry teachers´ PCK have been carried out [2]. These studies have investigated the PCK of teachers in practise, probably due to the following assumption made by Van Driel, De Jong and Verloop [3]: *"… we may suggest that (a) disciplinary education, naturally, constitutes the basis for knowledge of subject matter, (b) observation of classes may promote the knowledge of students´ conceptions, (c) classroom teaching experiences may stimulate the integration of subject matter knowledge and general pedagogical knowledge, thus contributing to the development of PCK, and (d) specific courses or workshops during teacher education have the potential to affect PCK …"*. This statement might lead to the hypotheses that PCK could only be developed based on a strong experience of teaching practise. However, the German system of teacher education implies courses of education in chemistry ("Fachdidaktik") already from the beginning. Students who are planning to become a teacher choose different Bachelor- and Master-courses as those who are planning to become a scientist (even though there is a strong overlap during the first two years). The teacher education system is divided into three steps: (1) a University education of four or five years (a three-year-Bachelor degree and a one or two-year-Master degree), (2) a pre-service teacher education for two years and (3) in-service training (mostly voluntary).

The interesting question arising from the statement of Van Driel *et al.* is weather or how far the development of aspects of PCK is already possible to achieve during university studies and how this development could be structured and supported through all phases of teacher education. For the design of our new Bachelor modules in chemistry education, we have therefore started to investigate the student teachers´ background, both regarding their content knowledge and their abilities in certain areas of PCK.

Theoretical Background

The teachers' knowledge base was divided by Shulman (in [2]) into seven categories: (1) content knowledge, (2) general pedagogical knowledge, (3) curriculum knowledge, (4) pedagogical content knowledge (PCK), (5) knowledge of learners and their characteristics, (6) knowledge of educational contexts, (7) knowledge of educational ends. PCK is described as: "[PCK] *represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction"*.

Baumert, Neubrand *et al.* have additionally integrated the dimensions of believes and motivation into the model of teachers´ professional decision-making and responsibility (Fig. 1). Based on this model, they have investigated correlations between the different dimensions for mathematic teachers and the effects of different specifications on their students´ learning. First results have shown such correlations between the content knowledge and the pedagogical content knowledge of teachers and their students learning results [4].

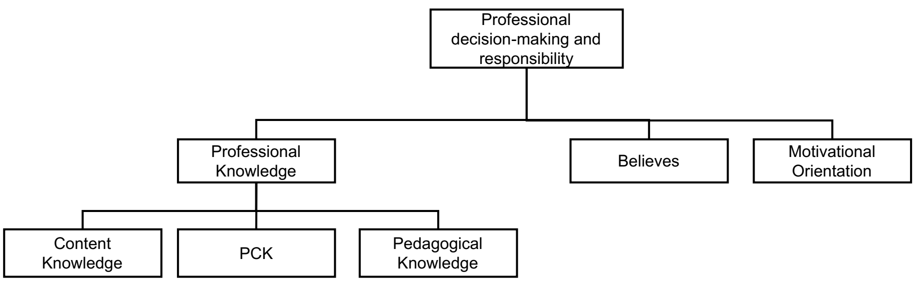

Fig. 1 Teachers' professional knowledge [4]

Referring to this model, we are aiming at investigating and characterising the background and first steps of development for chemistry teacher students at university.

Research questions and the design of empirical studies

Teacher students normally choose a subject to study at university, which they have also studied at school, at least for lower secondary education. Therefore, it will be interesting to investigate their background content knowledge and the development of content knowledge throughout their Bachelor und Master studies at university. As many students in Germany have already decided at the beginning of their Bachelor courses that they are aiming at a teaching degree at the end, we can assume that they will also have beliefs and motivational orientations about "how to become a good teacher". In contrast, we do not expect that they already have experiences of teaching or specific pedagogical knowledge at the beginning of their university time, but we assume that they might have some ideas about how to teach and learn a certain topic from their own school experience. Therefore, we are currently developing instruments to investigate the following research questions:

1) Which content knowledge do chemistry teacher students have at the beginning of their Bachelor studies? Is this background as good as the content knowledge of students who are aiming at a Science degree at the end of their studies?
2) How differentiated and on which background do chemistry teacher students evaluate different approaches and tools for teaching and learning chemical concepts?
3) How good is the self-estimation of chemistry teacher students, regarding their own content knowledge and their pedagogical content knowledge?

To investigate the students´ content knowledge, we have used a test instrument which contains items of school chemistry and 1st year-university-courses [5]. For the second question, we are giving the students tasks and descriptions of teaching and learning approaches which they have to evaluate on their own and in groups. We are analysing the results qualitatively with a special focus on the quality of argumentation (*e.g.* do they balance different reasons) and on the variety of the perspectives in their arguments (*e.g.* the perspective of the content structure and/or the perspective of the students´ interests and pre-knowledge). The questionnaire developed for the third research question contains items of interest and self-efficacy [6, 7] for the different areas of a chemistry teachers´ professional knowledge, in particular looking at content learning and pedagogical content knowledge. This data has been analysed quantitatively, similar to the content knowledge test.

First results and outlook

The content knowledge test shows similar problems for all 1st year students [5]. No significant differences between students aiming at a teaching degree and students aiming at a science degree have been found in the first trials. First impressions of the qualitative analyses of PCK aspects show that chemistry teacher students evaluate tasks and approaches of teaching and learning mainly on the base of their own learning experiences from school. The major perspective of their argumentation is the content structure of the topic. However, some students also integrate thoughts about students´ interests and daily-life knowledge. Further analyses are currently being carried out for the second research question.

Based on the results and impressions of the empirical studies and based on theoretical reflections of chemistry teacher education, a new structure of a first module in chemistry education has been designed and will be optimised this year. In the first part of the course, the teacher students will have to reflect their own learning at school and at university. In the second part of the course, they will be asked to use this background as well as the lectures on theories about the teaching and learning of chemistry (*e.g.* on motivation, pre-concepts, learning difficulties, school experiments, media) to evaluate different approaches and tools of chemistry teaching and learning systematically.

In the future, a systematic comparison between Bachelor students, Master students, pre-service teachers and in-service teachers is planned, too.

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Development of Organic Chemistry Teaching /Learning Environment for Health and Life Science students

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Summary. Over the last years the two-cycle study period has been shortened from 4+2 to 3+2 academic years for bachelor/master studies in the University of Latvia. Professional medical study programs have also been revised and contact hours for chemistry studies have been reduced. Due to these changes the content and methods of organic chemistry program for non-chemists need to be renewed in order to increase the efficiency of teaching and improve study quality.

The model of organic chemistry study program for non-chemists has been developed on the bases of more than five year research experiences. The main goals are: sequentially connected module system, unity of theory and practice, introduction of problem solving classes and active collaboration between students and teachers.

Introduction

The study process in the higher education is constantly evolving to reflect the dynamic changes in the external environment. According to Bologna process development of harmonized learning environment and comparable degrees in the higher education in Europe is going on and it deals with perfection of programs to improve quality of educational process with an objective to promote students' mobility and graduates' employability. Over the last years the two-cycle study period has been shortened from 4+2 to 3+2 academic years for bachelor/master studies in the University of Latvia. Professional medical study programs have also been revised and contact hours for chemistry studies have been reduced. Due to these changes the content and methods of organic chemistry program for non-chemists need to be renewed in order to ensure effectiveness and improve study quality. Each study course has a significant role in this process.

Organic chemistry is one of the compulsory chemistry courses of the medical, pharmacy, biology and optometry study programs. Compulsory courses form the background knowledge for the specialization courses. Knowledge and skills of organic chemistry are used in biochemistry, pharmacology, toxicology, ecology etc. In many cases due to students inability to see interface of chemistry and speciality their learning motivation is rather low. In addition first year students' background knowledge in chemistry often is quite heterogeneous

The quality of studies and the efficiency of teaching depend on quality of teaching resources and learning process organization. The aim of this research is to develop positive and creative teaching/learning environment for non-chemists organic chemistry studies.

Results and discussion

Development of teaching/ learning environment is based on analyses of students' questionnaires, interviews, testing results and teachers' experience. The target group has been the first year bachelor students of health and life science programs, average amount of contact hours for organic chemistry is 4 hours per week (one semester). Teaching learning environment has been developed step by step over the last four years.

Systematic identification of problems concerning organic chemistry learning had started with a questionnaire which was completed by more than 180 students of different specialities. Results showed positive attitude and wish to get good knowledge in organic chemistry. In general students recognised the role of chemistry, especially pharmacy students; however they pointed out that chemistry studies are difficult. The main problems identified were the following:

- speciality courses are time consuming and there is insufficient time for chemistry studies,
- low background knowledge in chemistry,
- rather low motivation for chemistry studies which concerns with speciality and chemistry unclear interrelationship.

The questionnaire did not indicate any specific local problems. The problems identified can be considered as characteristic of chemistry studies for non-chemists in general.

After literature survey and after discussions with students starting from academic year 2002/03 instead of 10 small parts (tests) all course content was divided into three modules as parts of the course:

1. Basic principles of organic chemistry and hydrocarbons and arenes.
2. Monofunctional organic compounds.
3. Structure and properties of biomolecules.

For each module the aims, content and overview are presented. The modules are compulsory and sequentially connected. The progression in these parts is along helix from more simple towards more complicated problems, from general principles of monofunctional compounds structure and properties to bifunctional and polifunctional biomolecules.

The evaluation is based on the results of three modules (50 %) and final examination (60 %) including laboratory work evaluation. Some positive experience has gained in assessing progression of knowledge and skills through the all course introducing “progress coefficient”. The system promotes students self-organised learning and allows each student better plan their learning schedule at the same time it ensures continuous learning.

To identify student’s background in organic chemistry and to promote students self-assessment the diagnostic test is administered in the beginning of the semester. Tests have been developed according testing principles described by Hassan *et al.* [1]. Results demonstrate the overall background knowledge level of the group and allow making small adjustments in the course contents presentation. The results are categorized in three levels: excellent and good, satisfactory, week. Every student gets feedback about his or her individual background.

Laboratory practices are based on unity of theory and practice and the development of problem solving skills is emphasised. Laboratory exercises are based on identification of compounds using chemical methods and spectral and chromatography date. Each laboratory practice starts with short discussion on independent work on compounds under investigation.

The 40% of whole contact time is devoted to revision lectures which begin with short question-answer sessions. Since the last two academic years e-learning elements have been included as well. On line - theoretical material contains problem solutions and explanations. Traditional topics of organic chemistry are illustrated with speciality oriented examples. The 95% of students used this material and estimate it as a helpful tool for learning.

A package of training exercises for module has been prepared. Tutorials are organised as seminars and in addition e-mail system is used. The emphasis is on intensive collaboration between students and teachers throughout the semester (in laboratory, in seminars or current tutorials, in lectures and by mail).

The analysis of the course evaluation questionnaires completed by students at the end of the semester after examination indicates that students positively evaluate learning process organization. They choose to use the module format of the course and appreciate different types of tutorials offered. Based on empirical observations students are enthusiastic and grateful for provision of the e-course materials in combination with different types of tutorials, however, these opportunities are mainly used by the students who had demonstrate high level of conscientiousness and had high attendance rate These students in general achieve better results.

The final course grades are categorized in three levels A (8–10), B (5–7), C (4 and below) in the 10 point grading scale to compare with the initial level of knowledge as indicated with diagnostic test. Analysis of these results shows that 95% of the students with excellent/ good background at the end of the course get the A level grade. On average 20 % of the students with satisfactory level of background knowledge also get the A level grade at the end of the course. This percentage is highly variable in different groups. On average 45 % of the students who started the course with weak background knowledge complete the course with B level grade and 2-3% get the A level final grade.

Conclusions

The module system has been introduced that facilitates students self -organized learning. The grades of each module and examination as well as the progression of the acquired knowledge and skills contribute to the final grade.

In order to ensure the quality of intensified study process the positive teaching/ learning environment based on active collaboration between students and teachers has been developed.

Analysis of the course evaluation questionnaires indicate that speciality topics included in the e-course do not have significant impact on the students' learning motivation. In general students' activity and effort are promoted by students' sense of responsibility rather than interest in the subject.

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Structured Study of Chemistry Teaching at University of West Bohemia in Pilsen

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Summary. The survey of a new chemistry teaching study at the University of West Bohemia in Pilsen is introduced. The main feature of the study is its division into two parts: a bachelor study and a continuing master study. A brief characteristic of the study programmes of both the stages is given.

Introduction

In accordance with Bologna Declaration [1] the very first programme introduced at the Faculty of Education at the University of West Bohemia (UWB) was the bachelor study programme called Science Study followed by continuing teacher--training master programmes within the study programmes Teaching at Basic School and Teaching at Secondary School. These new study programmes were accredited in 2004 and since the academic year 2005/2006 they have replaced the original five-year master programmes [2, 3].

The study programme Science Study and continuing teacher-training master study programmes [2]

The bachelor study programme *Science Study* includes the following majors: Study in Mathematics, Biology for Education, Physics for Education, Geography for Education, Information science for Education and Chemistry for Education. Within the study programme Teaching at Basic School the following majors have been accredited – teaching of chemistry, biology, mathematics, physics, geography and information science; and within the study programme Teaching at Secondary School the following majors have been accredited – teaching of chemistry, physics, geography and information science.

In the process of working out the bachelor – and continuing study programmes the crucial postulate was taken into account, of teachers' getting a master degree. Its total amount of credits reaches 300 credits. The total credit amount of the bachelor study programmes is 180 credits and the standard time of study is 3 years. The continuing master programme is value 120 credits and the standard time of study is 2 years. The programmes are organized into modules, so that students have a chance of choosing variably their curricular procedure.

<table>
<tr><td rowspan="4">3rd year</td><td rowspan="8">Bachelor Programme

Science Study</td><td rowspan="8">180</td><td rowspan="2">ST</td><td colspan="2">Bachelor Work</td><td colspan="2">3</td></tr>
<tr><td>PPD</td><td>MC</td><td>AC</td><td>Subsidiaries</td></tr>
<tr><td rowspan="2">WT</td><td colspan="2">Bachelor Work</td><td colspan="2">2</td></tr>
<tr><td rowspan="4">Pedagogical and Psychological Disciplines 10</td><td rowspan="4">Main Column 55</td><td rowspan="4">Adjacent Column 55</td><td rowspan="4">Subsidiaries 25</td></tr>
<tr><td rowspan="2">2nd year</td><td>ST</td></tr>
<tr><td>WT</td></tr>
<tr><td rowspan="2">1st year</td><td>ST</td></tr>
<tr><td>WT</td><td colspan="2">Fundamentals</td><td colspan="2">30</td></tr>
</table>

Figure 1. Bachelor study programme – two majors (*WT – winter term, ST – summer term*)

<table>
<tr><td rowspan="4">3rd year</td><td rowspan="8">Bachelor Programme

Science Study</td><td rowspan="8">180</td><td rowspan="2">ST</td><td>Bachelor Work</td><td colspan="2">3</td></tr>
<tr><td>MC</td><td>AC</td><td>Subsidiaries</td></tr>
<tr><td rowspan="2">WT</td><td>Bachelor Work</td><td colspan="2">2</td></tr>
<tr><td rowspan="4">Main Column 60</td><td rowspan="4">Adjacent Column 60</td><td rowspan="4">Subsidiaries 25</td></tr>
<tr><td rowspan="2">2nd year</td><td>ST</td></tr>
<tr><td>WT</td></tr>
<tr><td rowspan="2">1st year</td><td>ST</td></tr>
<tr><td>WT</td><td>Fundamentals</td><td colspan="2">30</td></tr>
</table>

Figure 2. Bachelor study programme – one major (*WT – winter term, ST – summer term*)

The bachelor major Chemistry for Education

Within the bachelor study programme *Science Study* students can choose the major *Chemistry for Education.* Having finished their first term, they are to choose either pedagogical or professional direction, within the frame of this major. In the case of pedagogical direction, the study includes two majors (*see* Fig. 1); students choose credits from the chemistry major (55 credits), credits from the other major (55 credits) and credits from pedagogical and psychological disciplines (10 credits). In the case of professional direction (specialisation *Applied Chemistry*) the study consists of one major (*see* Fig. 2); students choose the subjects of professional direction (60 credits from the main column, and another 60 credits from the adjacent column). Every type of the bachelor study programme includes the module of Subsidiary (25 credits) and in the first term the module the Fundamentals (30 credits).

A graduate in the bachelor major *Chemistry for Education* acquires basic knowledge in the major of chemistry (main column) and knowledge in the other chosen major (adjacent column) which are essential for the continuing teacher--training master study. By choosing appropriate elective subjects (adjacent column), students can obtain deeper knowledge in chemistry, and thus get a chance to continue their professional study of chemistry at another university.

Syllabuses of the bachelor study

All the majors of the bachelor study programme have the obligatory *fundamentals* in common, which includes the fundamentals of the sciences (mathematics, physics, chemistry, biology, geography, information science).

Main column contains the basic subjects of chemistry (general and inorganic chemistry, organic chemistry, physical chemistry, analytical chemistry, biochemistry). It also includes chemical calculations, informative systems in chemistry, chemical laboratory methods, chemical technologies, and laboratory practice in the above mentioned subjects.

Adjacent column in a two-major study programme it includes the subjects of the other chosen major (mathematics, physics, biology, geography, information science). *Adjacent column* in a one-major study programme it includes elective and specialized subjects of the major itself – chemistry. In this way, students have a possibility of completing their specialization for the continuing non teacher--training master programme.

Pedagogical and psychological module is incorporated only into a two-major master study programme. It contains basic pedagogical and psychological disciplines, biology of a child for teachers, multicultural education and observation practice.

Subsidiary module includes humanities, pedagogical and psychological disciplines, foreign languages, physical education and information technologies.

Continuing teacher-training master study programmes and majors [2]

The structured study and newly accredited master majors Chemistry Teaching at Basic School and Chemistry Teaching at Secondary School make it possible for the graduates in the bachelor major Chemistry for education to continue their study. These majors make it also possible for the graduates from other universities as well as non-graduated teachers to get the teacher's qualification.

Syllabuses of continuing teacher-training master study programmes Chemistry Teaching at Basic School and Secondary School

The syllabuses consist of individual modules.

Didactic module includes pedagogical and psychological subjects, student teaching and didactics of both majors. In the field of chemistry these are: didactics of chemistry (Basic School or Secondary School), techniques and didactics of school experiments (Basic School or Secondary School), ICT (information and communicative technologies) in teaching chemistry, special seminary in didactics of chemistry, history of chemistry, calculating tasks in teaching of chemistry, methods of research in chemistry and didactics of chemistry.

Module 1 is the module of the first major – chemistry. It includes obligatory subjects (structure of matter, toxicology, chemical excursion) and elective subjects (e.g. macromolecular chemistry, fermentation chemistry and biotechnologies, environmental chemistry, food chemistry, everyday life chemistry, chemical industry of the Czech Republic).

Module 2 is the module of the second major.

Elective subjects include the individual choice of various subjects.

The difference between the study programmes Teaching at Basic School and Teaching at Secondary School lies in the special - didactic subjects ratio covered by the Chemistry Department. In the programme Chemistry Teaching at Basic School it is the input of didactics that is enhanced, whereas the programme Chemistry Teaching at Secondary School is focused on maximum qualification. Some other differences are connected with the composition of the subjects included in the Module 1 and the Module 2. In the programme Chemistry Teaching at Secondary School there are two more compulsory subjects included into the Module 1 – instrumental analysis and laboratory practice in instrumental analysis, and one elective subject chapters in inorganic and nuclear chemistry.

Conclusion

The study based on the principles of the new study programmes at the Faculty of Education of the University of West Bohemia was initiated only two years ago. Therefore, possible changes of the syllabuses can be introduced only after the evaluation of the whole study by the first graduates.

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Chemistry in Lithuanian Schools and University of Technology

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Summary. Profiling, state examination system in Lithuanian school and studies in faculty of chemical technology of Kaunas University of Technology, computer aided programmes briefly discussed in the article.

Profile teaching

Since 2000, profile teaching has been introduced at Lithuanian schools. At the end of the 10th class pupils choose only one subject from natural sciences (chemistry, physics or biology) to study during the last two years at school. The aim of the profile teaching was to decrease the school load. Did the profile teaching decrease the school load of the scholars? The opinion poll of the last year pupils of the Gymnasium of Kaunas University of Technology (2002) was: 60 % profile teaching is negative; 30 % profile teaching is positive; 10 % didn't have opinion.
The decision of this poll was:

- The older the person gets, the better she/he understands the benefits of the general education.
- The younger the pupil is, more happy she/he is when few lessons disappear from the time table.

The negative influence of the profile teaching experiment is felt while teaching chemistry to the students of chemical specialities as well as the ones of nonchemical specialities. The opinion poll of 165 first year students of the Faculties of Informatics and Fundamental Sciences has revealed that the number of pupils choosing chemistry in the last grades decreases (Table 1). Therefore, nobody should be surprised by the results of the examination at the university (Table 2).

Table 1. Opinion poll of the 165 first year students-nonchemists (2003/2004) of the Faculties of Informatics and Fundamental Sciences

Question	Option	Number of students
Studied	At school	122
	At gymnasium	43
Profile	Humanitarian	6
	Real	159
Course	General	151
	Expanded	14
Image of chemistry	Positive	95
	Negative	70
Did she/he study chemistry	Yes	120
during the last 2 years?	No	45

Table 2. Examination grade of students-nonchemists (Module P401B401 Chemistry) in the year 2004/2005. Number of students 103 (from the initial number of students 145, *i.e.* the 37 % of initial students failed). For comparison, at the Faculty of Chemical Technology 28 % of first year students failed examination in 2004/2005 and 30 % in 2005/2006.

grade	number	%
10	–	–
9	9	8.73
8	8	7.77
7	13	12.62
6	30	29.13
5	43	41.45

State examination

2002 was a crucial year because since then schools turned to profile teaching completely. The increasing number of scholars failing examinations over the last 5 years (the number of scholars taking examinations hasn't changed much ~50 000) is an alarming phenomenon. *When the fraction of pupils failing examination is more than 10 % it is a sign that the critical point has been reached.* This is especially typical to examinations of Lithuanian and English languages, mathematics and history, *i.e.* examinations that are chosen most often by the scholars. We should be alarmed already when the fraction of failures reaches 5–7 %. The programmes of the subjects taught at schools must be fitted to the level of the pupils, because the information flow is increasing steadily. Though a person should use her/his memory more and more, but she/he is not capable of that. Despite the initial goal of profile teaching to decrease the load of pupils, it did not serve the purpose, because pupils wanted to protect themselves and studied more subjects. The programmes of different subjects are overloaded. It is often the case that school programmes “climb” into university level. School programmes should not be overloaded, because *“less can be more”.* Therefore, the following suggestions have been given to the Ministry of Education:

1. To teach all subjects at school and to provide the basic education in all subjects.
2. To resign profile teaching because it did not decrease the school load of scholars.
3. To decrease education programs of all subjects by 15–20 %.

This would help in better assimilation and use of the gained knowledge and the *motive* to study would be provided. The *basic education* should be provided by schools.

Profile teaching in Lithuania will be change since September, 2007. The compulsory core of general education will be 60 % of teaching time; and the rest time will be designated to the lessons chosen by pupils.

State examination of chemistry (main session)

If in 1997–2000 approximately 800 pupils took the state examination each year, later this number kept increasing. One of the reasons of this phenomenon could be creation of the *detailed* “Programme of maturity examinations. Chemistry”, invariability of requirements and the same members of the commission preparing the examination. Thus, the number of scholars failing the state examination of chemistry is minimal (Table 3).

Table 3. Data of state examination of chemistry (main session; Number of pupils who took school examination has decreased from 2811 in 2000 to 1684 in 2006)

Year	2000	2001	2002	2003	2004	2005	2006
Number of pupils	793	980	1214	1341	1696	1755	1852
Maximum of points	93	100	100	100	100	100	100
Obtained maximum of points	93	98	99	98	96	98	97
Minimum of points	31	20	17	18	17	18	20
Average of points	67.0	49.9	50.6	53.0	51.3	53.9	55.5
Fail, %/number	1.5/12	5.5/52	4.0/46	2.8/36	3.0/49	1.7/30	1.0/19

Increasing qualification of teachers

Annual conference "Chemistry at school" is the only event for teachers of chemistry that helps them to increase their qualification. If in order to teach scholars and get them interested in chemistry "Extramural School of Chemistry Knowledge" and internet site *http://chemija.mums.lt/* have been created, national Olympic games and acad. J. Janickis competition are organized, different events for motivated pupils are held by "National Academy" at the Gymnasium of Kaunas University of Technology, teachers of chemistry are left aside. Since the Association of Chemistry Teachers is not active, Kaunas University of Technology took the initiative to change the situation and initiated the conference "Chemistry at school". During 6 conferences of which abstract books are published. The 95 presentations were done, authors of 30 of them were from foreign countries (Latvia, Russia, Byelorussia and Poland). The 422 participants increased qualification, 36 of them were lecturers of universities.

Computer programs

According to the polls [1], 26.2 % of pupils (30.7 % of gymnasium pupils and 24.9 % of secondary school pupils) only indicated, that computer programs were used during other than informatics lessons. Up to 84.5 % of pupils would like to use computers during lessons of physics, chemistry and geography. Only 7.1 % of pupils are against such training aid during these lessons. The 73 % of pupils would wish to have their knowledge tested by computer, for example by programs-tests [1–2]. According to conclusions of analysis [3], in which "Chemistry Crocodile" programme was used, we need to organize more qualification courses for teachers and translate this programme to Lithuanian language. So far all of them are in English.

Usage of software in English at Lithuanian secondary schools obstructs acquirement of adequate education in the state language. Abundant information in English and other foreign languages drowns out native language [4]. Therefore, it is essential to uphold Lithuanian language and culture in information technologies, because pupils acquire the subject best when its computer programs are written in native language. It is said in the programme "Supplying the schools with the teaching software" [5] that all software which is included into compulsory education must be in Lithuanian language, while the one in the foreign language can be used in experimental projects of application of such software only.

We have Lithuanian computer programs of chemistry in 4 programmes:

1) In 2000 the author of this article together with his pupils created the computer program *Chemistry 2000* for Lithuanian schools. The Lithuanian Ministry of Education approved this program as suitable for usage in schools.
2) *Chemistry test.* This program should be used as testing program at the 12^{th} grade.
3) Demo program *Chemistry*. It can be used as additional visual aid during the lessons on different themes. Material was obtained from Internet.
4) *Examples of tasks.* In 2002 the new internet page providing examples of chemistry problems and their solutions was created: *http://www.ipc.lt/emokykla/vartai/chemijos_uzdaviniai/index.htm*

Teaching aids

At the Department of General Chemistry of Kaunas University of Technology chemistry module is taught to the students of non-chemical specialities in five languages: Lithuanian, English, German, Russian and French. Aiming to improve the assimilation of the course material, teaching books were published in all these languages.

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Effect of Instruction on the Future Teachers' Knowledge Structure Regarding the Solving Strategies of Chemical Problems

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Summary. Hungarian future teachers' knowledge structure regarding the solving strategies of chemical problems (stoichiometry, preparing solutions) was mapped before and after instruction using an extended version of knowledge space theory (KST). Changes in hierarchical connection of different strategies in the student's cognitive structure were demonstrated. This paper summarises the results obtained in solving stoichiometric problems on the composition of binary compounds. It was found that proportionality method was isolated in the students' knowledge structure before instruction. The KST analysis of the post-test showed a more organised hierarchical connection between the strategies (proportionality method → mole method → logical method), however the basic role of the algorithms thought at school could not be changed essentially by the instruction.

Introduction

In Hungary chemical calculations are important part of chemistry education. In preparing future teachers at the University of Debrecen students have three lessons per semester on the methodology of solving and teaching chemical calculations. During this course they have to be familiar in applying different problem-solving strategies.

In the case of simple stoichiometric problems on the composition of binary compounds, *e.g. "How many grams of oxygen are there in 32,0 g SO_2?"*, there are different solving strategies: the mole method, the proportionality method, the logical method, and the factor-label method [1, 2]. (Note that the factor-label method is not a widely known method in Europe, however it is the most popular strategy in the US.)

Schmidt reported [1–3] that the high school students in Germany and Sweden successfully used their own strategy (the logical method) in solving simple stoichiometric problems, but tended to use algorithmic methods (the mole method, the proportionality method) in the case of difficult problems, *e.g. "How many grams of lithium are there in 70,0 g Li_3N?"*. Contrary this Tóth and Kiss reported [4] that Hungarian secondary school students applied the strategies learned at school (the mole method and the proportionality method) in stoichiometric calculations. They also found that the success and the ratio of the mole method to the proportionality method increased with the grade of the students from the grade 7 to grade 11.

In this study we investigated the questions: (1) what kind of strategies our future teachers apply to solve stoichiometric problems; (2) what is the characteristic knowledge structure of the students regarding the solving strategies before the instruction; and (3) how this cognitive structure changes during instruction.

Methodology

In pre-test students (n = 22) were asked to solve 6 problems of different complexity. During instruction the possible solving strategies were discussed and exercised in solving a lot of problems. In the post-test students (n = 26) had to solve one problem with different methods. (Note that only 15 students participated in both pre-test and post-test.)

From students responses we could extracted different categories. These categories were the different solving strategies (the mole method, the proportionality method and the logical way). In the case of the pre-test we analysed responses as they contained the given strategy (1) or not (0) independently the fact that student could solve the problem or not. In the case of the post-test responses were also evaluated in binary fashion as student could solve the problem by using the given strategy (1) or not (0). The hierarchy of the strategies, i. e. the connections between the strategies in the students' cognitive structure was determined by using KST analysis of the data obtained from the students' group.

The knowledge space theory (KST) was developed by Doignon and Falmagne [5], and its application to science concepts have been previously demonstrated by Taagepera *et al.* [6–8], Arasasingham *et al.* [9, 10], and Tóth and Kiss. [11]. In this theory the organisation of knowledge in students' cognitive structure is described by a well-graded knowledge structure. Although knowledge space theory was originally developed for modelling the hierarchical organisation of knowledge needed to answer a set of problems, in our opinion, the formalism of this theory and the instruments for calculations can be extended to any hierarchically organised input data.

For this analysis responses were scored in a binary fashion, as they contained the given category or not (pre-test), and as the application of the given strategy gave the right answer or not (post-test). As we constructed three-item groups from the categories theoretically we can have 8 (2^3) possible response states, from the null state (000 or [0]) to the final state (111 or [Q]). A set of response states for student group gives the response structure. Starting from this response structure one can recognise a subset of response states (knowledge structure) fitted best to the original response structure (at least $p = 0.05$ level of significance). There are several methods to find the knowledge structure from the response structure. These methods have two common features: (1) Lucky-guess and careless-error probabilities (most often 0.1) for each item are estimated. (2) The knowledge structure has to be well graded (*e. g.* each knowledge state must have a predecessor state and a successor state except of the null state and the final state). Based on the knowledge structure we can determine the most probable hierarchy of the categories (represented by the so-called *Hasse* diagram) by a systematic trial and error process to minimise the χ^2 value. For the calculations a Visual Basic computer program [12] was used.

Results and discussion

Theoretically there are 19 possible connections between three categories (Fig. 1) from the totally separate state (A) to the strictly hierarchical order (E). Among these schemas we found the one fitted best to the input data (response structure of the students' group) using KST analysis.

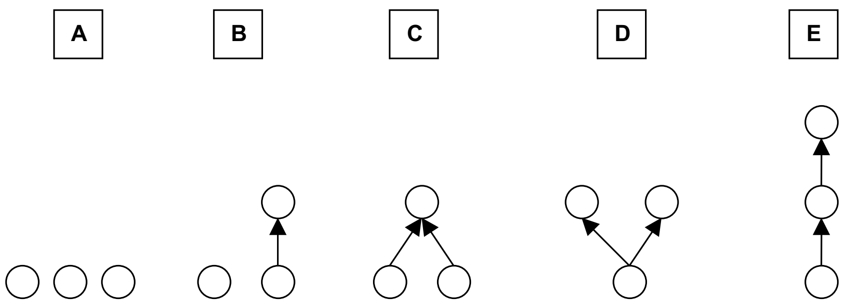

Fig. 1 Theoretically possible schemas for connection between three categories. (Number of variations in schemas: A = 1; B = 6; C = 3; D = 3; E = 6.)

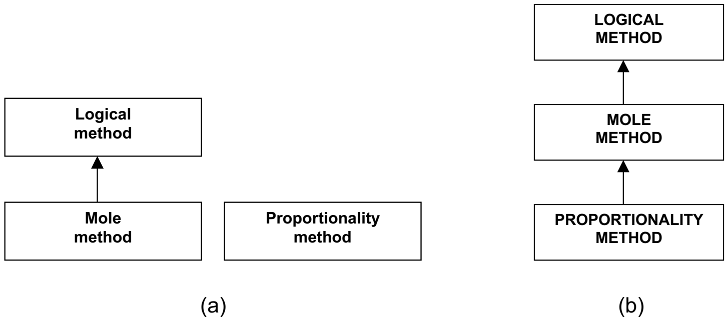

Fig. 2 The best models for representation of the future teachers' knowledge structure before (a) and after (b) the instruction.

Fig. 2 shows the result of the KST analysis both in the case of the pre-test and the post-test. It is seen that in the best models for representation of the students' knowledge structure proportionality method was isolated from the two others, and the logical method was built on the mole method. On the effect of the instruction the proportionality method was built in the hierarchy, but the logical method remained at the top of the hierarchy building on the two algorithms thought at school.

These results show that instruction has a small effect on the future students' knowledge structure regarding the problem-solving strategies. Unfortunately the basic role of the algorithms thought at school could not be changed essentially by the instruction.

The same study on another topic (preparing solutions) will also be presented.

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