EUROPEAN VARIETY IN CHEMISTRY EDUCATION

BOOK OF ABSTRACTS

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FACULTY OF CHEMISTRY, JAGIELLONIAN UNIVERSITY

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INTRODUCTION

PREFACE

For more than ten years, the Royal Society of Chemistry and the Physical Sciences Subject Centre of the Higher Education Academy in the UK have organized an annual conference, *Variety in Chemistry Education*, which has a practioner-oriented approach to chemistry education at university level. To widen the exchange of experience compassing staff from the universities of the continental Europe, this year we took the decision to organize a related conference in Poland, *European Variety in Chemistry Education-2005*.

The conference provides a forum for the exchange of ideas related to teaching and learning chemistry at degree level, the sharing of good practice and innovation, and the dissemination of outcomes of pedagogic research mapping to chemistry at university level in Europe.

Contributions on a core of key issues are presented: Chemistry for non-chemists, Practical education: the role, effectiveness and organisation of the laboratory, Student placement (internship), IT-supported education and assessment, Innovation in content, methods, and assessment, Interdisciplinarity, Relation and links between education and research, Chemical education research, Teacher training, European educational programmes and projects: examples of good, transferable practice. In addition, two general sessions are organised:

- Chemistry studies in the context of the Bologna process
- Chemical education for safety, peace and human welfare

Over 90 academic teachers from 16 European countries (Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Lithuania, Poland, Serbia and Montenegro, Spain, the Netherlands, the UK, Turkey) as well as teachers from outside our continent (Israel, New Zealand, Canada, Columbia) will participate. Six plenary lectures are to be given, as well as 40 conference communications. In addition, more than 30 posters will be displayed and there will be opportunity to participate in three scientific workshops.

The conference is under the patronage of Polskie Towarzystwo Chemiczne (Polish Chemistry Association), ECTN (European Chemistry Thematic Network), EuChemMS (European Association for Chemical and Molecular Sciences). The arrival of the guests and co-financing the stay of students and colleagues from the Eastern Europe will be made possible by much appreciated support from the OPCW (Organisation for Prevention of Chemical Weapons). The conference is organised by Faculty of Chemistry, Jagiellonian University. The organization of conference is made possible owing to the involvement and efforts of many of young people, doctoral students and academic teachers, They all deserve great thanks and gratitude. We are also very grateful to the members of the scientific committee for all their assistance, including their enormous contribution to the anonymous reviewing of the many submitted abstracts.

Finally, may I wish all conference participants a professionally fruitful time in Krakow as well as many agreeable and unforgettable impressions. Hopefully, this conference will act as a catalyst for a cycle of similar meetings in the years to come.

Iwona Maciejowska

Chairperson of the Organizing Committee

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PLENARY LECTURES

PROBLEM SOLVING AND ASSESSMENT

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Although assessment in higher education has always been a major driver for students, we rarely critically question why we assess. There are good reasons for assessment and some that are merely ritualistic. The advent of modular courses has resulted in an increase in the burden of assessment on both staff and students. Given the effort that is put into assessment, do current methods give us reliable and meaningful data?

Our recent research has involved chemistry-based courses from universities in the United Kingdom, Australia and North America. We have developed an analysis system which relates course and module outcomes to assessment methods and applied it to over 80 courses. The first observation from the work is that there is a significant mismatch between learning outcomes claimed and those actually tested in both examinations and continuous assessment. Embedded in the outcomes of many courses is a claim for the development of problem-solving skills in the students. Although there may be some attempt to develop these skills in the courses, there is little evidence that problem solving skills are ever tested. Indeed, where so-called problems do appear, they prove, on analysis, to be little more that linear, algorithmic exercises. As part of our analysis [1], we have developed a two-dimensional, classification system that can be readily applied to assessment questions and quickly identifies over-repetition of question types. Assessment analysis becomes particularly important where modular frameworks tend to make synoptic assessment more difficult.

Following on from this work, we are currently studying methods of grading of problem-solving questions [2]. Such problems are necessarily more challenging than conventional algorithmic-type problems [3] and can result in less able students performing poorly with paper assessment. We have interviewed a range of students and *orally* tested them with approaches to open-ended problems. In many cases, even less able students were able to make a reasonable attempt at a strategy for solving the problem but did not have the knowledge and skills to follow each step through. Indeed, in several cases there were examples of steps in the suggested strategy which, given greater experience and ability of the student, would have been seen not to be practicable. Nevertheless, it was apparent that these students were able to make a meaningful contribution to a problem-solving strategy orally [4] but this was not reflected in the methods that we were using for grading the paper assessment.

We set out to design a grading system for paper solutions from students that rewarded partial answers or valid contributions to a strategy but failed to take a solution right through to the end. With an algorithmic exercise there is little difficulty as an error early on can be accommodated with the student just losing marks for that error and not for the overall incorrect result. With a multi-strategy, open-ended problem such a structured marking scheme is not useful and consequently these problem types are more difficult to accommodate in science marking. What became immediately apparent is that we were asking inappropriate questions: not that the problems themselves were inappropriate but that we were asking for particular responses that did not give the less able student opportunity to perform.

The scheme constructed was to first ask students to gather together any information, observations and techniques that *might* be useful. Then they had to look at this list and to sketch out a potential route to the solution to the problem in the form of a flow chart of key steps. Students are than asked to indicate a confidence level for each step and to suggest how they might handle those steps for which they are confident. Next is to suggest alternatives for those steps for which confidence is not high. At each stage, students are asked to give an indication of the limits of precision where appropriate. This is important as these problems do not have defined answers.

The new grading scheme (together with the restructuring of the problems) was tested with students using control experiments in a comparison of paper assessment and oral, interview-type assessment. Compared with the original assessment, less able students showed a better correlation between paper and interview performance which was much closer to the correlation for the more able students (which was relatively close even with the original assessment method).

This presentation will highlight the data and statistical analysis and will be illustrated with exemplars together with interview responses.

Concurrently with this work, we are applying these ideas to the assessment of practical work which takes a major (both in time and cost) in many chemistry-based courses [5,6].

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WHAT IS SCHOLARSHIP IN CHEMISTRY EDUCATION?

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Most scholars have a reasonable idea of what scholarship is in their own academic discipline, so the first question to address becomes: "Is chemistry education an academic discipline?" Chemistry education research has set out its claim (de Jong, Schmidt et al, 1998), but although chemistry education research must be included, it is by no means the whole of chemistry education. Even when the practice of chemistry education is added, the body of knowledge on which the discipline could be founded is incomplete. We must add the methodologies, the principles, the educational techniques, the trials and errors of history, the personalities of the practitioners, and their distinctive educational philosophies. But what qualifies for admission to the definitive list? It will be a strange set of bedfellows – probably more disparate than for most disciplines. The big ideas of chemistry (Atkins 2005); interactive Web and CD-ROM based teaching materials (Chemistry Courseware Consortium); chemical misconceptions (Taber 2002); the problem solving approach (Bodner 2002); the ECTN Chemistry Test, and demonstrations of laboratory techniques (Chemistry Video Consortium) are among items for consideration. With roots like these there is a convincing basis for a scholarship to be established, but other questions then arise. How does it relate to scholarship in the parent discipline of chemistry, and in what ways is it distinct? Both require insight and innovation, both call upon observation and evaluation, both look to establish underlying principles, but the raw material to be moulded in the classroom and lecture theatre behaves very differently from that under investigation at the bench or in the spectroscopy lab. So how, and why, does a research finding or teaching innovation make the transition and become incorporated into the scholarship of chemistry education? And once there, how is it to be disseminated by the scholar, and accessed by the teacher and lecturer? Can defining a scholarship of chemistry education lead to improvements in teaching quality? And the biggest question of all: "Is an awareness of the scholarship of chemistry education of any value in improving the student learning experience?" As these and other questions are examined, in the light of recent developments, I hope that the audience will feel the question of the title is important to teachers of chemistry at every level.

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EUROVARIETY IN CHEMISTRY: ON THE WAY TO A EUROPEAN FRAMEWORK FOR CHEMICAL EDUCATION

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The LEONARDO DA VINCI network project FACE has brought together 30 partner institutions in 13 countries across Europe. FACE developed a homepage, www.face.fh-fresenius.de in which information on chemical education in European countries is gathered, also documented in a White Book [1]. From this information and numerous expert meetings, the project comes to some conclusions for European educational policy in the sector of chemistry.

Chemical education and training with integrated periods of work experience, e.g. industrial placement, have proven to be beneficial for industry and students and have a positive impact on employability. We think that a European House of Chemical Education needs to be extended and optimised under three basic pre-requisites:

Preservation of good practice in all member countries, with ways opened to transfer good practice examples into countries which decide to have them

- Enhancement of individual freedom and development through both trans-national and "trans-level" mobility in a sequence of life-long learning periods
- A fair chance for "alternating" learning models that include practical periods in the workplace, assigning credits to assessed practical periods at all levels of education

With many European partners, we want to initiate a process leading to a European system of education for the sector of chemistry which is based on the Bologna declaration; which is based on good practice in all European countries and on existing work (ECTN [2], Tuning) and models ("Eurobachelor"); which includes all ISCED levels from 3 to 6 (e.g. NVQ as well as tertiary education); which is characterised by only two formal elements: modules and degrees and which is described by only two sets of figures: credits (ECTS) and assessment grades. This would mean that the use of ECTS [3] has to be extended to vocational training. Attempts are being made in this direction.

At the end of such a process, country specific features may and will still exist. There will be multiple ways of obtaining a degree, from a continuous "classical" education in one "block" to forms of life long learning and continuing education. Each degree will be defined by minimum requirements in terms of modules to be obtained. Modules obtained once shall not be "lost" (although, after longer periods of job life, "catching up - modules" may be

necessary). The way/sequence in which modules are obtained shall leave lots of personal freedom and flexibility for learners and employers.
Specific features will be formats with integrated, clearly defined, tutored and assessed periods of practical experience in the work place. Another feature might be a basic (e.g. Bachelor) scientific and practical training followed by e.g. a Masters for future teachers (with pedagogical and didactic modules).

Possible degrees to be defined could be European "formats" of Dual training like vocational qualification, 3 years; Technical Assistant Training 2 years; Technical Schools like the HTL (A); Bachelor, 3-4 years; Master following a bachelor's degree, 2-1 years (total of 5 years) or, more radically said, formats which deliver degrees after 2, 3, 4, 5 and more years.
What is now described in years will ultimately be described in modules with credits (ECTS) and not only take into account years elapsed (which can be utterly misleading) but also workload per module and learning objectives.
At the end of the day, different national traditions may merge into a European set of highly differentiated multipurpose Chemistry qualifications. This seems still far away. Yet, it is the chemical community – school and university teachers, industrial and research chemists, and students, who have a chance to do the many small steps in such a development. We should know best what is best and find ways to agree upon concrete measures.

The paper will present concrete good practice examples for chemical education on all levels, including work placements, with appropriate case studies. It will make suggestions for action to be taken. The discussion it wants to initiate is intended to be a contribution to "Chemistry Eurovariety".

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[2] see http://www.cpe.fr/ectn-assoc/ where the initiatives Tuning and Eurobachelor are described. There is a download of the FACE White Book available.

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THE CHEMISTRY EUROBACHELOR - A FRAMEWORK FOR A EUROPEAN FIRST CYCLE DEGREE IN CHEMISTRY

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The origin and history of the development of this programme will be presented as well as its methodological base. A student oriented approach to teaching, learning and assessment methods formulated with regard to the future employability of first cycle degree holders will be summarised. Learning outcomes in terms of general and subject knowledge as well as abilities and skills will be described. Special attention will be devoted to chemistry-related cognitive abilities and competences, chemistry-related practical skills and generic competences. The content of the Eurobachelor course in a modular form and the distribution of credits with regard to student workload will be described. Students mobility and quality assurance will be underlined and Eurobachelor Label as an instrument of the international recognition of the degree qualification will be presented.

MULTIMEDIA EDUCATIONAL SOFTWARE AS MEANS FOR ATTRACTING BETTER CANDIDATES FOR CHEMICAL STUDIES IN POLAND

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Many academics involved in chemistry courses at Polish universities express concern about the level of chemical education represented by candidates for studying at departments of chemistry. The general opinion is that this level is not too high and, moreover, shows a declining tendency.

There is little doubt that this undesirable situation arises from many problems experienced by public post-secondary schools and generally related to insufficient funding. Because of limited budget, chemistry classes in many post-secondary schools do not include experiments in school laboratories. Pupils generally learn chemistry from lectures and textbooks, so they have little stimuli to develop particular interest in this discipline or to explore it on their own.

Seeing this problem and hoping for awakening more interest in chemistry among pupils of post-secondary schools, we embarked on a project of preparing a multimedia chemistry textbook for them. Multimedia techniques offer several benefits over traditional methods of teaching by capturing pupil's interest through more than one perception channels [1]. Moreover, they pass knowledge in attractive and interactive way, which increases chances for a pupil to develop interest in chemistry and related subjects. In order to ensure the most attractive shape for the mulitmedia textbook, we cooperated with the professional educational software manufacturer Young Digital Poland S.A. As the result, the new multimedia chemistry course aimed at post-secondary school students was prepared [2].

The experience gained during preparing screenplays for this and earlier multimedia textbooks [2,3] drove us to the conclusion that some elements of multimedia educational software are particularly suited to be used in teaching chemistry and are very likely to stimulate pupil's interest . They are briefly discussed below.

1. 'Real' films

'Real' films usually show experiments in chemical laboratory and give the student opportunity to see 'with her very eyes' the effects of chemical reactions. In a way, this is a substitute of real experiment that pupil had no opportunity to see in the school laboratory. Watching films pupils learn the appearances of many chemical substances (colour, structure, hardness, elasticity, viscosity, etc.), see basic operations carried out in the laboratory and observe how safety standards are met. Attractive effects of many reactions may trigger pupil's interest in the subject.

2. Animations

Animations are invaluable tool when we want to show pupils how chemistry works on microscopic level. Animations are particularly useful to show dynamic processes, eg. absorption and emission of energy by electron, orbital hybridisation, bond formation, reaction mechanisms, etc. Watching animation, pupils can actually see how certain processes occur and even difficult issues can be understood quite readily. Besides, pupils obtain much more useful information: about relative sizes of atoms, actual three-dimensional shapes of molecules, distribution of electric charge across the molecule, etc. Combinations of several animations are particularly effective, for example illustrating the reaction mechanism on molecular level with simultaneous plotting the energy diagram showing the energy changes during the reaction.

3. Simulations, virtual experiments

Simulations allow pupils to perform simple experiments on their own, using just keyboard and mouse. They can mimic real experiments, such as titrations, calorimetric measurements, identifying the reaction products. But moreover, they can also run simulations of experiments that cannot be performed in real word. For example, they can observe the potential energy changes when two hydrogen atoms approach each other. It is important that every virtual experiment ends with the derivation of experimental value: concentration of reagent in titration, specific heat capacity for a calorimetric measurement or the H-H bond length and bond energy for the simulation with two approaching hydrogen atoms. Chemistry is the experimental discipline therefore simulations are very important elements of multimedia software, giving the pupil feeling of being the real experimentalist.

The elements presented above are certainly not all the important elements of multimedia chemistry course. However, they are exceptional in expanding what a pupil can experience to the extent that is far beyond what she can get from classic textbooks and chemistry classes. This way, ‘real’ films, animations and simulations bring a new quality to teaching chemistry and may hopefully contribute to better chemical education of candidates for chemistry studies at universities.

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TRANSFORMING UNDERGRADUATE EDUCATION IN CHEMISTRY FOR PREPARING SECONDARY-LEVEL TEACHERS: THE NEED FOR A CLOSE COLLABORATION OF FACULTY IN SCIENCE AND SCIENCE EDUCATION

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Traditionally chemistry/science teachers are prepared in chemistry/science departments, receiving training only in the content of chemistry, but not in the process of learning. In recent years, in many countries, there has been a transition from this approach into one that includes additional undergraduate or postgraduate courses in education, psychology of learning, and in science and chemistry education. Is this however sufficient?

Science education research "focuses on understanding and improving science learning by studying variables relating to science content or to what the teacher or student does in a learning environment" (Herron & Nurrenburn, 1999). These two perspectives are not independent of each other: Science learning involves "a complex interplay between the more global perspective of the social sciences (i.e., the process of learning) and the analytical perspective of the physical sciences (i.e., the content)" (Herron & Nurrenburn, 1999). Therefore, knowledge of the *content* is a *necessary* but *not sufficient condition* for teaching chemistry (or any other subject); it is knowledge of the *process of learning* and *the learner* that provides the *sufficient condition*. The combination of *content knowledge* with *pedagogical knowledge* leads to *pedagogical content knowledge* (PCK) (Schlman, 1986; Bucat, 2004).

To satisfy these conditions, one then needs not just science courses plus psychology, education, and science education courses. A transformation of pure science content into PCK is necessary. In addition, emphasis should be moved from teaching and learning procedures and algorithms into concept understanding (Stamovlasis et al. 2004, and references therein). The *history and philosophy of science* (HPS) is also judged very important in shaping science content by becoming integrated with it (Niaz & Rodriguez, 2000, 2001). .Finally, the methods of teaching should change radically from the conventional lecture format to creating a constructivist and collaborative learning environment. Educational constructivism has assumed two forms (Matthews, 2000; Tsaparlis, 2001): (i) *personal constructivism*, which is associated with Piaget; and (ii) *social-cultural constructivism* which is linked to Vygotsky. The realisation of such a transformation is a Herculean job that cannot be undertaken by science educators alone. *A close collaboration of university faculty in science and in science education is required.*

Some examples from university physical chemistry will be provided to elucidate the some of the new requirements. According to Johnstone (2000) research has provided us with the tools "to harmonise a logical approach to our subject (chemistry) with a psychological approach to the teaching of our subject". Jensen (1998) proposed a scheme for the logical structure of chemistry, in which he distinguished three dimensions (composition and structure; energy; time), with each dimension treated at one of three levels (molar; molecular; electrical). Looking at university physical chemistry as it is exposed in the textbooks, one recognises that most authors follow a hierarchy (a logical sequence) which is not entirely consistent, with Jensen's scheme. Concentrating on concepts, we will discuss the impact an undergraduate quantum chemistry course had on students' knowledge and understanding of atomic orbitals, molecular orbitals and related concepts (Tsaparlis, 1997). On the other hand, problem solving is very important in physical chemistry teaching. In particular, it is crucial to provide problems with which 'students are asked to apply chemical reasoning to something approaching a real-life situation'. A study of the effect of some cognitive variables on problem solving in elementary physical chemistry will be outlined. Finally, problems of the conventional expository physical chemistry laboratory are discussed, and ways to overcome these. An attempt to accommodate an inquiry/project-based, collaborative-learning component will be presented together with its evaluation by the students (Tsaparlis & Gorezi, accepted)..

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CONFERENCE COMMUNICATIONS

TURKISH PROSPECTIVE CHEMISTRY TEACHERS' PEDAGOGICAL KNOWLEDGE: ORDERING TOPICS

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Introduction

PCK is defined as a "special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman, 1987, p. 8). This amalgamation is revealed by Shulman (1986) as "in a word, the ways of representing and formulating the subject that makes it comprehensible to others" (p.9), and he reports that PCK includes several components such as an understanding of common misconceptions of students, curriculum knowledge, and knowledge of instructional strategies. In addition, it is commonly agreed knowing about how topics ordered in the curriculum is included in PCK. Therefore, the decision of which topic to teach in order is a component of PCK. Although this definition has been made, the components of PCK have not been supported by data. The purpose of this study is to concentrate on the nature of pedagogical content knowledge (PCK) and its sources in the context of ordering topics. To clarify, the factors that could affect a teacher's decision on how to order topics will be explored.

Methodology

Data were collected in 2004 academic year from prospective chemistry teachers attending the Chemistry Education department in a university, Ankara, Turkey. This university accepts students who achieve a higher score on the University Entrance Exam than other Turkish universities do. A questionnaire containing an open-ended question about the ordering of topics was distributed to a class, 22 students. According to their responses, semi-structured interviews were carried out with three students. The main reason for the questionnaires is to get a general sense of students' responses and select some students with interesting answers to be interviewed. The question asked in the questionnaire is as follows:

In your opinion, how do you teach the following topics in which order?

- The particulate nature of matter
- Condensation
- Concepts of Mass and Volume

Research questions

- What is the PCK of prospective chemistry teachers attending the fifth year of a university in Turkey in terms of ordering topics?
- Which factors affect the PCK of prospective chemistry teachers?

Analysis

Analysis of the questionnaires indicated three main thoughts of prospective chemistry teachers. Most of the prospective teachers mentioned that they would prefer to concepts of particulate nature of matter, then mass and volume and finally condensation. Few students said that they would teach in the following order; particulate nature of matter, mass and volume, condensation topics. Few students told that they would prefer the following order; mass and volume, particulate nature of matter and finally condensation. To understand the reasons of these thoughts, we carried out semi-structured interviews with five students with three different views.

Results

A student who wrote that he/she preferred to teach the particulate nature of matter prior to the condensation and mass, volume concepts in the questionnaire explained his/her thought in the interviews by saying “For example, a change occurs in the volume of a substance or the mass of the substance does not change when we heat it. If a student does not know the particulate nature of matter, she/he can not understand the relationship between mass and volume”. From this explanation, it can be understood that this prospective teacher supports the view that students should know the particulate nature of matter to understand the mass, volume and condensation. In addition, His/her subject-matter knowledge indicating that students need to know particulate model to understand mass and volume, has become influential in deciding which topic to teach first, in a way her PCK.

Another prospective chemistry teacher we interviewed mentioned that mass and volume need to be taught before condensation and particulate nature of matter needs to be taught after topics of mass, volume and condensation. She explained the reason of her thought as; “Since students learn from concrete to abstract and among these three, mass, volume concepts are the most concrete ones and the most abstract is the particulate nature of matter”. The general pedagogical knowledge of this prospective teacher, which is students learn from concrete to abstract, has influenced her PCK. Another issue that drew our attention was that this prospective teacher memorized “students learn from concrete to abstract” as a rule to be applicable in all situations.

The other prospective teacher, who mentioned that mass and volume need to be taught before particulate nature of matter and condensation should be taught finally. She gave the below explanations in the interview; “Students need to know first what mass and volume are. After this, they can learn particulate nature of matter and mass and volume concepts can be linked with the explanation of particulate nature of matter. In this way, since their prior knowledge is linked with the following topic, the student could learn better. And finally condensation topic can be explained by particulate nature of matter”.

This prospective teacher amalgamated his/her general pedagogical knowledge and subject matter knowledge in deciding which topic to teach in what order. Therefore, both his/her subject matter knowledge and pedagogical content knowledge have become influential in the development of PCK.

Conclusion and Implications

In this study, three different decisions prospective teachers made about the order of topics to teach were discussed. The interviews with prospective teachers showed that there may be various factors such as subject matter knowledge, general pedagogical knowledge affecting the PCK. In one situation, only subject matter knowledge can be influential, in another one, general pedagogical content knowledge can be influential. In some situations, both subject matter knowledge and general pedagogical knowledge can be influential. This suggests that the relationship between different aspects of knowledge base of teachers is more complex than suggested in the literature. That is, we cannot suggest that there is always direct link between knowing the subject and knowing to teach that subject. Therefore, in teacher education programs subject specific pedagogy needs to be given more importance. Prospective teachers need to be confronted with as many different topic specific situations as possible that can be encountered in the classrooms in their method courses. They should be given chances to discuss pedagogical issues that are related to the topics in the school curriculum.

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INFORMATION TECHNOLOGY AT THE FACULTY OF CHEMISTRY AT ADAM MICKIEWICZ UNIVERSITY

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Information Technology (IT) covers computer science and communication. The main issues included in this subject are the means, such as computers, peripherals and computer networks, and the tools i.e. software and other technologies which primarily cover any issues regarding communication.

Information Technology is based on numerous computer applications and it plays a vital role in professional and social activity of man. It has become equally important as the ability to read and write used to be in the past. Its spread has exerted a vast influence on the shape of contemporary school. The need to use IT forces its users, including students, to gain certain skills which stimulate appropriate development and make studying more pleasing and less tedious, let alone less time-consuming.

According to the decision of the Minister of Education and Sport of 6 November 2003, a subject called Information Technology was introduced in Polish high schools as a continuation of Computer Science which is taught in grade and junior high schools.

The changes introduced in Polish educational system enforce a new approach to training teachers so that they could satisfy new needs of didactics and pedagogy.

The Department of Chemistry at Adam Mickiewicz University in Poznań, Poland, holds Information Technology courses which cover fifteen hours of lectures and fifteen hours of computer room classes.

Computer room classes were closely related to the issues presented during the lectures. Teams consisted of ten students, each of them working on a separate computer (ten computers in each computer room). Students began the IT course having previously done a thirty-hour basic computer handling course. The IT course covered the following computer skills:

- text and graphics using Microsoft Word ,
- graphics with the use of scanned drawings and photographs done with Photo Editor,
- making structures of chemical compounds with ChemDraw,
- making models of chemical compounds structures with Chem3D,
- preparing simulations of simple chemical processes with ChemLab,
- preparing simple didactic videos with Microsoft Movie Maker,
- making WWW sites on chemistry with Mozzila.

The purpose of the course was to familiarize students with selected computer tools allowing the use of IT in teaching Chemistry as well as to present the possibilities of IT as a didactic means and to draw the attention of the students to legal aspects regarding the use and processing of information.

The methodological concept that we propose is based on gradual implementing of the elements of the so called e-learning and remote teaching within the university level educational process. The concept involves the integration of such technical solutions as: simulation modules, internet interactive instructions, the elements of CBT, Internet hypermedia software, exercise, multimedia and interactive databases integrated within CMS sand LMS systems.The most vital feature of this method is effective individualization of the students' work which allows for unlimited introduction of the elements of the new didactics, stimulates the students' creativity adjusting their pace of work to their varying predispositions which is of vital importance in chemistry - the field that engages numerous spheres of the students' minds and personalities.

The concept of blended learning which has been introduced within the last three years was originally designed merely for classes on the application of didactic means in teaching Chemistry. The software used for managing the system of materials is FileMaker Server 7.0. The content of the material was based on scripts prepared at the Institute of Didactics of Chemistry in previous years. These materials were subsequently transferred to a structured hierarchical database and, owing to their dynamics, they can be easily updated, improved and adjusted to the users' needs. The students for whom the software was prepared are the fourth year students of General Chemistry and Environmental Chemistry, first and second year students of Material Chemistry as well as teachers participating in didactic classes of post-graduate studies at the Faculty of Chemistry at Adam Mickiewicz University in Poznań

Experiences gained during the first IT course have lead us to the conclusion that the suggested plan of IT lectures and classes fully meets the authors' expectations and shall also be implemented in subsequent academic years following the introduction of minute essential and practical corrections.

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CHEMICAL EDUCATION IN EUROPE AND THE EUCHEMS DIVISION OF CHEMICAL EDUCATION

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The EuCheMS (formerly FECS) Division of Chemical Education plays a unique role in chemical education in Europe as it (theoretically at any rate) links the chemical education activities of all the chemical societies in Europe. In practice not all chemical societies are members of EuCheMS and not all members have yet nominated members for the Division Council. The Council meets once a year at a chemical education meeting, this year at Eurovariety, and seeks to promote collaboration, cooperation and communication across Europe. Notable achievements are the ECRICE/ECCE series of conferences every two years, which predate the ESERA conferences, and seek to encourage both good researcha d good practice in chemical education. The free e-journal Chemical Education Research and Practice (formerly CERAPIE) was started by Georgios Tsaparlis from Ioannina after the ECRICE there and has been a great success. It has just merged with University Chemistry Education and is now published by the RSC. Position papers on chemical education research and how to give talks at European conferences have been produced and are freely available on the Division's website (http://www.chemsoc.org/networks/enc/fecs/fecschemedu.htm). The Division seeks to promote collaboration with other European bodies through shared membership and activities, such as ECTN and the UK and Irish Variety meetings and now Eurovariety.

DEVELOPMENT OF AN ELECTRONIC PEER LEARNING AND ASSESSMENT MODEL

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Although the concept of peer learning has been around for many decades it is perhaps not surprising that it has grown in popularity in recent years due to increasing student access to higher education. Falchikov discusses the academic merits of adopting peer learning methods but Boud also mentions the pragmatic benefits of peer learning. These pragmatic benefits involve the ability to cope with increasing student numbers arising from increased access to higher education whilst maintaining quality of the learning experience.

Increasing student numbers leads to escalating pressures on lecturers with burgeoning assessment demands on their time. Therefore, the benefits of peer learning can also be supplemented with peer assessment. As such, research has been undertaken on peer assessment and many different methods have arisen, such as those summarised by Lejk and Wyvill .

However, peer learning and assessment present their own problems. Ashwin discusses how many pilot studies into the adoption of peer learning do not consider how small scale pilot studies successfully transfer across organisations. This is also argued by Ballantyne where the literature only focuses on small groups of students taught by staff already committed to peer learning and assessment .

Peer assessment has the potential to ameliorate these problems but gains in staff time are often replaced or even superseded by losses due to increased administration of peer assessment systems. Ashwin addresses this issue but some time costs appear to be transferred to the students, as his results show. It is important therefore, that peer assessment not only supports the academic benefits afforded by peer learning but that it also brings benefits of its own in terms of time savings and being able to cope with larger student numbers.

This paper discusses how a peer learning model was adopted at the University of Hull for about 120 first year undergraduate students. There were a number of reasons for adopting a peer learning model along with peer assessment. Academically, there were a number of potential benefits, including helping students develop a better understanding of the topic and improving self confidence. Putting students into peer groups also helped them socialise and make contacts in the new electronic environment. From a practical sense, peer groups can mean less staff time focussed on face to face support, if organised appropriately and peer assessment can mean less staff time spent on marking.

The use of peer learning by the authors is not novel but this paper tackles the issue of how peer learning and assessment could provide real savings in terms of time, whilst maintaining academic quality .The major new development with this approach to peer assessment was the fact that it was supported by technology, as opposed to previous studies that only consider face to face peer models. As with many UK institutions, Hull uses a Virtual Learning Environment to support teaching and learning activities. The authors felt that the VLE could provide the necessary tools to facilitate a peer assessment model and provide benefits to both students and staff.

At the start of the module students were put into groups of 4 or 5 and were provided with their own group area on the VLE. This provided electronic tools such as email, discussion boards and file exchange. This provided a forum for the students to get to know each other and build up confidence through working in a group. The groups were given a task to complete over several weeks and used their group areas to record group activities, such as arranging meetings and sharing work. The product of the work was a single group assignment that was submitted electronically. Each group member then had to peer assess the contributions of the other group members and submit their marks electronically, via the VLE. To account for potential bias in the peer assessment the model proposed by Goldfinch and later refined by Li was used.

The results showed that students overwhelmingly liked working online in groups and felt that the peer assessment scheme was fair. Problems arose with the automation of the peer assessment marks and did not deliver the time savings hoped for. This paper will discuss the findings and recommend future developments to refine this model. It is anticipated that from this, such use of technology can be used appropriately to engage students in high quality learning through peer support and assessment, whilst also bringing real benefits and incentives for staff to engage in peer learning and assessment.

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CHEMISTRY TEACHING ON GRADUATE BIOLOGY STUDIES FOR PROSPECTIVE TEACHERS

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Most of chemistry teachers are graduated from chemical branches of study, mainly from universities [1]. Education of prospective teachers varies at different universities and is specific to a particular college [2]. On the other hand, a report on education at primary school in Poland from nineties of XX century showed, that 56% of biology teachers also taught chemistry [3]. In the light of the report it found out that it is very important to equip biology students with abilities that enable them to teach chemistry at primary and secondary school.

At the Pedagogical University of Kraków the didactics of chemistry course for biology students has been organised since the beginning of nineties of XX century. Initially the course was obligatory for every biology student, however since the academic year 1999/2000 the classes are the part of specialty "*Biology with teaching of chemistry and nature study"* [4].

Teaching of chemistry on non-chemical graduate studies, that give a certification for chemistry teaching at secondary school level, is a very specific process, because the teachers to be are not keen on chemistry and their main interest is focused on biology. Since the students encounter difficulties in assimilation of chemical content [5] their education process has to be led the way so that the difficulties could be overcame easily.

Education of prospective chemistry teacher at Pedagogical University of Kraków can be divided into two stages. The first one consists of typical chemistry classes. Students gain the knowledge and skills of comprehensive, physical, organic and inorganic chemistry, biochemistry, moreover, the methods of chemical analysis: classical (qualitative, quantitative) and instrumental. The second stage is filled with acquiring the skills which are necessary for doing a job of a chemistry teacher.

The didactics of chemistry course for students of specialty "*Biology with teaching of chemistry and nature study"* is preceded by classes such as psychology, pedagogy and didactics of biology that are obligatory for all biology students.

All of chemistry classes are oriented towards education of teachers-to-be because chemistry is not only a separate subject but also elements of chemistry appear in the subject "biology" and "nature study" as well. The didactics of chemistry course include lectures, laboratory classes and finally teacher practice [6].

During the classes students are taught appropriate methods of doing chemical experiments (in agreement with industrial safety rules). These experiments are starting point for students to develop skills of controlling the pupils' observations, and finally guiding the schoolchildren to conclude correctly.

For all the time we have led the course of didactics of chemistry, similarly to the universities leading in this branch, we are aware of the role of informative technologies in chemistry education process [7]. For that reason we place emphasis on developing teachers' abilities to use informative technologies in the education process that they will carry out at school. In order to achieve it we worked out, as one of pioneers, the classes with usage computer programs. The programs are not only the text processors but also advanced software such as HyperChem, CorelDraw, Macromedia Flash for designing animations and simple educative programs. In frames of specialty students learn creating models of molecules, presentations, animations and transparencies that model chemical processes.

Our course of didactics of chemistry is also realized at postgraduate chemistry studies for teachers, where most of participants graduated in biology.

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COMPUTER AIDED ASSESSMENT-HOW WE USE IT

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Computer Aided Assessment has been defined as," the use of computers in the assessment of student learning" [1].

A great deal has been written about "objective testing" [2] showing the scope of this type of testing.

However when discussing objective testing using a computer, too often it is the use of multiple choice questions (MCQs) that is being considered [3].

This emphasis may be because WebCT and similar platforms provide little other than MCQ templates.

A number of barriers to the implementation of computer aided assessment (CAA) [4] have been recognised:

a. Lack of understanding of the limitations and potential of the method of assessment.
b. An assumption that it is not possible to test higher order skills.
c. Organisational structures.

A study by Marie Bassford from Loughborough University [5] shows the wide range of authoring software that is available and the sophistication of the questions that can be provided.

There is therefore overwhelming evidence from the literature that provided the appropriate planning and evaluation is undertaken, computer aided assessment will provide for assessment at a variety of cognitive levels:

Knowing; measuring the ability to recall information.

Understanding; attributing meaning to what has been observed.

Applying; showing an understanding of a problem.

Computer Aided Assessment can be used to assess Higher Level/ Critical Thinking. Students view *summative assessment* as something that they have to do; their main aim is to get it out of the way and get the marks associated with it. *Formative assessment*, has no marks associated with it and therefore will not be undertaken by the majority.

We therefore need to provide a learning environment that encourages the students to engage with the subject.

As I have indicated CAA is not without its pitfalls and there is a range of assessment software.

The short presentation will look at the way in which "Questionmark Perception" has been used to provide a platform for both formative and summative assessment [6] that:

1. Reduces marking loads.
2. Broadens the range of knowledge that can be assessed.
3. Enhances feedback.
4. Increases the student's motivation to learn.
5. Increases administrative efficiency.

Examples will be taken from Chemistry, Analytical Chemistry and Biochemistry.

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NEW STUDY PROGRAMMES: CHEMICAL EDUCATION AT THE FACULTY OF SCIENCE - CHARLES UNIVERSITY

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New study programmes have complied (starting with 2003/2004 academic year) for the Chemistry and Chemistry education at the Faculty of Science - Charles University. These programmes meet the requirements of the European transfer credit system (ETCS) and the conclusions of the conference of rectors from European universities held in Bologne. The author of the contribution presented, who participates in the preparation of the new programme, offers the information on how to prepare and realize this new study programme that, in much greater extent than previously, would realize current requirements on the relations between Chemistry and everyday life and society as well as their mutual internal links.

The most important change is to implement a three-degree study programme, i.e. to split the study programme into bachelor, master and PhD studies. The Department of Chemistry is now offering eight study programmes, four of which geared towards chemical research and its applications, and four geared towards chemical education and preparing the secondary school chemistry teachers.

Study programmes, including the chemical education, are designed as study of one or two subjects. The most common combinations are chemistry and biology, physics, mathematics, geology or geography. The study programmes will be constructed as a study of mutually interconnected three or five study blocks – special education in the chemistry and second teaching subject, pedagogical and psychological education as well as didactic education in the chemistry and second teaching subject. Moreover, pedagogical practice, optional and some other subjects will form an integral part of the curricula for teachers' education.

In the bachelor programme, the students acquire the fundamentals of special training in Chemistry. The new curricula contain the novice subjects that the old curricula missed. These subjects are aimed at general educational issues, educational management, and the subjects where students acquire the knowledge related to the educational systems within EU. Another group of subjects, which rank among the bachelor study programme, is formed by the subjects necessary not only for professional training of teachers but also for any individual with university education – communicative competences, work with literature and databases, as well as computer literacy and internet. Students of this programme are not trained directly for the profession of the teacher. Bachelor studies are completed with a submission of bachelor project.

The master programme, where major subjects form the basis of study and their completion provides the students with fundamental professional competences, assures this. The subjects in question are didactics of Chemistry, pedagogy, and psychology. A great deal of attention is also paid to pedagogical practical training that enables the students to verify – in practice – the acquired knowledge and to develop their diploma projects. The diploma project and its defence proves the ability of future science teachers to solve independently science and didactic issues that can be met in practice, and to defend the solutions offered.

The PhD study programme will be designed to develop concept issues related to the education in respective subjects in accordance with current European trends. Students of this form of study will further widen their knowledge of chemistry, pedagogy, psychology, and didactics of chemistry. Their main aim is however independent work and solutions to current problems of chemical education at its all levels and in all its areas.

The important levels of teaching chemistry are primary and secondary school level, pregraduation and postgraduation university level etc.

The main areas are the following themes, that were designed and practised in the educational process: history and current state of chemical education, basic pedagogical documents for teaching chemistry, chemistry curricula, methods and forms of teaching chemistry, implements for teaching chemistry, educational tasks – their creation and use in teaching chemistry, methods of evaluation and grading in chemistry teaching etc.

The introduction of the third study degree for chemical education in the academic year 2004/05 will strongly support further development of the subject and teacher training. Various themes offered for chemical education are now a subject of scientific research of various PhD students.

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FIRST YEAR UNDERGRADUATE LABORATORIES IN CHEMISTRY – EXPERIENCE OF A PROBLEM-BASED LABORATORY APPROACH

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First year undergraduate chemistry students typically spend at least three hours per week in the chemistry laboratory. While in the laboratory, they carry out a series of generally predetermined tasks, designed to give predetermined outcomes in the limited time available. Students then submit results and a report on the laboratory session for marking. Introductory laboratory sessions focus on correct use of apparatus and concentrate on increasing manipulative skills. They can also be designed to complement lecture courses. Laboratory sessions are an extremely expensive component of the undergraduate programme and the questions that we asked were:

- Were the students benefiting from the experience, in the way that the lecturers on the course had envisaged?
- Was the laboratory session the most suitable place to tackle all the learning outcomes expected?
- Could an alternative approach be taken in the first year session to enhance the experience for the student and also achieve the expected learning outcomes?

After examination of the laboratory programme and discussion with students, an alternative laboratory programme was put in place. This programme involved the development of approx 16 problems that the students are then asked to solve in the laboratory. Each problem has a pre laboratory element that has to be completed before the laboratory session – this can range from writing reaction equations to deciding how to design a suitable experiment to solve the practical problem. The pre laboratory problem is then discussed on the day of the laboratory session before any laboratory activity can take place. Students then carry out the experimental task over one or two sessions (depending on the problem); generally, there are several ways of tackling the experimental task, so each student group may approach the problem in different ways. Specific examples of some of the problems will be shown and discussed.

This is a type of problem-based learning, a student-centred approach to teaching and learning which involves a shift from content coverage to problem engagement, and from students as passive recipients to active problem-solvers. (Tan, 2004) PBL promotes higher order thinking, and meta-cognition and has been shown to enhance student knowledge and motivation (Yuzhi 2003).

The final laboratory report can take many forms depending on the nature of the task assigned. Formal reports are required after some problems; others require the students to take a particular stance in a debate based on the laboratory results obtained and arguing the outcomes of the experiment. A poster presentation is also required in another case.

This revised problem based laboratory session has now run with first year undergraduate chemistry students for two years. The outcomes have been very interesting. On comparison with the other first year chemistry students, who take the conventional introductory laboratory, the problem based approach students have fared equally in chemistry examinations and in laboratory marks. However, a remarkable feature is that students will comment that they prefer the problem based laboratories (even if they have not taken chemistry before at second level), that they will engage more during the laboratory and that they are prepared to put in more effort themselves in pre-laboratory exercises.

Several tools have been used to evaluate the effectiveness of the problem-based approach, and results from these will be presented in the presentation. One evaluation involved interviewing several student groups on their experiences. On giving each interview group a small problem to tackle (based on the laboratory exercises carried out by both groups), the groups who had followed the problem based laboratory course could make reasonable attempts to tackle the problem while the groups who followed the conventional approach were unable to progress very far.

In conclusion, there is much time and energy devoted to introductory practical work in chemistry and we should be sure that our students are appropriately challenged and engaged in the process.

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COMPLEXITY THEORIES IN TERTIARY CHEMICAL EDUCATION: WHY AND HOW?

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In the second half of XX century numerous theories of complexity in natural and social sciences, such as system theory, cybernetics, synergetics and chaos theory have emerged [1,2]. Ideas coming from complexity and chaos theories appear in philosophy and theology, sociology and even inspire art and literature [3]. However, the society at large is mainly exposed to pseudo-scientific interpretations based on selected elements of modern science. Such notions as "chaos", "fractals", "black holes" etc. are abundant in present-day SF and esoteric literature. There is a lack of systematic education at various levels which would promote new ideas and show "the art of complexity" in proper perspective. [4]

In the Jagiellonian University (Faculty of Chemistry) we are gradually introducing the elements of „new science" of complexity into the chemistry curriculum. New elements are introduced at three levels:

Undergraduate level (3rd year): Within the „Theoretical Chemistry I" undergraduate course there are elements of theory of dynamical systems, application of chemical methodology to modeling of biological and social phenomena etc. The new elements (which usually do not appear in 'traditional' courses of theoretical chemistry in Polish universities) are marked in bold.

- Elements of theoretical mechanics: Newton, Lagrange and Hamilton formalisms.
- **Theory of dynamical systems as a generalisation of Hamiltonian mechanics. Deterministic chaos. Fractal geometry.**
- Liouville equation.
- **Non-equilibrium solutions of Liouville equations. Kinetic theory. Transport equations.**
- Statistical ensembles. Maxwell-Boltzmann distribution. Equilibrium fluctuations.
- **Noise-induced transitions. Order through fluctuations.**
- Quantum statistics. Fermi gas. Bose-Einstein condensation.
- Statistical thermodynamics. Molecular partition functions.
- Non-ideal gases. Second virial coefficient.
- **Simulation methods. Molecular dynamics, Monte Carlo, cellular automata.**

Master level (4th year) and Doctoral level:

- Both M.Sc. and doctoral courses contain the following elements:
- Basic concepts of the theory of dynamical systems: phase space, phase trajectory, attractors etc.

- Bifurcations, elements of catastrophe theory.
- Reduction of fast variables - Tikhonov theorem.
- Deterministic chaos.
- Fractal geometry.
- Reaction-diffusion equations.
- Basic concepts of the theory of stochastic processes. Markov processes. Master equation.
- External noise. Langevin equation. Noise-induced transitions.

Examples are taken from textbooks (mainly [5] and original research papers.

The main stress in M.Sc. course is put on chemical applications of synergetic approach. Most of examples concern chemical systems (oscillatory reactions, chemical chaos, surface reactions and pattern formation etc.). The course is illustrated by extensive computer simulations and laboratory shows of oscillating reactions.

The course for doctoral students concentrates on showing universality of complex phenomena. In particular, applications of methodology originating from chemistry (kinetic equations, reaction-diffusion processes etc.) to other areas of science (biology, ecology, sociology etc.) are shown. For example, the chemical scheme

$$A + X \rightarrow 2X$$

$$X \rightarrow D$$

can be also used in ecology (evolution of population of herbivores X) and epidemiology (A – healthy person, X – sick person). Hysteresis and phase transitions can also occur in social systems. Kinetic equations and cellular automata have been used to model historical processes.

Each course participant has to prepare an "essay" describing in a popular way an example of selforga→nisation in natural or social systems. Examples of essays (from academic year 2002/2003):

- "Dynamics of Marital Interactions: Divorce Prediction and Marriage Repair"
- "Noise-Induced Transitions in Photochemical Reaction"
- "Animal Coat Patterns"
- "Pattern Formation on Catalytic Surfaces"
- "Nyos – The Killing Lake"

Students are encouraged to present their essays during seminars, summer schools etc., promoting thus 'scientific literacy'.

Conclusion: Teaching modern complexity theories can be advocated

– as a part ob basic chemical education at the tertiary level
– as a tool to shape interdisciplinary, holistic vievpoint of students
– as a way of combating myths and 'black magic'

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WHAT DO STUDENTS LEARN FROM OPEN-ENDED RESEARCH TASKS?

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Although it is generally accepted that curricula of chemistry programmes at universities are aimed at providing students a preparation for future researchers, the contents of the curriculum seems to contradict this. During most lecture courses students are expected to acquire knowledge in a passive way. Lab courses are mainly focussed on the acquisition of laboratory skills, students performing prescribed experiments where the outcomes are not surprising for both students and staff.

Of course, this description is a caricature of traditional teaching at universities and there are many promising exceptions. But in many cases these exceptions are intiatives from individual enthusiastic faculty members.

The problem of the traditional approach is that it is hardly a preparation for the master phase, or, later, for a career in research. If we consider research as the production of new knowledge, it is strange that there is so little attention for the epistemic dimension of chemical knowledge. By epistemic dimension we mean knowledge about the production of knowledge. During lectures – or rather, more active teaching strategies for small groups of students – questions, like "How did this knowledge emerge?" or "On what kind of experiments is this knowledge based?", should be answered. In lab courses students should be engaged in research-like activities, aimed at developing their research abilities.

At he University of Amsterdam, the problem of the traditional lab courses has been recognised by the teachers involved with the lab course on general chemistry for first year undergraduates. In a PhD research project we tried to develop and evaluate some examples of *design-oriented lab experiments* intending students to design parts of the procedures in measurements.

Earlier research by one of the authors showed that design-oriented experiments may be effective to reveal conceptual problems. Another positive characteristic of these design-oriented experiments is that all kind of conditions necessary for a good result, which remain largely implicit in traditional experiments, becomes a matter of discussion (Goedhart & Verdonk 1991).

Some design decisions (take as example the number of measurements) can be motivated by the desired accuracy of the result. This emans that students should have some knowledge of statistical concepts like 'accuracy', 'precision', 'validity' etc. From several studies, it has become apparent that all kind of conceptual problems are connected with this kind of statistical concepts (Goedhart 1999, Seré et al. 1993). We expect however that using these concepts during the design of a measurement this will positively influence their comprehension by students.

Methods

A small group of 8 first-year chemsitry majors was assigned to design a method for the measurement of the kinetic properties of an enzyme. Students were guided by an experienced teacher, who was involved in the construction of the manual students used during their work.

During the research task students, working in pairs, were observed by the researcher and all written products by the students (lab notes, reports) were collected for analysis. Discussions between students and teacher were recorded on audiotape and written verbatim. The research task was set up in such a way that discussions were held frequently, giving students ample opportunities to explain their decisions and discuss these in the group.

Results

As expected students' decisions were not always correct form a chemist's point of view, but they were good enough to perform the research task and bring it to a successful end.

Moments where students reflected on their work were most interesting. Particularly, this took place during a discussion at the end of the project, when students looked back on their methods. An example was the discussion about the linearity of the Lineweaver-Burke plot. Students sometimes criticized their own decisions and proposed improvements.

Conclusions

It seemed possible that first-year students design their own measurements. Although the designs are not always perfect, this leaves a lot of points for the discussions between the students. The evaluation led to reflection on the designs and students criticised their own methods. Although this has not been investigated, it would be interesting to see how this affected their design skills during following tasks.

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THE NEW SYSTEM OF TEACHER TRAINING AT LICENTIATE STUDIES CHEMISTRY AND COMPUTER STUDIES, CHEMISTRY AND SCIENCE

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In the current academic year 2004/2005 the Department of Chemistry has assumed the duty to train teachers of two specialties. The need to simultaneously prepare the teachers to teach two subjects results from the implementation of the educational reform, which was introduced in Poland in 1999.

- This reform divided the educational system into four stages: a six year primary school – stages One and Two, a three year junior secondary school – stage Three, a three to four year secondary school – stage Four.
- New school subjects were introduced such as the integrated Natural Sciences block which is taught to 10-12 year old students
- The use of IT was enhanced, including Computers classes in junior high schools

The Department of Chemistry at Adam Mickiewicz University has suggested introducing two new licentiate specialties, each covering two subjects:

- *Chemistry and Computer Studies*
- *Chemistry and Natural Sciences*

The aims and tasks of the new licentiate studies include:

- Teaching two subjects, one being the main and the other an additional subject,
- Acquiring an advanced level of foreign language fluency,
- Acquiring competence with respect to IT.

The Polish Ministry of Education and Sport considered the proposal suggested by the Department of Chemistry as a valuable one both with respect to its curriculum as well as its organisation and has ensured appropriate financial means to support it.

The discussion of the assumptions of the studies on the basis of the specialty in Chemistry and Science.

The profile of the graduate

The graduates of our licentiate studies covering Chemistry and Science shall be competent in doing basic research typical for science studies, they will be able to structure the knowledge on nature with relation to its chemical, biological, physical and geographical phenomena in addition they shall be familiar with social and political issues. Moreover, they will have all the essential laboratory and workshop skills. They will be competent in basic issues relating to pedagogy, philosophy, logics and sociology of education, psychology and sociology of knowledge as well as in building relations with their students and dealing with classroom situations. They will be able to use multimedia and IT, to create curricula and to fluently use foreign languages according to the standards of the European Union applicable to this stage of education in Polish schools.

The organisation of studies and the system of teaching

The studies shall include classes according to the standards of training for General Chemistry teachers as well as they shall cover some basic knowledge in Physics, Biology and Geography. The students shall complete the courses in Didactics, which are designed to prepare them for the profession of a teacher. Laboratory and computer classes will be carried out in specialized and well-equipped classrooms of the Department of Chemistry. Additional subject classes (including Physics, Biology and Geography) shall be carried out once certain decisions are made, at the site of respective departments of our University within bilateral didactic work orders. The students will visit lessons at specified schools and they will be expected to complete their teaching practices in two subjects: *Chemistry* and *Science*.

The description of the manner of including the other specialty (Science) into the didactic process

Science was introduced to Polish educational system according to the educational reform of 1999 and covers the integrated teaching of the basics of Chemistry, Biology, Physics and Geography. Five years have passed since the educational reform was introduced and yet there are very few teachers adequately prepared to teach Science classes, which are extremely difficult since their scope, being a combination of several branches of science, is very wide. Most Science teachers are educated in only one field of science, some of them having post graduate education in Science. The Department of Chemistry in co-operation with three relating departments of our University has been conducting post-graduate Science studies since 1999 and we not only have some experience, and numerous graduates, but also many publications and a set of didactic resources suitable for this type of teaching. Based on our experience we believe that the organisation of dual subject teacher studies with the additional subject of Science shall be implemented to a very high level.

Licentiate studies *Chemistry* and *Natural Sciences* shall enable our students to:

1. **acquire basic chemical knowledge in such areas as:** Basic Chemistry, Math in Chemistry, Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Toxicology, Crystallography, Physical Chemistry, Instrumental Analysis, Chemical Technology, Environmental Chemistry and some optional subjects.

2. **acquire basic knowledge in Natural Sciences (Biology, Physics and Geography as well as some related subjects**). The students are offered the following subjects relating to Environmental Chemistry: Toxicology, Legal and Economic Aspects of Environmental Protection, Ecology, Analysis of Water and Soil Pollution, Photochemistry of the Environment, Nuclear Chemistry and Radiological Protection, Recycling and Neutralisation of Industrial Waste, Chemistry and Technology of Water and Waste Water Treatment, Analysis of Air Pollution, Biochemistry and Ecological Biochemistry, Chemistry and Technology of Gas Treatment, Chemistry and Technology of Water and Waste Water Treatment. Our students may also choose from among the following optional subjects: Hydrochemistry, Pesticides and the Environment, Monitoring the Environment, The Basics of Chromatographic Methods, Introduction to Marking Trace Elements in Environmental Samples.
3. **obtain the certificate allowing them to teach two subjects: *Chemistry* in junior high schools and *Science* in primary schools. They shall also be able to use IT in their classes.** The training covers such classes as: Psychology, Pedagogy, Didactics of Chemistry, Didactics of Science, Voice Production, IT, Classroom Safety.

In order to continue their licentiate studies and obtain the MSc degree, the students complete two more years of studies and thus they are be granted the title of Master of Science – Chemistry.

TRAINING POST-GRADUATE STUDENTS OF THE FACULTY OF CHEMISTRY, ADAM MICKIEWICZ UNIVERSITY, POZNAŃ, POLAND

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Studies show that first year post-graduate students are frequently inadequately qualified for teaching students resulting from the following reasons [1, 2]:

1. Post graduate students during their M.A. studies showed no interest in participating in courses of the didactic block due to the fact that having a very high opinion of their own intellectual abilities, they did not plan to work as teachers.
2. Post-graduate students are usually individualists, who are convinced of their own vast knowledge, which frequently results in giving their students tasks exceeding their potential. This stance, which results from the ignorance of basic principles of didactics leads to unnecessary conflicts with their students.
3. Numerous post-graduate students are not able to use computer and multimedia software as well as other teaching aids. For fear of humiliation they do not use information technology, which is not only to their own loss, but also to the loss of their students.
4. Post-graduate students frequently teach classes, which are not in line with their own interest and knowledge, which means that they are not adequately familiar with the topic or they lack the essential emotional involvement.

In order to avoid these unfortunate situations, the Department of Chemistry at Adam Mickiewicz University has introduced compulsory classes of university didactics for first year post-graduate students. The scope of these classes is being continuously increased and it currently includes lectures, seminars and classes as well as visiting didactic classes. The courses cover [2]:

1. **Lectures on university didactics**
   - Contemporary tendencies in educational changes and their conditions. The student as a subject for development. Education – contemporary theories and trends. The teacher as a professional, the expected competence with respect to the subject, didactics and interpersonal relationships. Psychological and physical condition of teachers.
   - Schools in the educational system – diversity of structure and function of schools depending on their type. Various concepts of schools – alternative schools – their advantages and disadvantages as well as "open" and "hidden" curricula.

– Learning and teaching in the context of implemented educational changes: The process of learning - contemporary psychological and didactic theories, the mechanisms of acquiring knowledge. The conditions of efficient learning, learning styles, the role of interests and previous knowledge. The meaning of social and communication skills as determinants of students' success and failure. Teaching as organising and managing the process of learning. Contemporary theories of teaching. Creating a favourable environment for learning, possibilities and ways of activating the learners. Concepts of didactic measurement and monitoring the students' achievements. Strategies for teaching currently promoted by the educational system. The problem solving method of teaching. Advantages and disadvantages of IT in education.

2. **Computer workshops**, which present the basic principles of using IT terminology, equipment, software and methods; the principles of using software and multimedia presentations, applying IT for searching for, storing and processing information, communicating and also teaching the subject.
3. **Practical teaching classes**. Microteaching (introduced for the first time in 1960 at Stanford University, USA) has proved to be a good method of teaching. This system covers mainly classes where one of the participants teaches a 10 to 20 minute class, which is then analysed and evaluated both by the instructor and the other student-teachers. The classes are video recorded and presented during the discussion, which facilitates detailed analysis of its subsequent stages. Classes that reveal substantial methodological or essential errors discovered by the participants as a result of the discussion are carried out and recorded again [1].

Topics for discussion after the classes

1. The correctness of content selection. Essential correctness.
2. The adequacy of the means selected to present the content.
3. The conspectus.
4. The manner of computer use in class.
5. The need to use other didactic means.
6. The methods of teaching applied.
7. Vocabulary, behaviour and the suggested didactic solutions.

Conclusions drawn from microteaching classes [3]

Having dealt with psychological difficulties (the fear of humiliation of post-graduate students in front of their peers), the classes are carefully prepared and the very manner of teaching those classes may be considered successful. The discussions after the presentations are very vivid and they usually cover a wide variety of issues. Many post-graduate students stress their eagerness to apply the methodological solutions of their colleagues in their own classes.

Therefore it may be said that the method of microteaching is effective for improving the didactic skills of post-graduate students; as a result new experience is acquired by the post-graduate students and also computer and multimedia software, conspectuses and videos with sample presentations are collected. All these materials may be used by a great number of post-graduate students in their search for the optimum implementation of IT for teaching and learning various university subjects.

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STREAMING VIDEO: SOME PRACTICALITIES

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There are a number of difficulties in using videos and animations in learning and teaching packages, e.g. students lose them, fail to return them, and damage VHS tapes, CD-ROMs and DVDs. It is not always possible for students to access such materials when they want them, e.g. laser video discs can only be accessed on site, the download times for video material from the *Internet* can be very long especially at certain times of the day, and material taken directly from the *Internet* is often not specific to the student's needs.

An answer to these difficulties is to deliver, i.e. 'stream', the video and audio material appropriate to the course, subject to copyright clearance and licensing, on the institution's *Intranet*. A number of sources, e.g. British Universities Film and Video Council (www.bufvc.ac.uk), have described and discussed the background to this topic in considerable detail and the names of commercial companies, which can provide "streaming" services, are available via the BUFVC www site.

At Southampton we have delivered the videos on 'Practical Laboratory Chemistry', produced by the Chemistry Video Consortium (www.chemistry.soton.ac.uk/cvc/), over a local 100Mbps network by two routes. In this Poster we shall not discuss the theoretical aspects of 'streaming' (see above) but rather we shall describe our practical experiences, including the resolution of the images, the technical specifications and costs of the servers, the software packages needed and the amount of time required to set up analogous systems.

Examples of the same video clip under the two regimes can be seen by clicking onto the www sites given below:

- '*Progressive download*' (http://dept.chem.soton.ac.uk/plc/B2_1.mpg)
- '*Streaming*' (http://dept.chem.soton.ac.uk/plc/B2_1.wvx)

ON-LINE SIMULATION OF CLASSICAL INORGANIC ANALYSIS

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Laboratory exercises, investigations, and experiments are invariably included in university chemistry teaching. The learning of empirical facts, chemical procedures and methods in chemistry depends heavily on the experience, which may be obtained from such teaching activities [1]. Experimental work in teaching is, however, both expensive and time consuming, and should therefor effectively benefit from the allotted student time, money, and staff time. If the instructions are too ambitious regarding what the students can manage to do and are overloaded with information [2,3], it may result in the students simply following a recipe, which is probably not effective relative to the efforts. The use of pre labs and post labs may be a way to enhance the effectiveness of the work in the laboratory [4,5]. If the purpose is <u>not</u> that the students become perfectly trained on the manipulative side of the procedure (and in university programmes it often isn't), but rather to give them experience with chemicals and methods, a computer-based laboratory simulation may function as a cheap and fast extension of student lab time. Virtual investigations seem to be a promising kind of tool [5,7,8] for several reasons and this has lead to the development of self-instructive, interactive PC-based learning resources closely related to an actual, running course in introductory inorganic chemistry [8]. Such a development is rather time consuming, but since the first experience was positive [8], it was considered worthwhile to develop the idea further for that course. This development of further resources to simulate a laboratory investigation will be described.

Classical qualitative and quantitative analysis of relatively simple soluble salts or co-ordination compounds with inorganic ligands only, has for a long time been part of introductory inorganic chemistry in spite of the fact that professional chemical analysis currently is far more advanced than chemical separation and identification reactions in test tubes and volumetric analysis. The reason to keep and use such an "anachronistic" element in an introductory inorganic chemistry course is first of all that this type of simple and classical procedures has a great learning potential; it offers a practical setting which can give a lot of experience with chemical reactions. We include a 20 hours laboratory assignment where simple soluble solid inorganic compounds and minerals, containing common s-, d- and p-block metal ions together with simple p-block anions and/or ammonium/ammonia are identified within a classical analysis scheme. The quantification of the compounds is not part of this limited laboratory investigation, but certainly of the "dry" part of the course. The students seem to accept this setting and some even enjoy the “game” of finding the identity of “unknowns”.

To optimise the outcome of the experimental work it should be supported by other activities. An interactive laboratory simulation for that purpose was developed, and the procedures in this electronic simulation follow the laboratory manual, which should be at hand and in mind when working with the simulation. The students are thus offered three different, but closely related learning resources to reinforce each other: the laboratory investigation, the computer simulation of it, and written problems involving the same macroscopic description of the chemistry to be solved by the paper-and-pencil method.

The laboratory simulation programme was designed. for use on a standard web-browser platform (se fig.1 for its simple appearance).

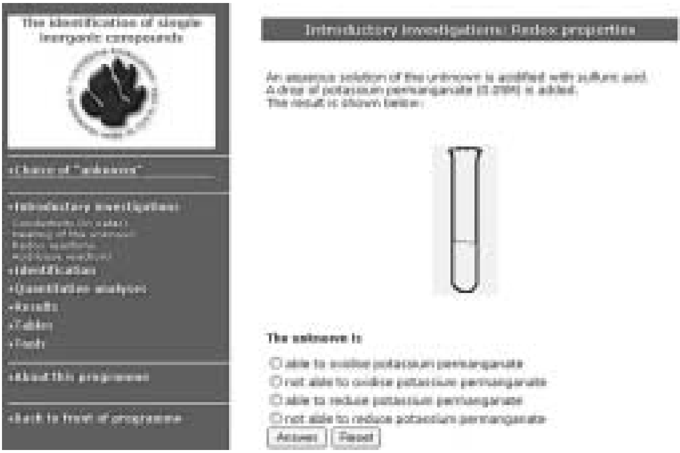

Figure 1. Appearance of one of the introducing experiments on redox-properties in the interactive simulation programme.

Figure 1 may illustrate the type of interactivity. After having got a specific “unknown” different introductory investigations may be done in some order: The solubility properties of it (soluble in water, different acids of different strengths, or in sodium hydroxide, etc.) further acid-base properties of the “unknown”, and its redox-properties. As seen the reducing power of the “unknown” is tested with potassium permanganate and the result is given as a picture of the testtube. This macroscopic result have to be interpreted and checked, and because quite a few students mix up oxidising and reducing power when presented to a result of this type, the potential correction of an erroneous conclusion is built into the programme. This simple kind of interactivity gives a specific response to each possible answer. For example, the correct answer gives a prompt to consider possible reducing agents, and tables of reducing and oxidising reagents are also included in the programme.

This simulation programme is expected to possess the same advantages as the previously described programme [8], and thus to provide the students with the opportunity to do experiments (to use different laboratory procedures and investigate different substances) outside the laboratory at the time, speed, and place chosen by the students themselves. They find this option useful as a supplement to the real laboratory.

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APPROACHES TO LEARNING OF UNDERGRADUATE CHEMISTRY STUDENTS – THE IRISH EXPERIENCE AND COMPARISON WITH AUSTRALIA

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Entry to third level science courses in Ireland is a competitive process with selection based on the individual students performance in a state examination at the end of their second level schooling. In the second level system, students are generally well prepared by their teachers for the state examinations. However, the transition to university education can be challenging for many students and non-progression is a problem after first year.

Within the context of a University education, the development of critical thinking skills is a key focus as well as the promotion of deep learning. The deep learner is characterised as (Marton and Saljo, 1997)

- Having the intention to understand the meaning;
- Using evidence;
- Relating to previous knowledge and experience;
- Having an interest in the subject matter.

However, an investigation into the type of teaching and learning which undergraduates experience reveals a potentially serious problem. The aim of this research is to determine what kind of learning students are involved in at university, and to determine what factors of the teaching and learning environment may contribute to this learning.

In this work, the approaches that first year undergraduate students (who were taking Chemistry in their undergraduate programmes) were determined. A subset of this group was then tracked when in second and third year. The measuring tool used to determine the study approaches was the ASSIST inventory. ASSIST (Entwistle & Tait 1996) is an inventory, which quantitatively measures the approaches and study skills of students. It allows for learners to be classed as predominantly deep or surface, with a third factor - strategic. All data was analysed and statistically verified.

This presentation reports on the results from a series of studies on 1st and 2nd year undergraduate chemistry students from two universities (Dublin City University and University of Wollongong), with approximately 450 students being examined initially. Since both cohorts of students have experienced a similar senior secondary school education and the fact that the Australian cohort has a similar experience in their first year chemistry module as their Irish counterparts, this analysis enabled for overall trends in performance and study processes to be established. The ASSIST inventory was validated for use in both university student cohorts. Key findings suggest that while students initially are tending towards a deep-strategic approach, this changes over the years spent in the University with some cohorts moving towards a more strategic and even surface-strategic approach.

The overall findings will be presented in terms of gender, age differences and the different approaches taken by students over the two universities. A similar study, within the Business School in Dublin City University, provides another platform for comparison. (Byrne *et al.* 2002) The type of teaching which students prefer will also be put into context, revealing interesting results. The study spanned three academic years, allowing two 1st year groups to be tracked into 2nd year.

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INTERLABORATORY STUDIES AND QUALITY SISTEM BASED ON ISO 9000 STANDARDS : PREPARATION OF CHEMISTRY STUDENTS FOR WORK IN INDUSTRY

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Modern society is highly dependent on a variety of analytical measurements. The environmental analyses as well as the globalisation of trade require even higher quality of analyses. In order to achieve such goal, the principal solutions are wide use of reference materials (their production is much lower than the demand), introduction of the quality system based on ISO 9000 standards (or some other standards) in chemical laboratories and establishing the system of accredited laboratories at national, regional and international level [1]. Participation in interlaboratory studies is one of the requirements for accreditation. The main idea of interlaboratory study is relatively simple – the same samples are distributed to several laboratories and each of them analyse samples according to given or freely selected procedure. All results are then collected and analysed by all participants according to different protocol. Each participant can also estimate the accuracy of all results and their deviation from the mean and median. Full confidentiality is usually guaranteed for the link between the results and identity of participants.

In 1991 the international ISO 9000 standards were also adopted in Yugoslavia. Like in other European countries, many laboratories in industry, research institutes, medical institutions, etc. were intensively introducing the quality system based on ISO 9000 standards. At the Faculty of Chemistry of the Belgrade University a long term project was initiated in order to improve the quality of chemical analyses. It was based on domestic, European and international experiences such as VAM initiative (Valid Analytical Measurement, UK), EURACHEM (A Focus for Analytical Chemistry in Europe), IMEP (International Measurement Evaluation Programme organised by EU Joint Research Centre-Institute for Reference Materials and Measurements), FECS, IUPAC, CITAC, etc. [1,2]. Within the mentioned project five interlaboratory studies on water analyses and two on liquid fuels were organised in Yugoslavia in the period 1995-2000. These activities could be recognized as joint research project and also as a part of continuous education programme (during the meetings of participants many lectures were presented with fruitful discussions about lectures and/or results of analyses).

Almost two decades international standards ISO 9000 are acknowledged by all industrial nations. There are extensive activities in many European and other countries regarding the introduction of quality systems based on these standards to various companies. However, there is little evidence how to teach university students about these important issues, which will definitely become an important part of daily activities of a laboratory chemist (especially if he/she is employed in industry).

For several years at the Faculty of Chemistry of Belgrade University we are teaching about the quality system based on ISO 9000 series of standards, laboratory accreditation and interlaboratory studies. All our undergraduate students intending to find job in industry as well as students who take the optional course on environmental chemistry were included. In theoretical lectures various aspects of quality education were discussed (quality system, quality assurance, quality control, quality handbook, standard operation procedures, protocols, traceability, reference materials, calibration, requirements for accreditation of laboratories, types of interlaboratory studies, etc.). Students were also informed about the efforts made by different institutions in order to improve chemical measurement: BCR (Community Bureau of Reference), CITAC, EURACHEM, FECS, IMEP, IUPAC, VAM, etc. The short video "Let's agree to agree" commissioned by the Laboratory of the Government Chemist (UK) within the promotion of Valid Analytical Measurement Initiative (VAM) was found both interesting and useful as teaching aid. The video was usually presented twice and then followed the discussion with students. Although the video was in English most of student understood it well. Beside the definitions of the terms such as quality control, certified reference material, validated methodology, interlaboratory study etc., the video illustrated the importance of quality in analytical measurements by showing the incidents where quality was lacking and the consequent problem which resulted. It also showed how the problems were solved, often quite simple and with minimal expense.

Practical work of student included two round interlaboratory study. Each student was in the role of chemist participating in the interlaboratory study. In each round every student received an identical sample of river water. Their task was to determine independently the content of the same component (e.g. chloride by Mohr method). Later students exchanged their results, calculated the median, mean, and standard deviations. They also analysed the results according to various protocols which were used in professional interlaboratory studies. Students were also informed about the results and protocols used in recent international interlaboratory study IMEP-9 (organized by EU Joint Research Centre-Institute for Reference Materials and Measurements) [2] and the regional interlaboratory study for South-Eastern Europe [3]. Accuracy and precision of the analyses performed by students were at the similar or better level than those obtained by their older colleagues in professional laboratories. Although they were all using the same method, it must be noted that their results were not completely comparable as all students were using the same standard solution.

During their last semester (about three months), all undergraduate chemistry students at the Faculty of Chemistry work on the research project under the supervision of their professors. One student took recently the interlaboratory study as the theme for his project. He actively participated in the national interlaboratory study on water analysis which was organised at the Faculty of Chemistry for professionals from industry, public water-works, research institutes and public health institutions. This student took part in the organization of interlaboratory study, preparation of samples, analysis and interpretation of results obtained from various laboratories.

Teaching and learning about interlaboratory studies, accreditation of laboratories and the quality system based on international ISO 9000 standards are important for education of chemistry students. It is also one of the preconditions for good laboratory practice, harmonisation among chemical and similar laboratories in Europe.

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EUROPEAN SAFETY LEGISLATION FOR EDUCATION AND RESEARCH

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One of the great concern of European Community is the health of population. Series of directives and other law acts are dedicated for this subject. All elements of environment influence the health of population: natural environment, living conditions; workplaces and public space. Health protection has to cover all of these elements.

Products placed on the market should be safe for both private and professional users. The series of directives concerns about safety of products, machines and apparatus; materials and chemicals, transport of dangerous goods. All organisations (education and research institutions are included in this term) are obliged not only to produce the safe products but to purchase safe machines, apparatus and materials. Research institutions should bother about regulations for drug precursors and genetically modified micro-organisms.

Employers (rectors of universities and directors of schools as well) have a primary responsibility for compliance with all applicable laws and regulations on protection of workers (teachers and others). A framework directive describes the obligations both employers and employees. Individual directives provide detailed requirements for workplace, work equipment, display screen equipment and others, occupational hazards: carcinogens and mutagens, chemical, biological and physical agents, manual handling of heavy items, etc. Particularly sensitive risk groups must be protected against the dangers which specifically affect them (pregnant workers and young people.) There is no specific EU regulation on protection of pupils and students, but directive on protection of young people at work covers problems connected with this group.

The protection of environment in education and research institutions are focused on waste management and hazardous wastes from laboratories.

The EC directives and regulations apply to all sectors of activity, both public and private. Exceptions are made while certain specific activities in the public and civil protection services are undertaken.

The Member States shall adopt EC directives and implement them into national legislation.

EMERGENCY MANAGEMENT DIVISION – AN EXAMPLE OF LEARNING AND TEACHING IN CONTEXT

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In this paper, an example of activity for students using a method "learning and teaching in context" has been described. Its concept was invented during the course for doctoral students. The method requires a lot of time and effort. Nevertheless, it is efficient and well accepted by students (Kimbrough et al.1995).

The target group are the students of Chemical Analytics specialization. Environmental Chemistry (lectures and seminars) is one of the compulsory courses within this specialization. Its curriculum is focused on environmental protection problems: potential hazards and hazardous substances in global and local environment, as well as the possibility of chemical accidents and contamination and finally methods of chemical pollution analysis.

However, there is a lack of appropriate practical exercise. We must also take into account the challenges of our civilization and necessity of students' practical preparation for real situation and unexpected events. Finally, searching for relevant data of inhabitants' safety in Polish cities we have noticed that in Cracow there are not any well prepared web sites concerned (Emergency Management Division web sites, 2004). Considering all these facts, we would like to propose an activity for one of seminars mentioned above.

During the classes, the students are asked to imagine that they are working in the Emergency Management Division in the Voivodeship Office in Cracow. They are playing the role of chemical experts and their task is to prepare a web site guideline for the residents. This web site must include some basic information and advice in case of risk of chemical dangers and accidents in Cracow.

What students (divided into several groups, each of them dealing with different problem) need to do, is to think out the following questions:

1. What are the potential sources of chemical contamination in Cracow? What might happen?
2. Which substances are the most hazardous for people and environment? What are their sources? How do they react? Which way can we identify them?
3. Is there any real possibility to predict dangers?
4. What should we do in case of accidents?

The activity is supported with some authentic materials: the city map of Cracow, safety data sheets of the most important substances, a list of bigger companies and factories in Cracow and its surroundings.

As a result of this task, students obtain information sheets including facts and advice that can be discussed and compared with other groups and with a teacher. The task of the teacher is also to give and explain some proper solutions of problems mentioned.

In the experiment presented, the students are given the opportunity to combine and – above all – check their theoretical knowledge in actual situations. It also acts as a way to encourage students for considering their ambient environment – in addition, they might develop their knowledge and skills, not necessarily only chemical ones. But, most importantly, the exercise presented is a good possibility to remind of and fix basic information about the chemical method of substances identification in the environment, as well as the safety rules of behaviour in a critical situation.

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TEACHING AND LEARNING STRATEGIES DEVELOPED TO SUPPORT LEARNING AND IMPROVE RETENTION OF CHEMISTRY STUDENTS IN HIGHER EDUCATION

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There has been a well-documented change in the type of student enrolling in general science courses at third level throughout Ireland over the last 5 years or so. Essentially, these students are different to the traditional intake in that they may not have experienced much academic success at second level and will rarely have studied chemistry or higher level Maths. These factors combined mean that they often perceive chemistry to be a difficult subject and may expect to fail or do poorly in the subject from the outset. They also show different learning styles to the traditional reflector and theorist styles and are generally not very well-prepared for higher education.

Approximately 46% of second level students progressed to higher education in 1991 in Ireland. By 2001, this had increased to 68% of second level students. The first year chemistry teaching team at the Dublin Institute of Technology (DIT) welcome it as a positive development to have an increased number of students participating in our courses. However, a consequence of this widened participation is an urgent need for changes in teaching methods and provision of learning support to accommodate and retain these new non-traditional types of learners [1].

Several changes in teaching and learning strategies that have been developed and implemented at DIT over the last few years will be discussed and evaluated. These measures to support learning in chemistry deal for the most part with first year undergraduates and, in some cases, second years, as it is felt that these are the students for whom this support is most valuable. They include

(1) the use of visual images and putting theory into context,
(2) assessment tasks that allow learners to use their creativity,
(3) making lab experiments more relevant and engaging,
(4) introduction of interactive activities,
(5) incorporation of e-learning methods,
(6) hands-on use of molecular models
(7) demystification of the marking process.
(8) induction viewed as a year long process

Students were asked to evaluate the benefits to their learning of some of these strategies and the feedback was positive. The pass rate in the summer chemistry examination for this course had dropped to a very low level (27%) but it has been steadily increasing since these teaching and learning strategies have been implemented (to 60% in 2004). This approach requires a greater commitment of teaching staff resources as attendance was closely monitored and tutorials were provided with a ratio of 6 to 8 students per tutor. However, it is felt that the resulting improvements justify this requirement. In addition, effective communication and teamwork among all staff teaching on the course, across all subjects, is very important to the success of an initiative like this. It is intended that the teaching and learning strategies that have been implemented will continue to be developed and expanded and similar initiatives in other colleges and other countries continue to provide useful new ideas [2].

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THE ROLE OF INTERACTIVE VISUALIZATION IN THE STRATEGY OF BLENDED LEARNING IN CHEMISTRY

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The strategy of application of blended modes of learning is based on the use of best elements of classroom model and remote teaching strategy. Remote teaching changes the access to educational tasks thus facilitating the individualization of educational process.

It is one of the factors influencing the increased efficiency of education in classic strategies. The strength of the classroom model, however, is the interaction between the participants and the possibility of the teacher's direct influence on the students via his exemplary behaviors. Both of the above elements decide about the success of the educational process. Blended Learning strategy allows for a better individualization of education and simultaneously preserves the advantages of the classroom model. A question may be asked here whether it is possible to employ this strategy for teaching Chemistry. Does the practical omnipresence of experimentalism in Chemistry teaching not block the possibilities of remote teaching? What aspects of teaching Chemistry may be assigned for tasks aiming at individualization of IT assisted educational process?

The above questions pervade numerous Chemistry methodologists who would like to modernize teaching this subject according to contemporary tendencies present in teaching other subjects. Many of the solutions implemented by the Department of Chemical Education at Adam Mickiewicz University in Poznan have in recent years incorporated Blended Learning within the methods of Chemistry teaching. These are among others Hypermedia Internet Educational Programs, Dynamic Internet Instructions, Laboratory Videos and first of all, Modules of Interactive Chemical Visualization. The latter is the example of application of state-of-the-art didactic means in which the efficiency of individualization of activities my be reflected.

Simultaneously, typical visualization issues are perceived by both students and teachers as the difficult ones due to a high level of abstraction combined with a multitude of theoretical information. Information techniques, which are the basis of contemporary remote teaching as well as the modern chemical visualization, constitute a clear link that enables the implementation of this methodology. These solutions have largely aided laboratory work, which is to be performed in the classroom model.

Appropriate tools for interactive learning were developed at Department of Chemical Education at Adam Mickiewicz University in Poznan to assist with acquisition of knowledge about spatial structure of simple compounds, the analysis of molecular models, summary formulae of compounds and balancing the equations of reaction as well as to support teaching those algorithms to students and building up appropriate skills.

In 2004 research was started whose aim was to define the efficiency of the designed solutions. Preliminary findings point to substantial qualitative changes, which may be achieved via the implementation of blended methods of Chemistry teaching.

AN EXAMINATION OF AWARENESS SCALE PREPARED ON THE SUBJECT OF RENEWABLE ENERGY

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Until recently while energy requirement that is caused by industrialization and the increased population in new millennium is covered by fossil fuel, the mentioned traditional energy production methods form one of the most important reasons for environmental pollution. Besides it is known that fossil fuel will extinct in a certain of time. Renewable energy sources concept come order by the researches done in the subject of alternative natural energy sources, alternatively to fossil fuels. For this reason, energy politics in society is intensifying on renewable energy sources. Today developed countries are keen on using energy sources that are renewable and a friend of the environment. Thus using clean energy and other endless sources with the sun and its derivative is great of importance. Renewable energy is defined as energy that is available the same in the next day in evolution of the nature itself. The reasoning in the renewable energy concept is, to gain energy from the energy sources existing in the natural environment continuously and renewable. For this reason, the point that should be taken into consideration is, producing energy by using this power. The realization and usage of production is possible with the individuals educated in the subject of renewable energy. In order to define how much the concept of the renewable energy is awareness in individuals, the study was conducted with 200 students attending to Hacettepe University, faculty of Education, Department of Chemistry Education. These students learn renewable energy subject in their educational program. The findings obtained in the study shows that the choosing of the items in the scale is very important and gives addition to the increase of awareness of students in renewable energy subject. A pool of items of Likert type with 50 questions has been prepared and factor analysis has been applied to the data obtained from those items. The results of the analysis show that 39 items of the scale constitute a cluster and besides using factor analysis the same 39 items that have 0.40 or greater factor loads have been remained in the scale. It was found that both factor and cluster analysis form the same items for the scale of renewable energy. Hence the scale is a useable scale in terms of measuring awareness for renewable energy. In the planned study Likert type "Renewable Energy Awareness Scale" has been developed and factor and cluster analysis have been performed. The results obtained from both analyses were supportive in quality for each other. In the end of the performed evaluations, a Likert type scale was developed with the reliability of 0, 94 for 39 items.

THE INFLUENCES OF ONLINE SEARCHING ON TRANSFERABLE SKILLS IN CHEMISTRY EDUCATION

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The transferable skills that are divided into 7 groups in chemistry education are; searching/using technology skills, team working skills, scientific thinking skills and written/oral communication skills. The mentioned skills effect the students'occupational choice and their success in their jobs (Assiter, 1995, Clarkeburn, et.all, 2000).In this study, the affect of online searching on teaching and learning activities about these subjects was investigated. For this reason, the projects of the students' attending Hacettepe University, Faculty of Education, Department of Chemistry Education that were prepared by online knowledge searching were determined according to transferable skills. In order to determine the students' transferable skills and the influences of the projects they prepared by way of online searching about these skills, an evaluation form was developed. The "Evaluation of Transferable Skills Form" was applied as a pre- and post test to the students. The students evaluated themselves in the test. There was an evaluation scale consisting of 0, 1, 2, 3 points in the evaluation form. In this scale, evaluation is done according to "does not have a skill in this field [0], does not have a skill/experience [1], have a noticeable skill [2], very skillful [3]". Parallel to these applications, online searching questionnaire was applied to the students. The results of the questionnaire were compared statistically with the pre- and post test results of the transferable skills test. Online searching brought about an increase in the students' ability in scientific thinking and working in teams.

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IMPROVEMENTS ON THE UTRECHT BACHELOR PROGRAM IN CHEMISTRY

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Since 2002 Utrecht University has adopted the Anglo-Saxon bachelor-master-system, students follow a three years bachelor program and a two years master program. Bachelor students are encouraged to choose a minor next to their major. With some minors students prepare themselves for specific interdisciplinary master programs (like Pharmacy for Drug Innovation). To facilitate students in this major-minor-system, an operation of harmonization of curricula (timetables, timeslots, uniform course size) has taken place.

Concurrent with this operation, the Department of Chemistry has chosen to make improvements on the major Chemistry. Improvements are aimed at better preparation of students for future careers in (master) study and work. Points for improvement were obtained from a survey of alumni of our faculty. Former students responded they had missed education in general skills and knowledge, e.g. being able to design new research, to use computers and statistics to solve practical an theoretical problems, to develop new products, do design new processes, to cooperate in project groups etc. These were in general more appreciated and missed than skills and knowledge in disciplinary chemistry.

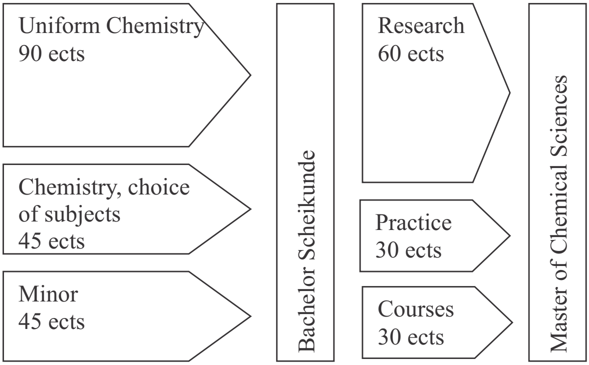
Other motifs that lead us to redesign our bachelor program were:

1. governmental pressure to introduce societal elements into beta studies;
2. didactical en educational reasons to introduce competence learning;
3. making beta studies more attractive to increase intake of new students;
4. increasing efficiency of the organization of beta courses.

With these issues in mind the department decided to reorganize the program into thematic periods aimed at integration of adjacent fields of (chemical) sciences, integration of research and general skills (including reporting skills) and subjecting students to learning situations that resemble real-life of working chemists. At the same time we aim at improving didactics within courses, meaning we seek ways to let students become more active learners instead of passive consumers of information.

A new curriculum was planned for the Chemistry major, of 2¼ years, in which students are prepared for any of our Chemical Sciences master programs (Chemistry & Physics, Biomolecular Sciences, Drug Innovation and Sustainable Development). The content of the “Uniform Chemistry” part (see scheme below) had been determined previously in 2002 and has been left virtually unchanged. On the other hand in the part of choice of subjects in chemistry (in which students could choose freely in the former program) it has been decided that choice should become restricted to certain periods and all students follow courses from thematic blocks in the field of “life sciences” and in the field of “materials sciences”, this way a broad major in chemistry is guaranteed for all students.

As an example of what has been accomplished, I would like to show you the start of our new program with the thematic block “Chemistry and Life” in which chemistry is introduced with combined lectures in organic chemistry, biochemistry and cell biology (“from molecule to cell”). At the same time students work on a project in our skills laboratory in which they work on basic experiments within the theme of chemistry and life. Apart from the introduction into chemistry this blocks aims at familiarizing students with the new way of studying at university and basic laboratory practice.



CHEMICAL KNOWLEDGE BACKGROUND OF FIRST YEAR STUDENT

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The main goal of teachers' education at university level is the widening of knowledge already gained on the former stages of education [1]. Students are expected to learn the newest science theories. For the majority of students it is the last stage of education – after completing it, the graduates become fully-fledged teachers [2].

The Department of Chemistry of Pedagogical Academy in Cracow provides chemistry classes, for the students of „biology with the skill of teaching chemistry and nature" major. For these students, chemistry isn't their main major, for there reason the amount of hours dedicated to chemistry isn't very large. Therefore the final ability to the teacher's job notably ensues from their previous knowledge [3].

In October 2004 a research was conducted of 109 first-year biology students [4]. The questions involved the basic knowledge and skills, which should be familiar to the high school graduates [5].

The findings indicate a very low level of adoption the theoretical knowledge and the skills by the students. They have particularly difficulty [6] to categorize the type of bonds [7] in chemical compounds and ensuing from this, physical and chemical properties of substances (i.e. oxides, acids, hydroxides, non-organic and organic salts [8], metals, their alloys and organic compounds). The students were not able to predetermine which from the named substances will dissociate in the water solutions, which ones in the molten state lead the electric current and what is the reaction of their water solutions. First year student have also a lot of difficulties with, what seems to be, basic skills:

- giving the systematic name of chemical compounds when knowing the formula - in this case they use lots of customary or old-fashioned names;
- writing the formulas of substances – especially the formulas of salts;
- performing easy calculations e.g. the number of atoms in the molecule or molecular weight.

Large percentage of questioned student couldn't attribute given chemical terms to the proper category of terms of the micro- and the macrocosm. The candidates for teachers have also problems with balance the chemical equations [9].

The low percentage of good answers is due to fact that the chemical theories presented at many elementary, middle and high schools are old-fashioned and imprecise [10]. Therefore the initial knowledge of the first-year students is incorrect and/or insufficient to start study, which not only include in their curriculum chemistry, but also educate the prospective chemistry teachers. Because of above reasons the teachers at university level have to devote their time to „re-educate" students during the classes instead of widening their knowledge with the newest theories and developments. This "re-education" is not only time-consuming – but it is also mostly ineffective – what ensues from the psychological theories: negative transfer [11] and Jost's principles [12].

Therefore it is essential to introduce on the lower stages of the chemical education new and more precise scientific theories. In addition more attention should be devoted to the practical applications of the theoretical knowledge for example to solve chemical exercises.

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IT-SUPPORTED LEARNING AND ASSESSMENT FOR FIRST YEAR UNDERGRADUATE CHEMISTRY STUDENTS

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Teaching staff should be encouraged to approach their teaching in the same way that they carry out research. This requires investigation and evaluation of new methodologies for teaching and learning [1] The use of information and communication technology (ICT) to support learning and assessment is one such developing methodology. The Dublin Institute of Technology (DIT) has a site licence for course management software called WebCT. A pilot project was initiated in the summer of 2004 to use this resource to develop a virtual learning environment (VLE) for a group of first year undergraduate chemistry students enrolled on an ordinary degree course in science at DIT. This cohort was chosen because many of them had not studied chemistry before. Thus, it was anticipated that the learning support provided would be of significant benefit to these students.

The aim of the project was to gather together the resources and material that chemistry teaching staff had available and to incorporate them into the virtual learning environment. In addition, it was planned to develop on-line assessment quizzes providing immediate and detailed feedback to the learner. It was hoped that provision of this VLE would encourage students to take control of their learning and allow them more flexibility and the opportunity to work at their own pace when accessing relevant material. This new initiative would also facilitate students who have poor attendance records (due to illness or personal circumstances) in keeping up with their course throughout the year. This may result in an improvement in student retention at the end of the year.

ICT is a very helpful supplementary tool but it should always be combined with more traditional teaching methods instead of replacing them *i.e.* a blended approach is recommended [2]. Also, it is advised that this method only be used when it will enrich and add value to what is being done already. Some areas where this is the case have been identified in our work to date.

<u>Added value obtained by using ICT:</u>

- flexibility (24 hour access, 365 days a year),
- computerised animations assist visualisation and the linking of what happens at molecular and at microscopic levels,
- suitable photographs and images aid contextualisation (putting theory into context) and engage the learner
- interactive tutorials and quizzes based on subject notes encourage students to become independent learners and allow them to work at their own pace

- easy storage and navigation of general course information (assessment criteria, paper structures, marking schemes)
- links to relevant web sites and information on careers and postgraduate opportunities provided
- course annual calendar and WebCT mail enhances communication (clarifies assignment deadlines, exam dates and holiday periods)
- on-line formative assessment quizzes (facilitates assessment for staff while improving the IT skills of the students)
- appeals to a different learner style compared to more traditional approaches and broadens the range of learner types accomodated [3].

Another advantage of the ICT tool that was initially overlooked was the way in which it helped learners to develop their organisational skills. The students were encouraged to take control of their course management and time management *via* the course calendar and WebCT mail. One factor that was found to be essential for the use of ICT methods is the availability of good IT and learning technology support as well as the local staff resources to create the working ICT template.

This pilot study will be evaluated by the staff and students involved in April of this year.

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INTEGRAL ACTIVE METHODOLOGY OF TEACHING: THE BASE OF INNOVATIONS FOR IMPROVING STUDENT'S KNOWLEDGE AND SKILLS

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The content of the modern science education shows us a complex panorama of the active methods in chemistry teaching at university level. The problem of educational innovations in science and chemical education can be properly treated by the analysis on this complexity on the basis of integral teaching methodology. To carry out with success the objectives of the educational process, the chemistry teacher must have deep knowledge of the modern methodology to employ well all these methods, depending on the objectives on the classes, type on classes, topic of the course, preparation of students and other factors, that influence directly and indirectly the results of the educational work.

But only this does not guarantee the success of this difficult work. The teacher must know theoretically and practically each one of the modern active methods and to apply them correctly in practice, together with other methods. The application of one or two active methods still does not guarantee the fulfillments of the objectives and the good knowledge and skills of the students. Either it is acceptable the formal using the modern methods of the teaching, without taking into account the principal objectives that should be achieved: the deep knowledge and the creative development in students.

The integral teaching methodology is the system of all active methods that teacher uses in classes and extra class work to achieve the best learning of students. It is important that the teacher uses thoroughly these methods and chooses those that permit to him/her to fulfill better this task. For all chemistry courses, it is recommendable to use all active forms of the classes: the conference, cooperative work, discussions, conferences and workshops together with the collective and cooperative activities (Nurrenbern, Robinson 1997; Orlik 2002, chapter 10), modern forms of examinations and other (Orlik 2002).

The experience of the best teachers shows us also (Chernobelskaia 1987, Orlik 2002, Orlik 2005), that practically in any class the teacher must apply at least 3-4 methods and active means (because the class time is short and it is not possible to use all methods and educational means), attempting to make it integrally to achieve the most adequate fulfillments of the objectives. It is necessary to carry out too the new analysis and restructuring the curriculum of the course to do this work properly.

Other essential problem is the appropriate representation of the central concepts and topics of the course, what can be done using modern systemic approaches for that (Orlik 2002, chapter 7). Modern audiovisual means of teaching together with using computers is another important alternative to traditional methods to give students the opportunities of deep understanding chemistry. But each active method should be applied by teacher with systemic links with other methods and with main objectives of the course. Together with the modern textbook and Internet resources this integral methodology can guarantee the realization of purposes of good quality chemistry teaching (Orlik2002).

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CHEMISTRY FOR NON-CHEMISTS MUST BE DELIVERED IN A MANNER THAT IS 'FIT FOR PURPOSE'

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Syllabuses for chemists are well-established and expanding. Attempts to trim them have been made. The development of the chemistry syllabus is that the "higher end" of cognitive ability and always extends present knowledge. So the presentation of a mainstream chemistry course invariably starts with the fundamental concepts and proceeds to develop these and apply them in order to explain the observed phenomena. For the non-chemist this approach presents several hurdles:

- The fundamental concepts are inherently abstract;
- The fundamental concepts are often described in mathematical terms;
- It the use of the concept so only appears at the end;
- The development of the concept is often counter intuitive;
- The understanding is less likely to be developed;
- The application or predictive ability or explanation of phenomena or may not be reliable.

So we can suggest an alternative approach, which is to start from students' experience and introduce explanations at increasingly detailed level. This process is taken as far as is required by the student for his immediate purpose. This leads us to recognise the importance of defining what level of explanation is required to constitute a "satisfactory explanation" in a given context. It is parallel to the analytical idea of "fitness for purpose".

The benefits of this approach should include:

- Removal of abstraction;
- The purpose of the knowledge is defined;
- The extent of the knowledge required (i.e. the syllabus) is determined by the purpose;
- Theory is related directly to the topic;
- Mathematical treatment is developed in context;
- Reliability of predictions is also determined by the purpose.

The implications of this approach in the design of textbooks and CIT material need considering. Few, if any, texts have tackled how to present material in a 'need-to-know' manner; so extensive guidance in the use of standard texts would have to be given to students. Web pages would seem to be best medium but, without extensive guidance students may well be distracted by inappropriate links. The challenge then is to locate and/or develop suitable back-up material to accompany such an approach.

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ANALYTICAL CHEMISTRY IN THE EUROPEAN HIGHER EDUCATION AREA

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The moves towards a general three-cycle structure (BSc/MSc/PhD) shall be completed within the Bologna countries until the year 2010. Chemistry plays a leading role in this development. An international pilot conference "Chemistry Studies in the European Higher Education Area" was organized in order to discus and approve recommendations for European Chemistry curricula based on multilateral accepted Bachelor and Master degrees, to describe requirements for a three-cycle education and graduation system, formulate development perspectives for European Chemistry curricula, and to discuss employment perspectives for Bachelor graduates in modern industry. Results of the conference and their impact on education in Analytical Chemistry will be discussed.

The draft of a Eurocurriculum II for Analytical Chemistry was discussed and approved in Thessaloniki during the 2003 Annual Meeting of the Division Analytical Chemistry of EuCheMS. Eurocurriculum II for Analytical Chemistry is fully based on the Eurobachelor proposal of the European Chemistry Thematic Network (ECTN). 15 credits (8.5 % of the total B.Sc. teaching time) have been regarded as the minimum needed for basic education in Analytical Chemistry. Additional (optional) modules may considerably vary between universities.

The four pillars of Analytical Chemistry, spectroscopy, chromatography, chemical sensors, chemometrics, are found again in Eurocurriculum II, whereas the chapter "Equilibria" has totally been omitted. It was replaced by the chapter "Wet Chemistry Methods", which covers such important fields like sampling, digestion, and sample preparation. More emphasis than previously has been laid on the chapter "Statistics, Chemometrics, Quality Assurance" because of its importance for problem-solving in Analytical Chemistry. Fundamentals of Structural Analysis are a matter of Analytical Chemistry as well. The multi-method approach has to be taught here, whereas any dedicated method of structure elucidation might be offered by chairs or institutes with a dominating synthetic orientation.

PROBLEM BASED LEARNING IN A DIGITAL PRELAB

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Lab exercises are indispensable parts of any Chemistry curriculum. The selection of experiments is based on didactic considerations, on current scientific standards and on demands by the professional situation as well. With respect to professional demands, contemporary Analytical Chemistry is almost exclusively performed as Instrumental Analysis. This poses a challenge to universities even in wealthy countries to provide the necessary resources already in a B.Sc. curriculum.

We are developing an Internet-based system of virtual instruments, which are intended to complement (not to replace!) the real lab instruments. Virtual instruments provide unrestricted access and are very well suited to familiarize with the basics of the technique, to study the influence of certain experimental parameters and to elaborate good start conditions for the succeeding real experiment. The most efficient way of learning Analytical Chemistry is based on problem-solving case studies [1,2]. This experience holds as well in case of using virtual instruments The virtual gaschromatograph, the virtual FTIR spectrometer and the virtual Raman spectrometer as well as examples of case studies can be accessed freely [3].

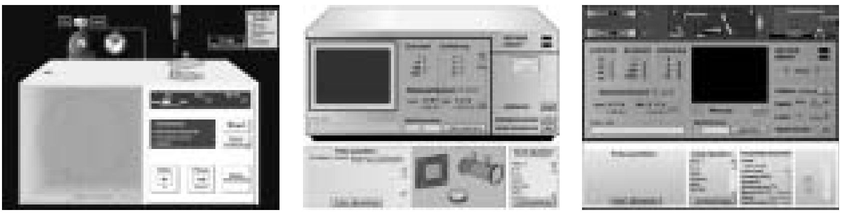

Figure 1. These virtual instruments can be operated via any standard internet browser. From left: virtual gaschromatograph, virtual FTIR spec-

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UNIVERSITY LABS FOR KIDS: SCIENCE EDUCATION FOR CHILDREN – TEACHER EDUCATION FOR STUDENTS!

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Universities for children? This idea has become popular at several universities in Germany during the last few years. One may think that such activities are first of all a result of worrying numbers of students in some areas, especially in "hard sciences", such as physics, chemistry or engineering [1]. Indeed, university laboratories aim at an increase of interest for science, and there are many reasons to start such activities with young children. First empirical results show that primary school children are not only highly motivated for (simple) scientific investigations and questions. They also show their ability to develop basic ideas and explanations about scientific phenomena and investigations [2].

The project CHEMOL at the university of Oldenburg has - as other science labs, too - developed a structure which integrates laboratories for school children into the university education of teachers in service and pre-service teacher students. CHEMOL offers teacher students the possibility to work with school children as part of their project work. It also offers the possibility to carry out educational research studies as part of their Master or Doctoral thesis. The topics of such research studies can investigate children´ s learning, using the theoretical background of conceptual change, as well as the effects on teacher training and the implementation of new concepts into the teaching routines at school. The results are used again to optimise the CHEMOL project, which can therefore be regarded as a research based developmental project, integrated in the teacher training at university level.

The project CHEMOL offers a great variety of experiments for primary school children *and* for teachers who work with children. Primary school teachers often do not have a scientific background and the syllabuses hardly integrate science questions and investigations in the first years at school in Germany. Neither the syllabuses nor teacher education programs for primary school teachers consider results which show that especially younger children have strong interests in scientific questions and activities and that they are able to develop first steps of scientific thinking and working [2]. CHEMOL aims at the development of a general understanding of basic concepts of science (with a special focus on chemistry) and of basic experimental skills. The children investigate four main areas in the CHEMOL lab: fire, air and gases, water and solutions and solid materials. They work in small groups, supported by science educators and by teacher students. The teacher students carry out this project for one semester: At first, they get an introduction into the theories of childrens ´learning and into the experiments and basic concepts themselves, the latter especially for non-chemistry students. The next step is to observe classes visiting the CHEMOL lab on the one hand and to visit classes at school on the other. School visits are possible because of a co-operation with a primary school teacher who also works in the project. Thirdly, they work with children themselves, and they analyse the childrens´ learning and development of explanations for the phenomena they had investigated. Finally, they are asked to develop an own experiment or series of experiments which can be integrated in the course in the future.

First experiences show that teacher students use their experiences from the CHEMOL project to a great extend in other experimental courses and that they reflect childrens´ learning when they have to discuss experimental approaches for teaching and learning. The numbers of students and in-service teachers participating in the project also point out the enormous interest in and need for such activities, especially for teachers without a science background. First results of a questionnaire given to teachers, however, show the difficulties of implementing science teaching into the teachers´ own routines at school. Therefore, further research studies shall investigate the effects of supporting teaching material and guidelines, which will be developed on the basis of observations made in the CHEMOL laboratory.

The paper which shall be presented at the conference will give insight into the structure of the CHEMOL project and into first results and designs of the accompanying educational research studies.

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ENVIRONMETRICS AS A SUSTAINABLE DEVELOPMENT TOOL AND CROSS ROAD OF RESEARCH, EDUCATION AND SOCIETY ISSUES

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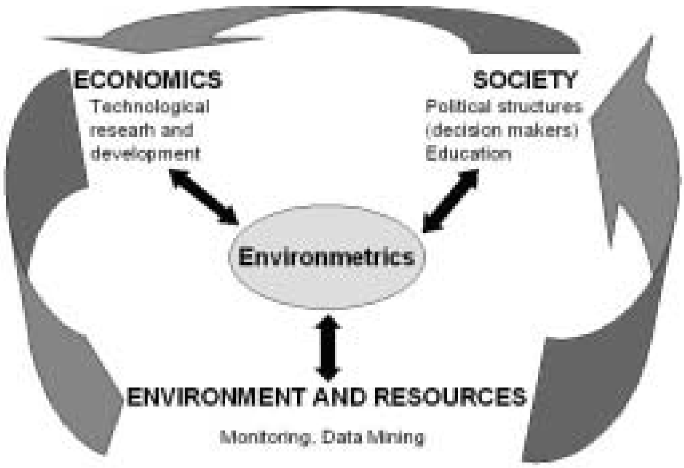
According to International Environmetrics society Environmetrics is scientific discipline covering a broad range of statistical, mathematical and engineering topics dealing with the analysis of environmental changes and their impacts on humans and various life forms and ecological relationships. The practical application of envirometrics methods has indicated that they could serve as a substantial part of a new metrics as applied to sustainable development. This is a result of the options offered by environmetric strategies for classification, modelling, interpretation, and data mining [1].

Sustainable development is the new development paradigm and environment goal of 21st century. The basic new development idea is ensuring of better quality of life for everyone, now and for generations to come. It means that society (community, individual) progress should match stable economic growth, effective environmetal protection and prudent use of natural resources. The sustainability development concept requires the implementation of standard sustainability measures in the industrial sector, in environmental policy, in economics, and in social life (see Figure). The challenge to become environmentally relevant has led to the development of two important concepts for sustainability indicators [2,3]:

- The P–S–R indicator concept (the Pressure of the socio-economic activities into natural systems leads to observable changes in the State of the environmental systems, which causes respective Response or socio-economic measures to reduce the hazardous effects);
- The D–P–S–R indicator concept (the socio-economic Drivers cause the Pressure, which changes the State and calls for Response).

The sustainability realization assigns to environmetrics simultaneously several tasks in different sustainable development components (see Figure):

- Research domain – Development *and optimization* of clean technologies, effective monitoring schemes and models which could be easily incorporated in integrative risk assesment models supporting society decision makers;
- Education domain – Implementation of *ideas* of environmental protection *issues* in secondary school *chemistry* course; transformation of existing bachelor courses and creation of new ones dealing with environment issues



to match the sustainability idea; development of environmental chemistry master programs including *all aspects of sustainable development (both technological and human)*; Ph.D studies in Environmetrics *ensuring* environmetric model*ing* to estimate natural and anthropogenic factors responsible for the environmental state.

In the research domain the ability of environmetrics strategies to assess *life* quality will be *demonstrated* by several *case* studies dealing with different environmental compartments. Environmetrics strategies *comprise* the environmental part of sustainable metrics for modeling, interpretation and data mining.

In the educational domain all levels of education will be illustrated by:

- Two different approaches (diffuse and fragmentary) for implementation environmetal protection issues in secondary school chemistry course;
- The modification of the bachelor degree course "Chemometrics" and creation of a new course " Environmetal Analytical Chemistry", according to sustainable development ideas;
- Representing the curriculum of a since 3 years operating master program "Environmental Chemistry"; this curriculum will be presented with respect to the linkage between studied items and competence of graduated students;
- Two Ph.D. studies describing the environmental state of environmental systems and regions.

In conclusion, it has to be stated that

- In the research field the modern Analytical Chemistry and Environmetrics, in particular, should be mainly oriented to develop methods, models, and strategies for effective management of clean technologies, safe products, natural resources, and life quality as sufficient part of the sustainable development metrics;

- Environmental education becomes a building block for establishment of a new type of education where the concept of sustainable development turns to be a central issue. Thus, the emerging sustainability education will play a vital role in a new sustainable society.

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PROBLEM SOLVING IN UNIVERSITY CHEMISTRY EDUCATION: A REVIEW OF RESEARCH WITH EMPHASIS ON THE ROLE OF PSYCHOMETRIC FACTORS

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This paper reviews contributions to problem solving in chemistry education, with emphasis on university chemistry and the role played by the following psychometric factors: Piagetian level of cognitive development, working-memory capacity; functional mental capacity (*M*-capacity); and disembedding ability or cognitive style (i.e., degree of perceptual field dependence/independence).

Working-memory capacity is crucial in the Johnstone-El Banna predictive model while disembedding ability, 'chunking' of the problem into familiar parts, as well as the so-called 'noise' which may be present in the problem have an effect too (Tsaparlis, 1998, Tsaparlis & Angelopoulos, 2000). In complicated problems, such as chemical-equilibrium ones, important becomes the logical structure of the problem (Tsaparlis, Kousathana, & Niaz, 1998). Extensive practice can turn the problems into algorithmic exercises; developmental level plays an important part then. In a study on acid-base equilibria (Demerouti et al. 2004), developmental level was connected with most cases of concept understanding, while disembedding ability was involved both in situations that required concept understanding alone, or in combination with chemical calculations. Disembedding ability and functional *M*-capacity were found to play the most important role in a study of problem solving in elementary physical chemistry.

The relation to problem solving of the *mobility-fixity* dimension, which arises from a combination of *M*-capacity and disembedding ability is also examined (Stamovlasis et al., 2002). Finally, the non-linear methodology of complexity theory was used recently in the treatment of problem-solving quantitative data with respect to the effect of psychometric variables, using indexes of complexity theory such as the *Hurst exponent*, *fractal dimensions*, or *entropy* (Stamovlasis & Tsaparlis, 2000, 2001, 2003a, 2003b, accepted).

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SELF-EFFICACY AND ATTITUDES OF CHEMISTRY OF PRESERVICE SCIENCE TEACHERS

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Introduction

Bandura (1986) described self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391). Applying Bandura's theory to teacher efficacy beliefs, self-efficacy belief can be examined under two facets. The first belief, called personal teaching efficacy (self-efficacy) can be described as the belief in one's own ability to effectively present knowledge, perform better in the class and guide students toward understanding. The second belief called outcome expectancy is one's expectancy of performing a specific task that leads to a desirable outcome. Bandura (1981, 1982) indicates that people's beliefs in their own abilities have an effect on their performance.

Ramey-Gassert and Schroyer (1992) summarized several studies by indicating that teachers' poor self-efficacy results in science anxiety and poor attitudes towards science. This shows that self-efficacy beliefs of teachers affect their attitudes towards science and their teaching performance. Therefore, it is important to identify attitudes of teachers towards science and their personal science teaching efficacy beliefs and promote teachers' self-efficacy beliefs about science teaching and attitudes towards science.

The purpose of this study

The purpose of this study is to explore the relationship between Turkish pre-service teachers' attitudes towards chemistry and science teaching self-efficacy beliefs. Research question according to this purpose is as follows:

Is there any relationship between Turkish pre-service chemistry teachers and pre-service science teachers' self-efficacy beliefs and their attitudes towards chemistry?

Methodology

Sample

Data were collected in the first semester of the 2004-2005 academic year from three different universities in Turkey. The sample consisted of undergraduate students from two departments which were secondary chemistry education and science education departments. The students attending secondary chemistry education program are supposed to be chemistry teachers in high schools after graduation and the students attending science education program are supposed to be science teachers in middle schools after graduation. All students were either in their fourth or fifth year of their five-year education programme and they all took some pedagogical courses before. The ages of the students participated in the study range from 21 to 23. Of 212 students, 83 were male and 129 were female. There were 86 students from chemistry education programme and 126 students from science education programme.

Instruments

The instruments used for this study were the science teaching efficacy belief instrument and the attitude scale. The science teaching efficacy belief instrument was developed for prospective teachers by Enochs and Riggs (1990). The science teaching efficacy belief instrument was a 23-item Likert-type instrument and measured pre-service teachers' personal science teaching efficacy beliefs and outcome expectancy. The Turkish version of this instrument developed by (Tekkaya, Çakıroğlu & Özkan, 2004) was used in this study. The overall Cronbach alpha estimates of internal consistency was found as 0.87. The Cronbach alpha estimates of internal consistency of personal science teaching efficacy beliefs dimension was found to be 0.84 and that of outcome expectancy dimension was found to be 0.76.

To measure the attitudes of pre-service science and chemistry teachers, attitude scale toward chemistry developed by Geban et al., 1994 was used in this study. The attitude scale contained 15 items in 5-point Likert type scale. The Cronbach alpha estimates of internal consistency of the attitude scale was found to be 0.94.

Procedure

Both attitude scale and science teaching efficacy belief instrument were administered to pre-service teachers in a class hour. It took nearly 20 minutes to complete the instruments.

Analysis

Pearson's r correlation coefficient was calculated by using SPSS program to look at whether there is a relationship between self-efficacy and attitude. It was found that there was a significant positive correlation between self-efficacy and attitude ($r= 0.369$; $p<0.01$). In addition, there was a significant positive correlation between personal science teaching efficacy belief and attitude ($r=0.345$; $p<0.01$) and between outcome expectancy and attitude ($r= 0.286$; $p<0.01$).

Conclusion and Implication

This study showed that there were significant positive relationships between attitude toward chemistry and science teaching efficacy beliefs. This result indicates that pre-service teachers with high science teaching efficacy have high positive attitude toward chemistry. This finding is consistent with Ramey-Gassert and Schroyer (1992) indicating that teachers' poor self-efficacy results in a poor attitudes towards science. Since self-efficacy is important in teaching, it is suggested that the causes of poor self-efficacy should be investigated. This study has implication that teachers' attitudes toward chemistry should be considered for increasing self-efficacy.

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THE „FLEXIBLE UNIVERSITY” AN ADAPTIVE CURRICULUM FOR STUDENTS OF CHEMISTRY JU

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The Faculty of Chemistry of the Jagiellonian University belongs to those academic institutions that provide no obligatory apprenticeships for students in their educational curriculum. However, a significant number of students of chemistry [1] expect some assisstance from the Faculty in organizing the students' placements. They consider holiday practices as an important part of their education. During the recent few years, some enterprises have started to be active in training of the students of the University [2].

Most of the employers expect the average age of well-educated and mobile alumni entering the labour market to be around 22-23 while the most popular Polish degree (magister ~ MA or MSc) may be achieved at the age of 24-25. As younger people are significantly more mobile, this apparent difference of age may lead to significant consequences like virtual lack of well-educated people in certain regions of the country and simultaneous unemployment in other regions.

The basic assumption of the project is formation of a *flexible* educational structure allowing for individualized treatment of every student within the formal education framework. The *formal* educational co-operation between the University and some *selected* industrial partners are other vital aspects of this project. Students may apply for a *summer apprenticeship* in one of the partner enterprises. If both parties (the student and their principal from the industry) find the further co-operation worthy, they (together with the tutor from the University) may propose an individual topic of the student's diploma work. This educational pathway may both help in career of individual students and help industry to find specialists.

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THE INFLUENCE OF COMPUTER-AIDED TEACHING & LEARNING ON STUDENTS' ACHIEVEMENTS.

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The presented work is based on the CAT&L experience gathered during the academic year 2004/5. Our goal was to build and test software that might be useful as an auxiliary tool in traditional (face to face) teaching. We present our opinion on how the use of web teaching tool influences the didactic process. The software Aria http://zinc.eu.org/aria/ was conceived by the authors of the presentation (idea: S. Witkowski: structure, encoding and all other technical aspects: J. Witkowski) with help of some suggestions taken from the literature [1,2] Special care was taken to assure the straightforward use of the software by students.

The software was tested in three kinds of teaching activities: seminars (with first-year students), lab exercises (with second-years) and lectures (with fourth-years). The main function of the web-site was to disseminate certain data for students (e.g. preparatory/auxiliary materials and scores). Students submited their reports via the web-site.

In most cases it was evident that thanks to Aria the didactic process became more disciplined and smooth. Quick access to all the necessary preparatory materials helped the students to prepare to seminars and lab exercises. However, we noticed that some students (10 to 20% of the total number) had problems with learning since the very beginning of the term (sooner than ever before). The questionnaire performed at the end of the term showed that some first-year students did not accept the auxiliary materials distributed via the network because they felt *overloaded* with their amount. Other opinions point at the *impersonal* character of this kind of teaching aid and some students came across certain *technical* barriers in learning.

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BEST CHOICE AN INTERACTIVE LEARNING PORTAL FOR CHEMISTRY

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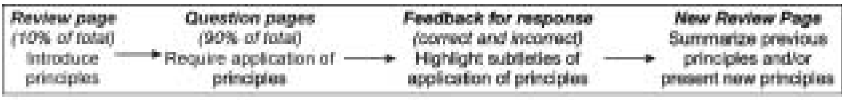
The BestChoice web site (www.che.auckland.ac.nz/bestchoice), developed by Dr Sheila Woodgate, has been used since 2002 to support both first-year university students at The University of Auckland and New Zealand high school students in their learning of chemistry. Over 60 modules with 2500 screen views and 4000 possibilities for interaction generating feedback are currently available.

The cohorts of students supported by BestChoice at first year at The University of Auckland is diverse both in previous chemistry studies and future program choices. Student cohorts include interdisciplinary students, science majors and students undertaking Foundational Certificates. The modules from BestChoice incorporated in year 1 courses include compulsory modules to reinforce lecture material, introduce laboratory work/techniques and review tests. In addition optional background/extension modules are recommended.

The primary focus of *BestChoice* is to facilitate self-directed learning using web-based interactive tutorials. Each of the modules is a carefully constructed learning activity intended to give students insight into Chemistry and therefore to promote deeper understanding. The scheme below outlines the methodology used to systematically develop content while constantly reinforcing important principles through liberal use of feedback.



The high percentage of Question pages relative to Review pages attempts to avoid cognitive overload for users. The user takes an active role by entering answers to questions. This results in the student then receiving detailed constructive feedback appropriate to the user's response. The questions take a variety of formats including various types of multichoice (including list boxes and image map) and text-entry. In calculations, students enter the data into the appropriate formula on screen in a similar way to pen and paper calculations. The ability to have a variety of answer formats with the feedback makes this system unique.

Through an on-line survey users can both rate the modules and type in comments. Users are, in general, very complimentary about the *BestChoice* interface and the learner-friendly delivery of content. Suggestions for improvements through the on-line feedback/evaluation system have guided development of new features.

FORENSIC CHEMISTRY SPECIALIZATION - HOW TO CATCH THE BEST STUDENT?

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Forensic Chemistry Specialization (FCS) for undergraduate students at Jagiellonian University was the first one in Poland. It was set in 1997 but the original concept was born few years before. In 2000, the Laboratory for Forensic Chemistry (LFC) was established at the Faculty of Chemistry, Jagiellonian University.

Teaching is the important task of the Laboratory while the research area is focused on the development and the modification of analytical methods for forensic purposes. However, the laboratory job is essential, LFC is responsible for the organization of the course of the forensic chemistry. In this way, the Laboratory Team is involved in the enrolment which takes place after the seventh semester.

Each year forensic chemistry offers between 10 and 14 places in the course. This limit is associated with the number of the topics being worked out by the Department of Analytical Chemistry and the Institute of Forensic Research in Krakow which is the co-organizer of the course. These topics enforce the students' further master's theses, which are distributed among students after the first semester at the specialization.

It was observed that the number of candidates for FCS significantly varies every year and similarly, the applicants' mean of marks (from all exams before the qualification) changes from the medium level to the highest one. Until now there was no explanation of this situation.

The goal of this work is to present the strategy of informing students of chemistry and candidates for the chemistry study about forensic chemistry specialization at the Jagiellonian University and to research the profile of forensic chemistry student. This investigation should give a feedback to the Laboratory Team and help to encourage the best students to take the Forensic Chemistry Specialization.

Generally, all information about forensic chemistry at the Jagiellonian University may be divided into two streams: formal and informal. The first one is represented by several types of actions being done by authorities of the Faculty of Chemistry and the staff of the Department of Analytical Chemistry. They may be listed as follows:

1. International and local conferences.

2. Publications in scientific journals.
3. Publications and interviews in other media.
4. University open-days for schools.
5. Festival of Science in Krakow
6. Scholarship programs, e.g. Socrates-Erasmus.
7. Invited lectures at other universities, schools or associations.
8. Web site, etc.

While the very first two actions are supposed not to have a significant influence on taking the Forensic Chemistry Specialization by students or choosing studying chemistry at JU, the rest of them should not be neglected. Especially demonstrations of Laboratory for Forensic Chemistry during the University open-days and the Festival of Science are the one of special importance. LFC puts attention on participating in those events, at least every two years. The role of the LFC's web page is also considerable, although the Internet page still needs many improvements.

The informal knowledge about the forensic chemistry comes form a numerous information channels: talks between students themselves, between students and teachers and the Internet Forum. Due to the study schedule, the staff of LFC leads not only the forensic specialization classes but also teaches other analytical subjects. It was noticed that students are interested in forensics just at the beginning of the study when they meet the analytical chemistry at the very first time during the one semester long course. This moment is essential for students thinking about their future at FCS. They have to realize that the only way to pass the qualification is to posses the high mean of marks which involves a hard work just from the first semester.

The "second meeting" with analytical chemistry falls out at the sixth semester, when students are acquainted to advanced instrumental techniques and methods. Laboratory Team attempts to introduce some forensic aspects into the laboratory practice. This is the last moment for students to make decision to apply for the FCS and for us it seems to be the vital period for catching the best students. There is a strong competition between several specialization offered at the Faculty of Chemistry JU. This is the reason why LFC focus its efforts on attracting new and fine candidates. Further work with excellent students leads to the development of the Laboratory and in future, after graduate, the possibility of extending the Laboratory Team.

Going to improve the LFC's strategy, the profile of the forensic chemistry student is investigated. The questionnaires filled up by students form each year of the specialization are collected and just after the following qualification the results will be accounted. The statistic model is expected to support the effectiveness of informing about Forensic Chemistry Specialization and give the great possibility of the improvement of the qualification process.

LEONARDO DA VINCI PILOT PROJECT CHLASTS – WP 2.2 PRODUCTS

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Leonardo da Vinci pilot project # PL/02/B/P/PP 140 099 Chemical Laboratory Safety Training System (CHLASTS).

Health and safety at work are becoming increasingly important in laboratories throughout Europe, in industry as well as in teaching and research. The project CHLASTS addresses the training needs for employers, teachers, researchers and students in recognising the health and safety aspects of working in laboratories and in transferring good practice and skills into work-related environments throughout Europe.

Partners:

- National University of Cyprus Department of Educational Sciences
- The International Council of Associations for Science Education
- University of Bremen, Centre for Environmental Research and Technology UFT
- University of Barcelona
- European Chemistry Thematic Network
- Institute of Chemistry, Vilnius, Lithuania
- Faculty of Science and Technology - University of Coimbra
- Universidade de Lisboa - Faculdade de Ciencias
- Jagiellonian University
- The University of Silesia
- Silesian University of Technology
- Nicholas Copernicus University
- University of Gdansk, Faculty of Chemistry
- State Higher Vocational School in Tarnow
- Maria Curie-Sklodowska University

The specific aims of the project are to develop an agreed set of good practices for safety in laboratories through training schemes and manuals. To achieve these aims it was necessary to analyse existing practices in selected institutions throughout the participating institutions and to identify existing legislation in health and safety in laboratories. The next stage was preparing training manuals and guides in a variety of media, including printed versions, CD ROMs, video clips, as well as internet-related data bases. Each of these will need to be evaluated through testing and assessment by end users.

The following results are anticipated:

Examples of best practice in safety procedures were be published and disseminated, common training modules for safety measures were developed, a set of symbols and visual indictors of safety practices was developed and published. An active web site on laboratory safety is created and maintained (www.chlasts.org). A multilingual dictionary on laboratory health and safety is prepared, published and disseminated.

Work Package 2.2
Safety procedures for chemical laboratories and Higher Education Institutions

Aims:

To develop procedures for chemical laboratories in order to promote the culture of safety work based on prevention and protection both of the people (students, teachers and workers) and the environment.

Outputs:

1. DVD - as a introduction to students and layman
2. Specific Risk Assessment Form - for students and co-workers
3. Interactive CD - developing DVD material
4. Booklets - advanced information concerning safety
5. Training materials - handbooks integrated meritum and safety
6. Website - summing of all material

The project finish is expected on the end of September 2005.

WORKSHOPS

PROMOTING LEARNING THROUGH PEER GROUP WORK

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Higher Education has experienced educational development and commitment to teaching on an unprecedented scale over the past twenty years. Unfortunately there does not appear to be any clear evidence for improved learning by our students during this period. This would seem to suggest that our current efforts are either misguided or badly focussed. I hope and believe that it is the latter and would suggest that what is needed is a more active or better still a more interactive approach to learning by our students. This workshop will show how such an approach can be facilitated when students are permitted to work in groups. The workshop will invite participants to consider the pedagogical advantages, cognitive and affective, offered by group work and to consider how group work can be effective in promoting learning. Factors that tend to inhibit such learning in group work will also be considered. The value of group work in supporting retention and in encouraging students to take responsibility for their own learning will be highlighted.

Group work can easily be introduced into all conventional teaching activities and examples of its use in lectures, laboratories, case studies, projects and role-play will all be considered. Ways in which active involvement of all group members can be promoted, the problems of assessment and the way in which skills development occurs as a by-product of much group work will also be considered. Participants will take part in a number of exercises, be introduced to the facilitator's own version of 'Russian roulette' and be invited to select an area of their own teaching where they are currently dissatisfied with the learning outcomes and hence consider how the introduction of some group activity could be used to improve this.

IONIC EQUILIBRIUM PROBLEMS: IS THERE A BETTER WAY TO SOLVE THEM?

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Ionic equilibrium calculations are a tough subject that have inspired a lot of interest and publications. A search on the JCE Online index showed some 700 articles on the subject. (1) Ionic equilibrium calculations constitute an homogeneus group of problems that are of substantial educational importance and present cognitive difficulties to those who have to learn how to solve them. Basically, ionic equilibrium problems are still solved using the 5% approximation rule. (2) Students apply memorized formula without knowing that the obtained result can be wrong. Often, this method leads to correct results, but the logical abilities of the student are used at a very low level. If one asks students to find the hydrogen ion concentration of a water solution of acetic acid (K_a = 1.753 x 10^{-5} M) 1.00 x 10^{-7} M, very easily the most popular solution is the following:

$$[H^+] = (K_aC_a)^{1/2} = 1.32 \text{ x } 10^{-6} \text{ M}$$

where C_a is the total acid concentration. How is it possible that $[H^+]$ = 13.2 x C_a? (3) This method fails because, in many cases, the student cannot estimate the result with the necessary precision. The didactic approach of acid-base calculation must, as Freiser suggested years ago, avoid the Scylla of oversimplification to achieve "clarity" and the Charybdis of "cumbersome" rigorous equations. (4) Twenty-five years ago I have developed a logical approach that relied on the information derived from the ionic equilibrium theory: (5)

1. Water is always ionized according to the equilibrium: H_2O $H^+ + OH^-$ and the ion product of water must always be verified: $[H^+][OH^-] = K_w$. Sometimes the H^+ coming from water ionization must be taken into account.
2. Acids and bases always react.
3. Strong acids, bases and ionic salts are completely ionized.
4. Weak acids and bases are partially ionized; conjugate species undergo hydrolysis:

$$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$$

5 Sudents use the mass balance equation and the electro-neutrality condition for verifying the correctness of the result.

The only approximations allowed are of a numerical nature: 1.00 x 10^{-2} + 3.45 x 10^{-8} = 1.00 x 10^{-2}. The tolerable relative error is 1%. The approximations are made by comparing calculated values instead of using estimated ones. Students enjoy this method because with a logical reasoning they can solve the problems.

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"ECHEMTEST", A EUROPEAN EVALUATION TOOL TO CERTIFY AT UNIVERSITY LEVEL BOTH THE ACADEMIC AND PROFESSIONAL KNOWLEDGE IN CHEMISTRY

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The European Chemistry Thematic Network (ECTN) and the ECTN Association (1) represents over 130 major university chemistry departments, from 30 countries. Each ECTN member is involved in various fields of investigation dealing with the chemistry education in the European Higher Education Area; one of these is "EChemTest", the European Chemistry Test (2), an evaluation tool in Chemistry based on a common core chemistry curricula agreed within the European Union (3).

Originally dedicated to the academic public and the student exchanges, EChemTest will enables Universities and Candidates to have a clear evaluation of the student's knowledge level and a clear understanding of the University's pre-requisite level. The potential value of the common core approach is to give a ruling on the equivalency of levels between both the host and guest. One of the issue of EChemTest in a close future, is the use and the dissemination of the Chemistry Eurobachelor according to the recommendation of the Bologna declaration. The second issue is the professional career evolution, from which the industrial world represents a challenging target for us, having broad and sharp needs depending on the industrial sectors and departments.

After an overview of the development of the European core curriculum approach at the university level, we will focus on the analytical chemistry Euro-curriculum recently approved by the Division of Analytical Chemistry of the FECS. Then as an example of application, the use of EChemTest in the professional context, focusing on both the organic chemistry and the analytical chemistry tests. A qualitative survey will be given after analysing the results of several sessions of continuous education dedicated to the organic synthesis where the organic chemistry test at level 3, equivalent to the Eurobachelor level, was chosen and successfully used to evaluate the understanding of our trainees at the end of the session.

All attendees of the EuroVariety conference will have an opportunity to run demo sessions of tests (free registration for individual account). The whole question bank of EChemTest allowing us to issue a certificate of knowledge in chemistry is currently beta-tested and will officially be launched at the Annual Conference of ECTN in Thessaloniki, GR (May 2005).

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POSTERS

MONITORING THE USER'S WORK – A NEW RESEARCH TOOL IN CHEMISTRY EDUCATION

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Computer science makes it possible to create a computer program monitoring the user's work with it. Such a program would be an indispensable tool created for the purpose of education research. If properly used, in terms of research and ethics, it could serve as a valuable source of information for general and detailed didactic.

Multimedia program could become a desired 'matrix' for the incorporation of the tool that is the computer program. During the last few years dynamic increase in the number of multimedia programs prepared for the elementary level of education purpose has been observed. Additionally, a number of programs stimulating the student-centred learning at the university level become available. The situation concerns also the field of chemistry. Chemical programs function as a didactic tool that has met with an interest of the learners at all levels. According to the conducted research, chemical programs have turned out to be useful also at the higher, university level. The essential factor of the programs is the fact that while including completed content-related issues (such as texts of the lectures) illustrated with photographs, drawings, animations, films and supplemented with simulations and interactive examples, can be treated as a basic didactic device. The observation of the evolution of such programs leads to a conclusion that on the lower level of education they can be successfully applied. Supplying the programs with the measure analysing the process of education would be highly promising.

Therefore, the necessity to create the multimedia program monitoring the individual user's work with the program has been observed.

Such a program has been created by Mr P. Bieniek as a part of his Ph.D. thesis titled 'Test of multimedia application of the education process in chemistry realized by serving and problematic method' prepared under Prof. H. Gulińska, Ph.D. guidance.

The created program incorporates all the elements typical for the multimedia programs in the field of chemistry: texts dealing with chosen issues, films and animations depicting the process of related chemical experiments, drawings, photographs, simulations, models of chemical compounds and other objects of the microworld, as well as exercises for learners (where the concept checking questions have been selected and generated at random). The research conducted in 2003-2004 in a group of the overall number over 500 participants revealed that the program has fulfilled their expectations in terms of educational programs. Moreover, it showed its high education effectiveness (the level of education progress grew up to 25% after the program application).

The created program has been supplied with the module monitoring its work. The module itself was operating invisibly during the whole computer-based learning time and its aim was to respond to the events initiated by its user. What is more, the other goals of a created program were to record and code certain activities and also stages in program using. It has created the opportunity to carry out the experiment in a different way than it has been done so far: learners were using the program during their individual work at home, following their individual needs and without being supervised. As a result of the experiment, data concerning the chemical education research have been discovered.

Along with the creation of the monitoring module, ethical doubts concerning its usage have been raised. Eventually, it has been assumed that the monitoring module is a device similar to the accepted by the methodology of pedagogical and psychological research hidden camera, and as such, it does not violate the ethical principles of the research. The ethical aspects have been discussed in details in work [1].

The computer program and the experiment have been set on the lower secondary school level, but all of the included solutions can be applied to every level of an education. The program of such kind is particularly convenient in didactic research at the universities, where the computers are used during chemistry classes more frequently than in lower secondary schools or even in high schools, where the computers are exploited during computer science classes exclusively. Whereas, the intranet in the class could deliver the information about the work of an individual student or group of them during the classes. At the same time the computer program could, to some extent, assess their work (e.g. accept the result of chemical analysis), and sent it to the lecturer's computer. Additionally, computer program could create the data base helping to gain information similar to those presented above. As students (mainly of science studies) have their own computers, the analysis of their work at home would also be possible.

Summing up, the formerly inaccessible possibilities of the chemical education research have been created. Learners and students favour the multimedia programs. The usage of such programs gives measurable educational advantages and results in gaining promising perspectives in better understanding of the chemistry learning process, analysing the appearing difficulties as well as to more effective chemical education research. Consequently, it leads to the increase of the effectiveness in teaching chemistry from the point of view of the a teacher/lecturer and the satisfaction of its exploring from the point of view of a learner/student.

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COURSE FOR THE POSTGRADUATE STUDENTS IN THE FIELD OF IT EDUCATION FOR THE CHEMICAL EDUCATION PURPOSE

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Chemistry department at the Pedagogical Academy in Cracow has been running a postgraduate course titled ‘Chemistry for the lower secondary school teachers’ for the last few years. While attending the classes titled ‘Computer Methods in Chemical Education’* participants are instructed how to use the computers during their work as chemistry teachers. Course syllabus has been prepared and conducted by the author of the paper.

The postgraduate course attracted participants of different age level. There are recent university graduates among them as well as those who graduated from the university a few years ago. Thus, what differs them most, is the degree to which they make use of computers for private or professional purposes and, what follows, the practical knowledge of computer programs. What is more, the differences in motivations concerning the exploration of a new, more complex teaching tool and the pressing necessity to change one’s teaching habits are easily observed. Before the course starts, its older participants’ behaviour suggests their conservative attitude towards the IT Education. They seem to perceive it as an undesired interference in chemical education. In contrast, younger participants that were brought up during the IT Education development are perfectly aware of the benefits it may bring.

The discrepancy in attitudes towards the computer science issue leads to the problem with organising the classes in such a way so that all the differences in computer using skills were levelled. The other aim of the course is to train all the participants to make the most of IT in chemical education and to acquaint them with the profits while working with it.

The key to solve the problem was to name each section of the course. The given title concerns chemistry, e.g. ‘Source of knowledge about the structure of a matter.’ During the course the participants’ task is to prepare an exhaustive outline of the leading topic that would cover illustrations (drawings, photographs, models of chemical compounds, etc.), presentations (originally using multimedia OHP or an interactive board) as well as www pages for students (incorporating links to the pages with the related topics). In order to tackle the task successfully, the participants become familiar with certain computer programs, computer science issues and specific problems associated with the usage of IT in chemical education.

Topics to be discussed were classified into groups:

- Preparing outlines and diagrams by means of MS Word program, creating charts in Corel program, constructing chemical compounds models in

*due to the fact that the term ‘IT Education’ has been widely spread, it is planned to change the name of a course

HyperChem Lite and ChemSketch program, formulating structural formula in ChemWindow program.

- Lesson visualisation, drawing up a lesson plan in MS PowerPoint, preparing an animation accompanying the lesson (Corel, Ulead Gif Animator programs), creating charts (MS Excel)
- Using Internet in chemical education, as well as presenting individual didactic ideas on www pages (html option used by means of MS Office, FrontPage or WYSIWYG and HTML), Internet as a source of information, pages devoted to chemistry (e.g. ChemFan), discussion forums, chat, registering one's own e-mail address within the confines of free options offered by the Internet search engines, e-mail programs, educational portals
- Educational computer programs supporting the chemical education (e.g. 'Chemistry with ecology aspect,' 'Periodic table') and freeware programs freely available in the Internet.

Classes are conducted mainly due to the problematic method in order to prepare the learners to the individual programs research in the future. The emphasise is not put on the ability to recognise the details of the software but on the learner's comprehension of the computer programs organisation.

Comprehension of the computer programs' organisation is a key to eliminate user's inner obstacle towards 'something new.' Particularly the older participants of the course faces this problem. The younger learners frequently use a variety of computer programs during their studies or in their spare time. As a result, their intuition in finding particular details in the explored programs has been already developed.

During the postgraduate course the main emphasise is put on the principality in using didactic source in the field of IT. For example, it is said that although chemistry is a science based on the experiments, it is not advised to avoid conducting chemical experiments in favour of matching their processes on TV (excluding the situations like a shortage of chemical reagents or the importance to observe the kinetic reaction). However, the films may serve as an excellent source during the learner's individual work at home. The restrictions and the risk of visualisation when using computer programs (e.g. presentation of a reaction process without drawing attention to its real mechanism) as well as the necessity to verify the information read on the Internet are also discussed.

While conducting the classes in the way described above, the author of the paper has observed the increase of the course attendants' motivation in developing their knowledge in the field of IT Education. What is more, participants' engagement in the tasks has been also detected. This fact has a significant impact on the course results.

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APPLICATION OF A PROBLEM SOLVING METHOD IN TEACHING OF BIOINORGANIC CHEMISTRY

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Our experience indicates that students of chemistry do not realize that subjects they study should be treated rather as a part of the whole chemistry knowledge than separate courses. Students find difficult combining their knowledge from various courses to solve a given problem. The development of this skill (using the whole knowledge to solve the task) is very important for students during their work on master projects as well as in their future job career.

Seminars on bioinorganic chemistry are a selected part of the whole course ‘Inorganic Chemistry II’ (an advanced course of inorganic chemistry for the 3rd year chemistry students). Five seminars, associated with five lectures, are limited to 45 min each, which is insufficient to cover the topic in detail and encouraged us to prepare these seminars rather as tutorial than regular. Before the seminars students receive the text of all discussed problems together with related questions [1]. The text should help to understand the rules governing some processes found in bioinorganic chemistry. For example the ‘Metal complexes as drugs’ were discussed presenting *cisplatin* ($[PtCl_2(NH)_3]$), a well known anticancer drug. *Cisplatin* is a coordination compound and students should be familiar with its chemistry (*e.g. trans* effect, HSAB theory, kinetics, equilibrium constants, substitution reaction mechanism). This basic knowledge is helpful in understanding the mode of this drug action. Another subject discussed during seminars was ‘Light + photosensitizer = a new approach to therapy’. This combination is unknown for students as a phenomenon called *photodynamic therapy* (PDT), however, they have learnt the principles of photochemistry and after drawing the discussion in a proper direction they should be able to understand the principles of PDT and discuss related problems such as properties of a good photosensitizers. Other topic encompassed energy and electron transfer processes and thermodynamics. The discussed examples are based on photosynthesis and enzymatic reactions (photons and electrons counting, energetic efficiency estimation *etc*.).

Teaching of bioinorganic chemistry within this course involved solving problems. Students should use their knowledge of general, inorganic, physical and organic chemistry to understand the principles of bioinorganic chemistry discussing and solving problems. The role of a teacher is reduced to guide discussion towards the intended learning outcomes. Assessment includes two components the students’ activity during seminars and the result of written exam (solving problem of similar type).

The main goal of these seminars was to show students that their knowledge possessed during education process is not limited to particular subject but can be useful in analyzing problems dealing with entirely different fields [2]. Moreover, this type of classes allow verification if knowledge gained by students in previous courses is fully understood or only memorized. Students develop a range of skills including problem solving, critical thinking, and oral communication. Most of the students find this type of seminars quite difficult and innovative [3]. However, for some of them it was an excellent way of review previous knowledge and to learn something new [4].

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CHEMICAL EXPERIMENT IN LIGHT OF NEW REGULATIONS ON DEALING WITH HAZARDOUS SUBSTANCES AND PREPARATIONS

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The work in chemical laboratory may be dangerous both for the experimenter and the environment as well. In order to protect human health and the environment a number of regulations regarding the principles of handling those substances have been introduced. The issue of safe usage of hazardous substances and preparations is extremely important especially that students carrying out experiments must use a number of chemical reagents thus generating hazardous waste.

One of very important questions is the issue of empty chemical substances packaging which were used for experiments and contain small quantities of hazardous chemicals. After the accession of Poland to the European Union in 2004, it became necessary to unify the regulations on hazardous substances, chemical laboratory waste materials generated by students and researchers as well as the regulations on empty chemical substance containers.

It is extremely important for the teacher to bear in mind some crucial principles of conscious experimental work which would guarantee that students remain unharmed and the environment unpolluted.

Hazardous materials safety sheets are of great help with this respect and anybody working on chemical experiments should be familiar with them. Safety sheets must unconditionally be enclosed with any hazardous substances used in the lab.

Hazardous substance safety sheet contains a set of information on dangerous properties of the substance or preparation and it must contain directions for its safe use.

The sheet is to be used by professionals who must observe certain precautions whilst working in their labs in order to guarantee their own safety and the safety of the environment.

Another valid issue is unifying the labels which are to inform on the risk the substances may pose.

Hazardous substances must be marked with clear ad legible labels. This requirement must be met at schools and universities where students use such substances and preparations during their classes. According to regulations specified in separate directives on legal aspects of marking hazardous substances and preparations it is essential that the labels are in Polish.

The regulations pertaining to disposal of hazardous waste are contained in seven basic legal acts and tens of executory orders.

The legal act of most importance is the one regulating the issue of waste. It introduces basic definitions and classifications of waste including classification of hazardous waste. It specifies the obligations of waste owners and describes what requirements must be met by any entity willing to undertake activity which may produce waste, any company that plans to collect, transport, recycle and neutralize waste so that they could obtain an appropriate permit.

A number of duties are imposed on the anyone who produces waste, including Chemistry teachers.

Such obligations include among others:

1. Specifying the amount of hazardous waste produced.
2. Keeping a register of waste.
3. Specifying the manner of collecting particular hazardous waste as well as deciding which waste may be handled together with another waste and which must be stored separately.
4. Decreasing the amount of hazardous waste, for instance by precipitating a hazardous component from the solution, separating it from the solution and, thus having minimized its volume, storing it until professional company neutralizes it.
5. Decreasing the aggressiveness of the waste in the laboratory e.g. by neutralizing acid with alkalis, etc.
6. Ordering collection of hazardous waste by an authorized company.

Another issue is fee for return packaging of some hazardous materials. The act on packaging and packaging waste imposes fees on chemical substance packaging which is particularly dangerous for people and the environment. The system of return packaging fees is to support the obligation of managing return packaging or packaging containing residues of harmful substances. It must be stressed that such obligations are often mutually complementary.

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MODERN GRAPHIC TOOLS FOR DESIGNING DIDACTIC AIDS FOR CHEMISTRY AND NATURAL SCIENCE

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Little effective does it seem to use a computer with no suited software. Teachers having appropriate software at hand may independently prepare didactic aids necessary in their everyday work thus enabling them to continuously improve those teaching aids and adjust them to the changing advancement level of their students. The teacher may prepare graphic schemes, transparencies, phasograms, posters, computer animations of chemical compounds and processes. Practically any issue may be visualized so that it makes it more understandable for the students.

The most basic type of graphic software, and simultaneously most commonly used one, are programs for bitmap graphics processing also called raster graphics. They allow for preparing transparencies, phasograms and graphic elements designed for WWW sites and for multimedia software. Three programs must be mentioned here: Adobe Photoshop CS, Paint Shop Pro and GIMP 2.0. The first two offer vast possibilities but at the same time they are commercial products yet the third one is free.

Vector graphics software is applied for preparing illustrations, schemes and posters. This software has one major advantage: a limited number of output files which allows for designing even large format posters. The following programs are available here: Illustrator CS, FreeHand MX, CoreDraw 12. All three of them are commercial ones. Older versions of CorelDraw are frequently added to scanners or graphic tablets.

There are two kinds of computer animations: graphic and vector ones. 3D animations may be applied for visualizations of chemical compounds structures, for crystalline networks, etc. Such programs as 3D Studio MAX 7, LightWave and Maya may be used here. These are commercial programs, however Maya is available as a free educational version. User friendliness and the manner of preparing animations is identical in all of these programs. The results of didactic research showed the efficiency of this kind of animations in teaching.

Another type of animation is vector animation and the only program which allows to create such animations is Flash. Besides creating simple animations, Flash makes it possible to prepare educational games and dynamic WWW sites.

The above mentioned programs were used whilst preparing the following multimedia software: “The intensification of agricultural production and its threats. Ecological farming”, “Organic chemistry - a multimedia manual”, “Chemical experiments in junior high schools”, „Chemical experiment in computer database”, “Basic laboratory techniques for chemical experiment”.

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SCIENTIFIC RESEARCH AS AN INTEGRATED PART OF CHEMICAL EDUCATION IN VILNIUS UNIVERSITY

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The teaching of chemistry at the Vilnius University was introduced in the 18th century when the Rector of the old Almae Matris decided to establish a College of Medicine. In 1784, Juoseph Sartorius, a member of the Royal Academy of Turin, came from Italy and started lectures on chemistry in Latin for medical students. He is considered as the founder of the Faculty of Chemistry at the University. Although specialists in chemistry were not trained properly at the university during the first period of history, chemistry was taught by a number of prominent scientists, such as J.Sniadecki, I. Fonberg, A. Domeika an other, who also carried out for scientific study in the University. So, the scientific research has been carried out for more than 200 years in the Faculty of Chemistry [1]. Such long experience has an impact on chemical education methods.

In the meantime, the level and intensity of scientific research carried out is considered a duty and counts considerably in the evaluation and promotion system of teaching staff in Vilnius University. Therefore, all teachers despite of their position (lecturers, associate professors – docents, and professors) are involved into various short- and long-terms projects. Therefore, elements of scientific research are involved into the education of Bachelors and original research scientific study is involved into education of Masters. Usually, the last one is the continuation of bachelor's work in the same department of the faculty. Due to the lack of the strict governmental regulations concerning both Bachelor's and Master's theses, every department of the faculty has its own regulations concerning preparation and presentation of Bachelor's theses, and every faculty has corresponding rules concerning preparation of Master's theses. The Bachelor study of chemistry at Vilnius University consists of eight semesters, and Master study consists of four semesters. Bachelor's programs obligatory are completed by the public defending of corresponding thesis. In other words, the performing a scientific research is compulsory. To gain a Bachelor's degree, 15 credits are necessary within two semesters, whereas to gain Master's degree 30 credits are necessary within four semesters. Moreover, the last one is completely dedicated for Master's thesis preparation. In both cases, the Committee for thesis evaluation consists of Faculty staff and social partners (up to 50 %). The social partners of the Faculty of Chemistry are: Institute of Chemistry, Joint Company "Fermentas", Institute of Biochemistry, and etc). All theses are reviewed by one independent scientist possessing at least doctoral degree.

Students may select any faculty member in the Faculty of Chemistry as well as in the social partner institution to serve as their research advisor. Usually, students tend to choose research advisor by their intuitive scientific interests and based on the list of long-term projects, and presently includes the following tasks:

- Creation of analytical methods and instruments for analysis of environmental, industrial, and biological objects;
- Electrochemical processes at the interface (comprising “Adsorption in electrochemical system” as a separate task);
- New functional inorganic materials and chemical compounds containing oxides: synthesis, self assembling and research of properties;
- Ionic polymers: synthesis, modification and research
- Stereoselective reactions of chiralic alyclic compounds
- Synthesis and research of functional derivatives from polycyclic nitrogen heterocyclic compounds

Another way to orient students into one or another research area are annual presentations prepared by leading scientific and teaching staff. Such presentations cover problems, objectives and methods used in scientific research carrying out in certain department or in the significant part of that, such as a specialized laboratory.

Usually, each teacher is advising for 1-2 bachelor’s and 1-2 master’s works. Qualification requirements for master’s work performed in Faculty of Chemistry meet those used at the scientific journals. Usually, based on the data collected in Bachelor’s and Master’s theses are prepared 10-15 articles in scientific journals each year (approx. 15% of publications prepared by faculty members).

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THE ROLE OF CHEMISTRY IN EDUCATION AT GDYNIA MARITIME UNIVERSITY

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Gdynia Maritime University (GMU) educates specialists in sea and land services of the maritime infrastructure. The educational process at GMU is conducted at four faculties (Faculty of Business Administration, Faculty of Navigation, Faculty of Marine Engineering, Faculty of Marine Electrical Engineering). Each of these faculties educates specialists whose preparation needs profound chemistry studies. Chemistry education at GMU varies depends on faculty character and is focused on specificity of specialization.

The main goal of Faculty of Business Administration is the preparation of specialists in the following areas: quality control of goods and cargo, organization of hotel and tourist services, organization and management of sea-harbour trade. Faculty of Navigation is preparing specialists for ship operation during sea transport and for technical sea-harbour operations. The aim of Faculty of Marine Engineering is to prepare marine mechanical engineers experts in operation of ship or in operation of industrial plant fittings. Chemical education at the Faculty of Marine Electrical Engineering is limited to subjects concerned with environmental protection.

The studying process in GMU is grouped into three levels (Fig 1). There are basic, directional and specialized courses. Chemistry belongs to the second one. Chemistry education is realized by means the lectures and laboratory workshops. The main aim of teaching of basic chemistry (inorganic and organic) is to reach the necessary background for studying other subjects such as: physical chemistry, foodstuff chemistry and biochemistry, microbiology as well as commodity and cargo science, ecology, environment protection, quality of goods, instrumental analysis, human nutrition etc.

The programme of chemical education at GMU is adjusted to requirements of the professional specificity. Thus students of faculty of Marine Engineering broaden their knowledge of corrosion, environmental protection techniques, chemistry of fuels, greases and water. Students of Faculty of Navigation are trained especially in the area of cargo science. The most amply chemical education is realized at some specializations of Faculty of Business Administration. For the Hospitality Management the teaching is focused on chemistry disciplines connected with human feeding (such as biochemistry, microbiology, food chemistry, storage). Students of Commodity Science and Quality Management, after studying inorganic, organic and physical chemistry acquire knowledge about goods, industrial processes of production, chemical and instrumental methods of analysis, packaging materials.

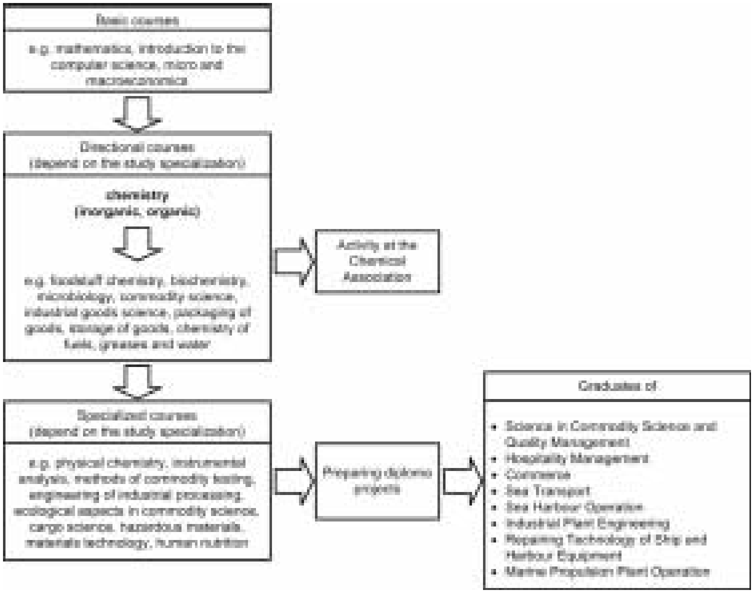

Figure 1. The role of chemistry in the educational process at Gdynia Maritime University

Moreover, some students obtain advanced chemistry education during preparation of their master thesis. Such problems of master theses are relevant to the hazardous goods transportation by sea, protection of the Baltic Sea environment, biodegradability of packaging materials, paint coatings or other organic compounds in different environments etc.

The activity of students scientific associations is the additional element of the educational process. The Chemical Association gathers students who are interested in chemistry especially. The main goals of the Association is to amplify their activity by scientific researches or organization and participation in students scientific meetings and workshops. The activity of the researches are generally connected with marine environment problems. Detailed information about activity and attainment of the Association is accessible through the Internet [4].

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THE E-LEARNING PORTAL FOR CHEMICAL EDUCATION

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In recent years, the potential of distance learning methods has been receiving an increasing amount of interest and international recognition in the field of education [1-4]. Numerous academic institutions choose to supplement their educational offer by introducing elements of distance learning, which is a growing trend also in Poland [5-6].

The project that has been carried out for one year in the Rzeszów University of Technology is aimed at introducing elements of distance learning at the Faculty of Chemistry. The figure below presents the project's internet home page.

The Virtual Learning Environment (VLE) will become a new facility for the prospective and present undergraduate and postgraduate students of our Faculty. With time, it will be developed further, to become also a complementary tool for the specialist training and courses offered to the local industry.

Much effort has been made to encourage the involvement of our students in the creation and testing process, with student-staff teams co-operating in every department and across the departments. In this way, the sense of ownership of the project can be fostered by the whole academic community who are to be involved in the running and the use of the VLE.

The project seems to be particularly important also in its wider social aspect by helping us to reach the students that would not have otherwise been able to achieve their full academic and personal potential due to time or financial constraints. It will also encourage the students to actively co-operate with each other and with their tutors to promote more independent, mature and reflective learners and practitioners [7]. Moreover, talks are under way with a number of our international partners in order to widen the community of those who will create and use the platform.

At present, work is carried out to develop appropriate multimedial interactive materials in subjects covering the areas of expertise of the Faculty's researchers and lecturers, with 'chemometrics' being the first section completed. The work is co-ordinated both on the level of each department (a team in each department) and on the level of the whole faculty (the Department of Computer Chemistry is co-ordinating the entire project).

The progress of our project will be presented at this conference.

Acknowledgements

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CHEMISTRY AND JEWELLERY: A DIDACTIC PROPOSAL

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Introduction

Since very old times men have discovered properties in the metals that allowed them to prepare many objects that were useful to the life of mankind (instruments for cooking, for agriculture, arms…). However, soon a new application was found for the use of metals, with a very different aim. That was the ornamental one, more accessory but of great importance. Thus, men have elaborated beautiful objects of high value, in order to ornate themselves and show their opulence and their power too. The jewels were destinated not only for the living, but also for the dead, so that they could own these precious objects in their other life. Nevertheless, jewels could have a religious and mystic meaning. So, together with necklaces, ear rings or bracelets we can find in the Archaeological Museums, for instance, precious cups, candelabra, censers… employed as amulets and votive offerings or in sacred rituals.

In any case, the art of jewellery was very important in old times -even nowadays too- and had a very close relation with metallurgy. Jewellers, with the contribution of goldsmiths, worked with precious metals, gold and silver, attracted by the beauty of their colour and brightness, as well as by their resistance against the environmental aggression. They also worked with their alloys, such as the Egyptian *asem* (natural alloy of gold and silver, named *electron* among Romans and Greeks), or alloyed with copper or other metals. Besides, in the elaboration of these beautiful and valuable objects precious and semiprecious stones were also employed (such as ruby, diamonds, emeralds, jade, lapis lazuli…), as well as some materials of organic origin (pearls, jet, corn, fish-bone..) and even synthetic materials (glass and enamels). Jewellery and gold and silver work were very developed in ancient times, being Egyptian and Mesopotamian craftsmen the best in that art.

A great number of jewellery works were really chemical processes. On the one hand, obtaining, purification and testing of metals and alloys and, even, their manipulation during the elaboration of the jewel, such as melting, soldering, alloying or moulding. On the other hand, the production of glass and enamels. Nevertheless, where chemistry played a central role was in the imitation jewellery, very often with a fraudulent purpose too. At first, old jewellers worked only with precious materials, but as the demand of jewels was increasing, these craftsmen began to look for formulae in order to prepare materials with the appearance of precious metals and stones, starting from materials of low cost. As a consequence, they employed alloys with a poor -and even no- content in gold and silver or they gave special colours to metal surfaces, so that they would remind of noble metals. Hence, their great interest in colouration. In this way, they gilded metals and also dyed stones and glass to imitate gold or precious stones. Of all these practices, some written testimonies are left, such as an Assyrian tablet (1700 B.C.) or the Leyden and Stockholm papyri (III A.D.). For instance, there are recipes to dye glass in a blue colour so that it looked like lapis lazuli, to turn stones in false emeralds by colouring them in green or to gild copper with orpiment (As_2S_3).

With all that in mind, we can conclude that, from its beginning, jewellery has highly contributed to the development of chemistry. Even, it has been considered that the jewellery was the core of alchemy, of its procedures and philosophy, with its central idea of the transmutation of metals in gold.

Conclusions and educational implications

Taking into account these ideas, the treatment of this subject in the classroom could produce some didactic advantages. On the one hand, it gives the opportunity of bringing chemistry nearer to everyday life; on the other hand, to introduce students to the analysis of the history of science.

And from a practical perspective, some activities can be carried out, such as some simple and easy experiments and observations of an experimental and theoretical type:

- With some common metals (gold, silver, copper, tin…): to observe some physical properties, such as colour, brightness, plain surface, ductility (for instance, with copper wires), malleability (for instance, with fine sheets tin), how they can be distorted without breaking by means of pressure (to comb, to change its form by knocking), etc..
- With some precious or semiprecious stones: to observe its crystals (in quartz), colour (violet in amethysts, green-blue in malachite…), its hardness (in diamonds employed as abrasive), etc..
- To represent the chemical composition of minerals corresponding to gems (silicon oxide, aluminium oxide, hydrate copper carbonate, beryllium aluminium silicates, pure carbon…).
- To represent the corresponding formulae.
- To explain the relationship between many of these properties and the electronic structure of atoms and the bonding theory (metallic, ionic and covalent bonds, colour of the compounds with transition metals ions…).
- To carry out some simple experiments, such as the Hg-Cu amalgam, by using a coin or a wire of copper, and to observe its silver appearance.

And, finally, all that involves enhancing the interest and curiosity of the students for science, making their learning more amusing and amplifying their scientific culture.

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CHEMISTRY TEACHERS' EDUCATION AT THE UNIVERSITY OF GDAŃSK

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At the Department of Chemistry, University of Gdańsk education of teachers is a part of master degree study on two major fields: chemistry and environmental protection. Students may choose a facultative special course which gives them a possibility to get professional teachers qualification. The plan of chemistry teacher course follows a directive of MEN (Polish Ministry of Education) about teacher education and qualification (23.09.03). Gdańsk University is now offering the course called "*dydaktyka chemii*" (polish) –didactics of chemistry. The project of the course created at UG [1] and was modifying during last years.

Description of didactics of chemistry course at UG

Different kinds of teacher's competences need a variety of education form of didactics chemistry course. Didactics of chemistry course consist of lecture, laboratory exercises, seminars, training at school (165 hours, 12 ETSC) and school practicum (professional training) at gymnasium and post-gymnasium schools (8 weeks). The plan is included in Table 1.

Table 1

Didactics of chemistry	**Hours**
Lectures	15
Laboratory exercises	60
Seminars	30
Exercises at school (School practicum)	30
School practicum at gymnasium (13-16)	4 week
School practicum at post-gymnasium schools (16-19)	4 week

1. The lectures of chemistry didactics include also: the role of chemical experiment in teaching chemistry, organization of a chemical laboratory, application of various audiovisual and computer methods and tools, the role of chemistry in environmental studies.
2. Seminars are devoted to create skills in chemistry teaching, such as: creating curricula of chemistry, writing reports, using IT, movies, molecular models, transparencies. System includes work with underachiever students and with gifted ones.

3. Laboratory exercises include independent performance of most important school chemistry experiments.
4. Training at school is devoted to: observing the classes carried on by experienced chemistry teachers, and two individual students' classes, being observed by experienced teachers and other students. Then the results of these classes are discussed and commented by the group. Also, these classes are supervised by the tutors and evaluated on the base of students' reports and students' writing materials.

Study on developing a chemistry teacher training

Our didactic of chemistry course contain two kind of professional training: exercises at school (groups) and long term school practicum (individual student training). Some aspects of professional teacher training were a subject of our research. We follow the reports about the development of chemistry teachers training and study on improving effectiveness of chemistry teacher's education [2, 3, 4, and 5]. The results were that the any kind of practice is the best way in teachers training. In polish education system the long term practicum at school is obligatory. However during last years some universities replaced exercises at school by the other type of students activity e.g. microteaching.

The goal of our research is to develop the strategy of chemistry teaching training at the Gdansk University.

1. We used the inquiry method to collect the opinions of students concerning school practicum (73 students, in October 2004). The general students' opinion was that the chemistry didactics courses give them quite good professional education. A majority of respondents suggest that it is necessary to modify the laboratory exercises. The experiments should correspond to the present school reality (after the reform of polish education system and in current economic conditions). The other respondents suggested that the students need more experiences for presentation of some scientific facts and theories as elements of the general human education and understanding of our life.
2. The additional aim of our work was the study on some students' achievements during course of the chemistry didactics. Preliminary results [6] show that our students have a lot of troubles with knowledge transformation for didactics purposes and exercises at school and exercises in laboratory seem to be most useful for training of their teaching competencies.
3. The consequence of our study was an innovation in chemistry teacher training to improve the students teaching abilities. We implemented the new teaching methods in seminar (project method, module method [7] and new projects of school experiments [8].
4. The interesting could be new conception of exercises at school concerning with the reform of polish education system. We pay our attention of some problems important for future teachers: different type of curricula and

textbooks, new teaching methods, interdisciplinary problems in chemistry teaching, using of IT and multimedia programs.

New educational targets imply specific responsibilities for the teachers. Student practicum in school is integrated part of chemistry education process. The aim of the group is to take part in chemistry teaching process in existing school condition. They fallow the qualified teacher and their preference of curriculum, textbook and teaching methods. Students have opportunity to be familiar with different kind of lesson category, teaching methods and many kind of teacher activates e.g. evaluation, teaching of interdisciplinary problems. Some aspects of students work during exercise at school will be described on examples (e.g. a lesson on subject "Transgenic food").

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EVALUATION OF CHEMISTRY TEACHER BY NON-CHEMISTRY FACULTY STUDENT

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Evaluation of lecturer by students is one of important components of obligatory, demanded by Polish Ministry of Education and Sport [1], every fourth year evaluation of university teachers and researches. Evaluation questionnaire forms [2] were prepared by the University Senate, modified each year and used anonymously by students to evaluate the effectiveness and quality of chemistry teaching at the August Cieszkowski Agricultural University of Poznan, Poland. Planed to be presented during the Conference questions were simple, easy to answer, with three possibilities scored as follows: yes – 2, rather yes – 1 and no – 0, which was easy to analyze statistically. During the recent four years, close to 2000 questionnaires, answered by students of four faculties of the University (Horticulture, Forestry, Agronomy and Environment Protection) were collected at the end of the obligatory course of chemistry lectures and were carefully analyzed. In some cases additional discussion with students was organized.

The total score earned in each questionnaire was strongly faculty dependent, which indicates different levels of average chemistry knowledge and in consequence, different difficulties in the understanding of the subject by students.

It is also worth to underline that the above mentioned scores were strongly dependent on attendance on lectures (a higher percentage of absences at classes was correlated with a lower score). It seems that difficulties in chemistry understanding generate aggression against both the taught subject and the tutor, but active and ambitious students, easy in cooperation, are ready to overcome problems and improve the situation.

It was interesting to notice that in the analyzed questionnaires a significant number of students is expecting additional scientific problems to solve (individual work) to improve their skills. Further discussion on students "homework assignments" increases their activity and improves the student – teacher relation.

The obtained results indicate that the evaluation of their chemistry tutor by a given student is a good way to promote self-control of the teacher with significant possibilities to increase effectiveness of the teaching process. Statistic analysis of questionnaire data confirms that the application in practice of students' remarks, suggestions and demands usually improves both the average scores of exams (a higher level of chemistry knowledge) and cooperation between students and professor.

The obtained results reject the hypothesis concerning an improper (unjust) evaluation of being exacting teachers. It was proved that even a strict, but enthusiastic and honest lecturer is well accepted by students.

In conclusion: a well-prepared questionnaire with careful analysis of students answers is an excellent tool and important help in the teaching process.

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VISUALIZATION OF MECHANISMS OF CHEMICAL REACTIONS

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The rapid development of hypermedia has brought about transformations in the process of teaching and multimedia software has become a widely used didactic facility. Interactivity is one of the most important features as it activates intellectual processes and helps to structure the contents of the subject being taught. The use of computers in a didactic process results in more visually attractive presentations of information as well as enabling the simulations of phenomena by means of computer graphics, interactions and computer animations.

A few of the lecture visualization projects and laboratory classes in General Chemistry, Inorganic Chemistry as well as Organic and Physical Chemistry have been proved to be very successful e.g. the project of multimedia aided teaching of first year students at Columbia University (USA) [1]. The multimedia software, which is an integral part of the system, was designed as a tool for teachers and students and it was primarily aimed at acquiring interdisciplinary skills by the students, which is mainly achieved through simulating the course of various processes and events, visualizations and calculations. This system was to widen the curricular contents and improve the efficiency of both university teachers and their students.

Similar didactic tasks were performed by multimedia systems at McGill University, Quebec, Canada, where they assisted teaching Chemistry in the form of lectures and individual work. They facilitated, among others, the analysis of IR and NMR spectrums through a 3D animation, which allowed analysis of the character of vibration of molecules of chemical compounds as well as to acquisition of data on the origin of signals and their sources [2].

Innovative teaching techniques were also introduced at Williams College (USA), where multimedia software “Crime and Chemistry: From Sherlock Holmes to Contemporary Science” was included to in elementary course of general chemistry taught to the students, who had chosen Chemistry as their additional subject [3]. The software could be used during the lectures as well as in practical classes. It included a laboratory, where using simulated lab equipment and reagents, one could carry out analyses in order to investigate the crime and reveal the criminals, who committed those crimes. The software aimed at reinforcing the interest and enthusiasm of students and making learning and teaching Chemistry a less difficult and, at the same time, a more attractive task.

The Polish market of multimedia publications offers software, which aid teaching Chemistry mainly in primary and junior secondary schools, neglecting secondary school and university students and teachers. A preliminary survey carried out among the students of the Department of Chemistry at Adam Mickiewicz University points to the fact that they have some difficulty understanding Organic Chemistry material, and especially the mechanisms of chemical reactions. In order to meet their needs, the Institute of Didactics of Chemistry prepared a piece of multimedia software “The Mechanisms of Chemical Reactions”, which contains a set of visual teaching aids [4-6].

This software was prepared in *Macromedia Authorware* environment, which facilitates the preparation of professional software containing modern media solutions: animations, films, simulations, interactive modelling. *Authorware* creates applications accessible both from the Internet and saved on CD-ROMs. *Macromedia Flash* was used to create animations as it enables one to work with vector graphics, imported images, bitmaps as well as with sounds. Through ActionScript, an internal script language, Flash animations are designed to interactively co-operate with the users. The videos, which illustrate the course of chemical experiments in which the discussed mechanisms take place, were made at the film studio of the Institute of Didactics of Chemistry. Our studio is a semi-professional one. Some of its elements include: a stand for performing chemical experiments, professional lighting, digital camera Sony DCR-TRV 900E with a tripod, a computer equipped with software necessary for transferring the film sequences on the hard disk. The films were put together using a non-linear editing of *Adobe Premiere*.

“The Mechanisms of Chemical Reactions” was designed for university students of chemical and natural science departments as well as for secondary school students. **The software consists of the following modules:**

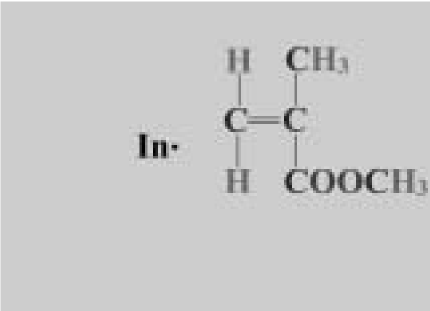
1. Claisen condensation
2. Dieckman cyclization
3. Polymerisation of methyl metacrylate
4. Nitration of benzene
5. Dehydration of ethanol
6. Bromination of benzene
7. Bromination of aniline
8. Bromination of alkanes and alkenes
9. Acid hydrolysis of ethyl acetate
10. Alkaline hydrolysis of ethyl acetate

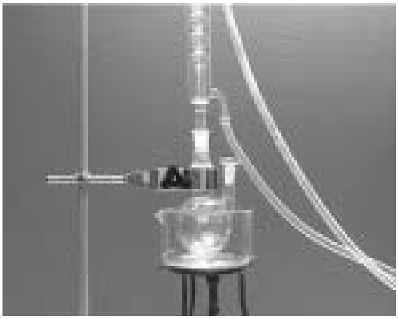
Each of the above modules contains:

- texts and hypertexts relating to the subject of the experiment,
- a set of animations explaining the mechanism of chemical reactions,
- dynamic models of chemical compounds,
- a set of videos presenting the course of the experiment

- information on laboratory techniques,
- a list of safety rules to be observed whilst performing experiments,
- additional information and interesting details broadening the knowledge on a given issue,
- problems, tasks, exercises and tests for self-study.

Pedagogical research on the efficiency of this multimedia software has been planned to be carried out in the academic year 2005/6. The results of this research are expected to answer the question whether this didactic means shall contribute to a better understanding of issues connected with mechanisms of chemical reactions.





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INNOVATIVE FORMS OF VISUALIZATION OF ORGANIC CHEMISTRY ISSUES

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The development and common use of IT spread the use of computers, educational software as well as the Internet in the process of teaching. The availability of multimedia software, its relatively moderate price as well as a better access to well equipped school computer rooms make it possible to use these state-of-the art didactic means in teaching Chemistry. Moreover, Polish market offers a wide variety of multimedia software in many branches of science, from specialized programs designed for teaching various subjects on every stage of education to the software dedicated to a wide spectrum of users. Owing to such projects as "The Internet Computer Room In Every School" organized by the Ministry of Education and Sport and "School Computer Rooms" subsidized by the European Social Fund as well as the projects carried out under the auspices of the President of the Republic of Poland, Mr. Aleksander Kwaśniewski, didactic institutions have been equipped with computer rooms and appropriate software.

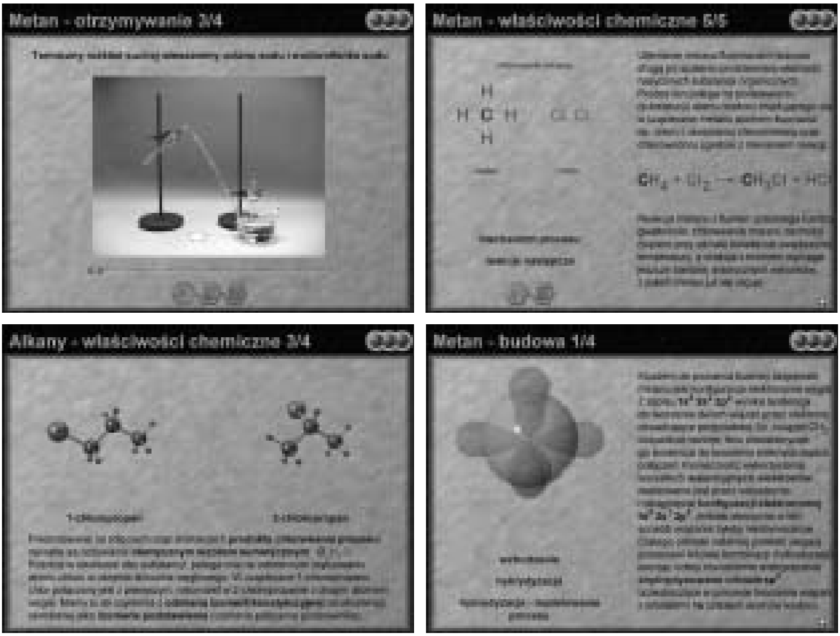
Unfortunately, among the multitude of offers little is there to be offered to high schools students and teachers. The authors, aiming to fill this empty space, believe that it was necessary to prepare a multimedia manual for teaching organic chemistry.

Organic Chemistry For High Schools **covers the following issues:**

1. dynamic models of chemical compounds as well as 3D models (anaglyphs to be watched with special 3D glasses). Visualizations of structurally simple chemical compounds may be of use to teachers as excellent examples for modeling by their students. However, multimedia animations of structurally complicated compounds which are time-consuming to model, constitute a particularly valuable part of the manual. The application of computer visualization of theses issues, e.g. modeling of hybridization processes, imaging the ó (sigma) and đ (pi) bonds, or the manner of creating molecular orbitals allows to visually present quite abstract issues.
2. video sequences presenting the course of chemical experiments and all of the essential laboratory activities. Each video may be viewed with the full screen option. Chemical experiments filmed by professionals (particularly the one which call for complicated apparatuses, expensive reagents, which are either time-consuming or dangerous) may constitute a source of valuable information and skill for the students. The videos are equipped with professional comment and may be replayed which influences memorizing the contents by the students.

3. **visualizations of phenomena and physical and chemical processes** e.g. the process of hybridization of valence atom orbitals of carbon.
4. **animations of chemical processes** were approached in an innovative way not only from the point of view of programming but of the essence as well. Each chemical bond treated as a pair of electrons used to be presented as lines which emerge or disappear at the time of chemical reactions (which illustrates breaking and creating new links but is not actually true since electrons do not disappear or appear out of nowhere). In the discussed approach the pair of electrons is first transformed into two separate electrons which then may independently participate in secondary processes, e.g. create new combinations with the electrons of other atoms. In certain justified events two structures are presented on the screen which is particularly grounded when isomers are discussed.
5. **simulations of the mechanisms of chemical processes**, e.g. chlorination or polymerization, enable to visualize the actual course of these processes and surpass the traditional static images which are presented in traditional books. These simulations render it possible for the student to watch the moment of crashing the molecules of substrates, the processes of breaking bonds and creating new connections in the molecules of the products.

Preliminary research confirmed the educational efficiency of the discussed multimedia manual, which has encouraged the authors to continue their work.



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INTERACTIVE STAR BOARD

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The Institute of Didactics of Chemistry in co-operation with a publishing house Wydawnictwa Szkolne i Pedagogiczne is currently working on the methodology of using an interactive Star Board manufactured by Hitachi Software for teaching Science. **One of our tasks is** to prepare software for imaging the mechanism of chemical reactions and creating of principles of presentation of the ready made product on the interactive board.

Star Board is a device which combines the elements of the screen for viewing presentations, self-copying board and the computer screen. The board is connected to the computer via a cable or an infrared connection which renders it possible to carry out dynamic work and continuously save the notes on the hard disk. An electronic pen is used to write on the board (which is an alternative for the traditional whiteboard). The software allows to stop the presentation at any moment and to transfer any of its elements to the environment compatible with its software in order to modify it.

In the course of our preparatory work we make use of such tool programs as Authorware Attain (used to create the environment of the software) as well as Flash MX (for creating animations).

Authorware Attain is applied to prepare a dynamic environment of the software. It was created as an interactive software which will allow its users to move around all the modules and to control all its functions from the board eliminating the need to do so via the computer eliminating the need to stop the presentation. The modules planned to function in the full version of the software shall cover animations of the mechanism of chemical reaction, video sequences showing the course of these reactions in real conditions, instructions for appropriate execution of chemical experiments, explaining the processes that take place in the course of these experiments, dynamic models of compounds, tests and problem tasks which check the knowledge of students.

Tool software Flash MX is designed to create computer simulations of the mechanisms of reactions as computer animations. At advanced stages this application allows to prepare interactive animations as well as complete programs which co-operate with its user in a flexible way. The finished animations were equipped with essential comments which discuss the most important stages of each and every illustrated reaction mechanism.

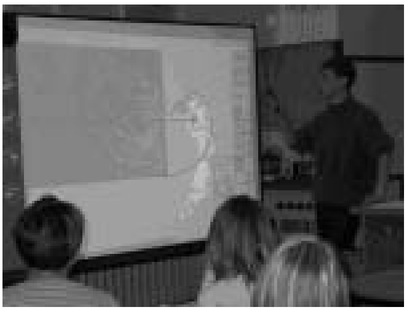
The software of interactive Star Board allows to actively work with all of the presentations. It is possible to make and save notes on particular elements of the presentation. The notes are dynamically saved on the hard disk from which the presentation is currently being carried out. It must be remembered that the notes are not saved directly in the presentation file but in a separate file which prevents introducing changes in the original document, the only piece of information being saved is a copy of this particular element of the presentation. The Star Board software enables the user to work with particular elements of the presentation such as computer animations, video sequences, texts, graphs, etc. Applying Star Bard software delivered by Hitachi Software enables copying particular elements to the clipboard and introducing any changes which are then saved on the hard disk or any other carrier, and may be printed and handed out to the participants of the presentation.

Currently available animations of mechanisms of chemical reactions:

1. Claisen condensation
2. Dieckman cyclization
3. Polimerization of methyl metacrylate
4. Nitration of benzene
5. Dehydratation of ethanol
6. Bromination of benzene
7. Bromination of aniline
8. Bromination of alkanes and alkenes
9. Acid hydrolysis of ethyl acetate
10. Alkaline hydrolysis of ethyl acetate

Subsequent mechanisms of reactions are currently being prepared.

All of the mechanisms were enriched with video sequences illustrating the course of reactions in laboratory conditions.



The Star Board software enables the teacher to dynamically present the mechanisms of chemical reactions during a lecture and to replace a deficient, and yet omnipresent, manner of illustrating the course of reaction by means of schemes, drawings and static records of reaction equations. The application of interactive Star Board makes it possible to print materials from classes which relieves the students from making detailed notes and focuses their attention directly on the subject of the class.

Moreover, the dynamic manner of presenting the lecture will allow the lecturer to perform problem tasks directly in elements copied from the presented program, eliminating the need to create additional presentations which will economize on the time spent by the lecturer preparing his classes.

Interactive Star Board may be widely applied not only for academic teaching but at every stage of education for teaching any subject.

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APPLICATION OF THE “TAXONOMY METHOD” FOR CONSTRUCTING TESTS ON THE COURSE “SURFACE AND COLLOID SCIENCE” IN THE SOFIA UNIVERSITY

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Pupils today live, learn and play in a media-saturated society. For many of them the curriculum is not relevant, and they become disengaged from learning. Rapid developments in technology have brought many exciting changes to life, presenting new challenges for schools. Multiple new literacies are required to navigate the forest of signs and symbols of our globalized media culture. Globalization, immigration, poverty i.e, have created a society of increased diversity. All these change the education in the higher university level. The trends in the field of higher education have been discussed on a series of international and national forums are indicated and discussed in the paper. Raising the quality of student training have been related to the teaching, learning and checking (control) in the higher education [1-8].

Here special attention is being to the developing an effective system of training and control in the higher education. The paper presents new and nontraditinal for the Bulgarian higher education idea. The idea for the periodical testing is concerned with the usage of the didactical test as a tool for the permanent (periodical) control during the whole course of the instruction *Surface and Colloid Scince*. The periodical testing directly have been related to the teaching, learning and checking (control) in the higher education. The main objective of the system is to raise the quality of student training. The first results from its implementation are presented in the paper. On the basis of research data the following conclusion is drawn *developed methods for elaborating the tests and managed the training of the teaching-learning process, including developing the educational standards, provides for the students higher interests, to stimulate the students to learn and manage the process of learning.* Also periodical testing can help students gain insight into the things they can do well, the misconceptions that need correction, the degree of skill they have. Main aspect of introducing a system of training and control in the higher education is a correction function over the teaching process as a way to raise the quality of student training.

In perspective the idea of usage of the didactical test as a tool for the permanent (periodical) control will grow into a system for controlling the quality of studies which in turn will be a component of the University system for overall quality control of the teaching process in all its phases and degrees.

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OBTAINING THE HANDS ON EXPERIENCE IN TEACHING BY STUDENT OF CHEMISTRY DURING THEIR STANDARD STUDY COURSE

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At the Faculty of Chemistry at the University of Gdańsk the preparation of future teachers for teaching chemistry is realized as an optional subject. It is organized for students of specializations Chemistry and Environmental Protection, who choose careers in teaching.

This is the special teacher education program, which include following subjects:

- pedagogies,
- psychology
- didactic of chemistry course

Didactic of chemistry course comprise other subjects:

- lecture
- laboratory exercise
- sleminars
- teacher trainings at school

  These forms of activity take place at gymnasium and secondary school, when the 6 and 8 semesters have finished. Each student makes choice of school where she or he wants to carry out their practice. These practice trainings are done only under control school teacher.
- Exercise at school (school practicum)

  The school practicum takes place during the semester. At first, students observe an experienced chemistry teacher and pupils at work and then carry on individual two classes being observed by a teacher, other students and university tutor. The results of these classes are then discussed and commented by the group.
- Computer science
- Environmental chemistry.

All subjects of program of teacher education course focus on good preparation of the students for working as chemistry teacher. The plan of chemistry teacher course is following a directive of MEN about teacher education and qualification [1].

The aim of this paper is to examine student's ability to select the proper teaching material from wide chemistry knowledge. Two groups of the students have been tested. Group one comprises students who have entered the teacher education program, whereas group two includes students who are at advanced level of it.

It appears that students have many difficulties with preparing possessed knowledge for appropriate teaching level and intellectual abilities of pupils. However, students from the second group are better prepared to manage this task than students from group one. Many students from first group show tendency to introducing pupils to extensive, university knowledge with many details and professional terminology, and they do not distinguish important issues from inessential ones.

Our research indicates that School Practicum prepares students much better for teaching in comparison with teacher trainings at school.

More details will be described on the poster.

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BECOMING AN INTERDISCIPLINARY CHEMIST: CHEMISTRY REQUIREMENTS FOR THE INTER-FACULTY COURSE OF STUDIES IN MATHEMATICS AND THE NATURAL SCIENCES AT THE JAGIELLONIAN UNIVERSITY OF CRACOW, POLAND

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To become an interdisciplinary chemist has now been seemingly in vogue among science-oriented secondary school students in Poland. To meet this unwonted demand the Jagiellonian University of Cracow, among few other Universities in Poland, has prepared in its study offer the Inter-Faculty Course of Studies in Mathematics and the Natural Sciences. This research-oriented, five-year Master's program is aimed at outstanding secondary schools graduates who come to the University with a well-formulated scientific interest commonly broader than just one classical field. The underlying concept of the program is that students assisted by tutors design their curricula individually by combining the courses from different Faculties in accord with their interest and ambition, and most importantly, participate actively in research from the early stages of their course of studies. The admission to the program has been based on the entrance examination that consists of mathematics and one other subject selected from among physics, chemistry, biology and geography.

In this paper we present the chemistry requirements that the candidates for the program have to meet. The requirements are based on the chemistry curriculum for science-profiled classes of Polish secondary schools of general education [1,2]. To illustrate these we present 2004 chemistry entrance exam test. In preparing the test our ideology was to check not only the candidates' school knowledge of chemistry but first and foremost their ability to use this knowledge in less typical or entirely new contexts [3-5]. Of our priority were real life understanding-oriented contexts that we tried to formulate both in an informative, interesting and attractive way. In our opinion, the questions thus formulated checked not only the candidates' level of knowledge but also their broader understanding of problems, their ability of concentration and quickness of perception.

The exam test presented is composed of 50 questions, and of the four answers proposed to each question one is correct/best. In writing the exam the candidates use neither calculators nor tables; the periodic table forms part of the exam-set supplied, and the time assigned to the exam is 2.5 hours.

In conclusion, we wish to express our hope that the test can be used by chemistry teachers in other countries in comparing the requirements set by our

University for this modern and attractive type of interdisciplinary chemistry studies with their requirements.

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TRAINING OF UNIVERSITY STUDENTS FOR SUCCESSFUL PROBLEM CREATING

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The development of pupil thinking is largely contributed to by complex and well thought of activities that can be realized through problem solving. Any problem solving involves perception and interrelation of respective concepts (1). This may not prove right unless scientific concepts have been formed, acquired at application level and systems of concepts have been developed. Chemistry problem creating should involve scientific problems indirectly related and previously taught within different themes (2).

In order to train future chemistry teachers in applying the teaching method of learning through problem solving, it is necessary, apart from acquiring such knowledge during studies, to train them to create problems by themselves.

Students of Teacher Training Department at the Faculty of Chemistry realize projects (final papers) at the end of their studies and carry out diverse ideas related to learning through problem solving in primary and secondary school. The way how this is being performed is presented by one of a student's final papers. The student's task was to think of and prepare problems for checking the acquisition level of concepts involved by teaching themes acids and bases as well as qualitative chemical analysis. An instruction was enclosed: create a problem that will contain the identification of three crystal salts of white color; problem solving should comprise knowledge about acids, bases, salts, hydrolysis, solution pH value, indicators and evidence reactions for cations and anions; problem solving is to proceed through lab task.

To solve such task, the student applied knowledge acquired from various teaching subjects during his four-year studies (General Chemistry – theory of acids and bases, Analytical Chemistry – qualitative chemical analysis, Natural Product Chemistry – indicator isolation and identification from natural products). To accomplish the task, the student:

- created several combinations of three salts each (containing cations of the 5th analytical group with carbonate, chloride, sulfate, and phosphate anion), whose solutions have acid, base or neutral reactions due to hydrolysis or dissociation;
- chose acid-base indicators. He tested the application of substances from a larger number of natural products as indicators and selected three indicators: red cabbage juice (*Brassica oleracea*), sour cherry juice (*Fructus Cerasi nigri*) and beet juice (*Beta vulgaris*). The criteria for selecting those three indicators and their application were as follows: well defined change

of color in acid, base and neutral medium, color stability in the air and easy to prepare the extract of fruit containing an indicator. Absorption spectrums in a visible area of all plant colors were recorded at different time intervals. The pH values of indicators (extracts) were determined spectrophotometrically. The absorption curves recorded after 24 h demonstrated that those plant colors (anthocyans) are unstable (absorbances are reduced). A method of how to keep and apply them was proposed.

For problem solving (identification of three unknown substances), the student scheduled the following stages of experimental work:

1. Color determination of natural indicators in acid, base and natural medium. Students should choose at their own discretion among available acid, base or neutral substances (solutions of different acids, bases and salts) that will be used to determine the color of natural indicators in those media and based on the results to make a table of indicator colors in a certain medium.
2. Test water solutions of the three unknown salts by three natural indicators.
3. Test for cations of the 5th analytical group and anions (carbonate, sulfate, chloride and phosphate) by using evidence reactions.
4. The analysis of obtained results on the basis of knowledge about acids, bases, salts, hydrolysis, solution pH values, indicators and evidence reactions for cations and anions.
5. Conclusion drawing and formula writing for the examined substances.

In order that the student can perceive his idea in realistic conditions, the created problem was being solved by 113 secondary school pupils who demonstrated in the initial test good acquisition level (61.3%) of concepts needed for this practical problem solving. During experimental work, pupils wrote down their perceptions and conclusions in work sheets. The results demonstrated that they had collected facts extremely successfully through experiments, needed for problem solving i.e. 88.7-99.0% of pupils gave correct responses to tasks assigned in the first three stages of experimental work. The accuracy of 63.3% was achieved in conclusion making and formula writing for unknown substances. The achievement is very good, especially when it is considered that for the first time pupils are approaching to a complex problem in this way.

Training students for problem creating, accomplished in such a way, makes provisions for the student to pass through all stages of problem creating, from an idea through its elaboration to problem learning realization, and to assess and verify his work through discussion with pupils and his professor.

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SIMULATING THE ANALYTICAL PROCEDURES AS A VALUABLE TOOL FOR *A PRIORI* OPTIMISATION OF ANALYTICAL PRESCRIPTIONS

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Analytical prescriptions, met in different monographs and referred to visual or potentiometric titrations, are sometimes incomplete and then susceptible to different interpretations. Such a gap in an information expected (required) may be a source of systematic error of analysis. It is then necessary to develop a knowledge that enables the analytical prescription to be fully reconstructed and, moreover, an optimal *a priori* prescription to be found.

This communication provides some examples, where a heuristic procedure for searching the best *a priori* conditions of analysis is elaborated on the basis of simulating procedure, based on all atainable (pre–selected) physicochemical knowledge concerning a system considered. The simulation is referred to the titration performed according to *quasistatic* mode, under isothermal conditions assumed.

The first example concerns formaldehyde determination by back titration of an excess of iodine with ascorbic acid. It is the example of simulated redox titration made in the complex system where the conditions of analysis were delivered in insufficient, 'damaged' form [1]. The procedure is optimised and the best conditions of analysis are attained.

The second example concerns the iodometric method of arsenic trioxide determination. This method was known since a long time as the potentiometric method where potential E is registered. In [2] it was stated, that – under defined conditions of analysis – the titration curve consists of two rectilinear segments [3]. This fact provides the possibility of pH–metric titration of the analyte with I_2+KI as the titrant. Another uncommon occurence is the fact, that the pH–metric titration is done in buffered system. The third unusual fact is the shape of the titration curve that ressembles the ones obtained in photometric, conductimetric, pH–static or surface acoustic wave titrations.

The third example is the pH–static titration method [4], where two: primary (PT) and auxiliary (AT) titrants are added, sequentially and repeatedly, into the titrand solution. The searching procedure has been applied, particularly, for the modified Liebig–Deniges method [5]. This method requires to find a proper buffer, characterised by acid–base and complexing properties in defined media, by low volatility and sufficiently high solubility. Moreover, the pH–static titration method requires moderate action of the buffer in aspect of precision of the method. Another factor is the increment of PT added during the titrimetric procedure.

The last example is the choice of the best *a priori* conditions for titrimetric analysis realised according to Gran (I and II) methods and comparative testing of both methods in aspects of (a) a real slope of ion–selective electrode, (b) drift effects resulting from excessive simplification of the model applied, (c) increments of titrant added, (d) number of experimental points, (e) choice of a region of the curve applicable for calculation, and (f) precision in volume and potential measurements. Such data provide full introspection in the possibilities inherent in the method.

In all instances, the thermodynamic data obtained from calculation can be considered as a valuable tool providing a kind of reference for real analytical procedures, where kinetics and transportation phenomena affect the results of analyses. It is possible only after application of the generalised approach to electrolytic systems suggested in [6] and the author's references cited therein. It enables also to state unusual properties inherent in electrolytic systems [3].

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INTERRELATIONS BETWEEN MATERIAL BALANCES RELATED TO ELECTROLYTIC SYSTEMS (AQUEOUS SOLUTIONS)

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In chemical systems, one can refer to different rules of conservation, due to elements, protons, electrons and external charges of species – particularly the species entering the electrolytic systems where none nuclear transformations occur. In order to apply the rules of conservation, one should refer to a closed system, i.e. one where mass transport can occur only between the phases consisting the system. In thermodynamic considerations of dynamic electrolytic systems it is also assumed that the processes occur in *quasistatic* manner, under isothermal conditions.

Some rules of conservation are interrelated and this fact will be raised on simple and more complex examples, referred to electrolytic systems. This way, the problems of interdependency of the balances and indicating the set of independent relations will be considered on due examples where complex nature of the system, e.g. formation of aqua–complexes by the ionic and neutral species will be taken into account.

For non-redox systems one can state that both linear combination (a) of elemental balances for H and O and (b) balances referred to protons and electrons lead to charge balance. As concerns redox systems, the linear combination of elemental balances for H and O provides the equation that is a particular case of an equation devised by Michałowski [1] whereas linear combination of balances referred to protons and electrons provides an equation for charge balance.

Some pitfalls in the balances formulation are also indicated.

The above relationships were formulated under assumption that the particular species can exist as hydrates. The calculation procedure has been illustated by examples. The general relationships are also derived. The problem of independency of balances is raised in context with:

(a) the new formulation of the phase rule done by Michałowski for multicomponent, polyphase systems, where all complexity of electrolytic systems is involved;

(b) the theromodynamic resolution of complex electrolytic systems [1-10];

(c) the equivalent mass concept formulated by Michałowski [11-14];

The equivalence mass concept is different from one based on chemical reaction notation formulated *a posteriori* and obligatory according to obligatory

IUPAC decision in this matter. On the contrary, the definition done by Michałowski is formulated *a priori*, with all physicochemical knowledge involved and refers to analytical (electrolytic) systems of any degree of complexity. The advantages of the latter approach are indicated.

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THE GENERALISED BUFFER CAPACITY (GBC) CONCEPT REFERRED TO ALL TYPES OF EQUILIBRIA JOINED IN ELECTROLYTIC SYSTEMS

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The buffer capacity concept has been primarily involved with acid–base equilibria, although redox and complexation phenomena were also taken into account, as a response of the related system against an action of external (e.g. reducing or complexing) agent. However, such concepts were considered exclusively from the qualitative viewpoint of Le Chatelier – Brown principle or alike.

Up to now, the buffer capacity was not a univocally defined concept, also from the viewpoint of acid–base systems. Generally, one can distinguish the definitions considered from theoretical (descriptive) and practical viewpoints. The descriptive approaches were based on derivatives (with infinitesimal pH–changes, dpH) and marked as β (at constant volume of the system assumed, and then named as static) [1] or β_V (with dilution effect involved) [2], being in close relevance to pH–metric titration. The practical viewpoint concerns finite pH–changes (ΔpH) and is characterised by B_V value [3]. At the point of junction of these concepts, false interpretations or misinterpretations of the buffer capacity concept are met in contemporary literature.

This state of the matter cannot be tolerated; more than 1400 papers in scientific journals found in Internet under the conjunction of search terms: *buffer capacity* and *acid–base* testifies about the necessity to introduce the correct formulation of this term. The new definition proposed here takes into account:

1. The finite changes in pH (ΔpH, e.g. ΔpH = 1) involved with addition of a finite volume of reagent endowed with acid–base properties, e.g. base, with a finite concentration and
2. The buffer capacities: β, β_V and B_V are non–linear functions of pH or volume V of a reagent added as titrant.

The B_V concept will be formulated first for acid–base systems and then exemplified by more complex systems, with several types of reactions involved. A general idea of buffer capacity formulation is also suggested. Moreover, the effect of buffer capacity is not involved only with addition of a strong acid or base, as was suggested in all definitions known hitherto. The titrant containing more than one reagent can also be considered; a special case of such an approach has already been realised for analytical [4,5] and physicochemical [6,7] purposes.

The present communication provides an interconnection between the three concepts (β, β_V and B_V) of the buffer capacity known hitherto.

For acid–base systems, the B_V function is defined as $|B_V = \Delta c/\Delta X|$, where $\Delta c/\Delta X = \beta_V(pH) + \Sigma_{k=1}^{n}(d^k\beta_V(pH)/dpH^k)_{pH}(\Delta pH)^k/(k+1)!$ (1)

The concept of generalised buffer capacity (GBC), denoted as $|B_V = \Delta c/\Delta X|$, is related to electrolytes where other equilibria occurred. This concept is related to different species X_i and potential E (in redox systems). The problem is presented uniformly and consistently. When applying the generalising approach to thermodynamics of electrolytic systems [2], mainly after formulation of generalised electron balance [8,9], one can resolve, from thermodynamic viewpoint, a thermodynamic or metastable system of any degree of complexity, with all physicochemical knowledge involved, with none simplifying assumptions done, with the possibility to imitate any analytical prescription, related to any *quasistatic* isothermal process [10,11]. Any changes occurring in the system can be performed according to titrimetric mode, where a solution of a disturbing factor (or containing a mixture of disturbing factors) is introduced. Among others, the systems involving all four fundamental kinds of reactions (i.e. acid–base, redox, complexation and precipitation reactions) can be considered. What is more, any kind of the reactions can involve many representatives, e.g. complexation can be represented by different cations and ligands [2,9,12].

In general case, one can distinguish different species X_i whose concentrations $[X_i]$ and then $pX_i = -\log[X_i]$ values can be accounted for. It enables the expressions for $B_V(pX_i)$ to be presented as follows

$B_V(pX_i) = \beta_V(pX_i) + (d\beta_V(pX_i)/dpX_i)_{pXi}\cdot\Delta pX_i/2 + (d^2\beta_V(pX_i)/dpX_i^2)_{pXi}(pX_i)^2/6 + ...$ analogous to eq. (1), where pX_i value refers to V = 0 and

$\beta_V(pX_i) = |dc/dpX_i|$,

where c is the current concentration of a disturbing (e.g. reducing, complexing) factor. Note that the disturbing agent may – in general case – act, simultaneously, as acid–base, complexing and precipitating agent (e.g. NH_3). For redox systems one can, moreover, to formulate the expression

$B_V(E) = \beta_V(E) + (d\beta_V(E)/dE)_E\cdot\Delta E/2 + (d^2\beta_V(E)/dE^2)_E(\Delta E)^2/6 + ...$ where potential E value refers to V = 0 and

$\beta_V(E) = dc/dE$

and c is the current concentration of disturbing (reducing, oxidising, disproportionating, or synproportionating) reagent that can act, simultaneously, e.g. in acid–base, complexation and precipitation equilibria. It is even possible to take into account the case where the titrant involves several substances and the buffering action of a particular agent can be considered on a 'background' of accompanying species.

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THE SOLUBILITY CALCULATIONS: A STRICTURE OF THE APPROACH BASED ON CHEMICAL REACTION NOTATION

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In handbooks on general and analytical chemistry and in educational proposals offered in Internet, e.g. [1], one can find incorrect approaches to the calculation of solubility (s, mole/L) of different precipitates in water and in aqueous media, in general. In the present communication, the criticism is directed against the approach based on the principle of chemical reaction notation. We will refer here to thermodynamic processes involved with precipitates. The criticism will be summarised in the following points.

1. Ambiguity in a chemical reaction notation. Two or more algebraic equations: $f_i(x) = 0$

   ($i = 1,...,k$, k2) when multiplied by scalars a_i and added, provide the linear combination $_{i=1}^{k}$ $a_i f_i(x) = 0$, where $x = [x_1,...,x_n]^T$ is the vector of independent variables. The a_i values can be chosen arbitrarily and then the number of linear combinations is infinite. Similar remark refers to chemical reaction notations, in close connotation with their *quasi*–algebraic properties. The main disadvantage of the approach based on the chemical reaction notation is then its ambiguity: the number of possible linear combinations of two or more (partial) reactions is unlimited. Any linear combination is correct, from formal viewpoint; it testifies how extremely ambiguous a chemical reaction is. Particularly, there are ambiguities between notations:

   $MgNH_4PO_4 = Mg^{+2} + NH_4^{+1} + PO_4^{-3}$

   and $MgNH_4PO_4 = Mg^{+2} + NH_3 + HPO_4^{-2}$ (1)

2. Stoichiometry and the solubility product. The ambiguity in reaction notations affects the ambiguity in formulation of the related equilibrium constant. For (1) we have:

   $K_{sp} = [Mg^{+2}][NH_4^{+1}][PO_4^{-3}]$

   and $K_{sp}' = [Mg^{+2}][NH_3][HPO_4^{-2}] = K_{sp}K_{1P}^{H}/K_{1N}^{H}$ (2)

   where $[NH_4^{+1}] = K_{1N}^{H}[H^{+1}][NH_3]$ and $[HPO_4^{-2}] = K_{1P}^{H}[H^{+1}][PO_4^{-3}]$.

3. Ready–to–use formula for calculation of s in two–phase system obtained after introducing the precipitate $pr = Me_nL_u$ into pure water provided in literature, e.g. [2], is as follows

   $s = (n^{-n}u^{-u}K_{sp})^{1/(n+u)}$ where $K_{sp} = [Me^{+u}]^n[L^{-n}]^u$ (3)

4. Examples

Eq. (3) gives erroneous results, as a rule; particularly, the value for $[Fe^{+3}]$ obtained from the formula (3) for pr = $Fe(OH)_3$ is $4 10^7$ times greater than the correct value found from the equations:

$$3[Fe^{+3}] + 2[FeOH^{+2}] + [Fe(OH)_2^{+1}] + 4[Fe_2(OH)_2^{+4}] + [H^{+1}] - [OH^{-1}] = 0$$

$[Fe^{+3}][OH^{-1}]^3 = K_{sp}$ ($pK_{sp} = 38.6$) and $[H^{+1}][OH^{-1}] = K_w$ ($pK_w = 14.0$) and other equilibrium constants as ones cited in ref. [3]. Analogous procedure, based on extended form of eq. (3), has been applied in [1] e.g. for hydroxyapatite. The formula suggested e.g. in [4] for solubility s of struvite (pr1 = $MgNH_4PO_4 6H_2O$, $pK_{sp} = 12.6$) in pure water was as follows

$$s = (K_{sp})^{1/3} \quad (4)$$

However, as results from detailed calculations [5], pr1 when introduced into pure water or aqueous solution of *CO_2* (C_{CO2} mole/L) is not the equilibrium solid phase. Before the solubility product (K_{sp}) for pr1 is attained, the solubility product (K_{sp}') of another precipitate (pr2 = $Mg_3(PO_4)_2$, $pK_{sp}' = 24.38$) is crossed and further precipitation of pr2 is accompanied by evolution of ammonia [6], owing to reaction

$$3pr1 = pr2 + HPO_4^{-2} + 2NH_4^{+1} + NH_3 + 6H_2O \quad (5)$$

Further step of the process depends on the initial concentration C_0 [mole/L] of struvite in the system. At $C_0 = 10^{-3}$ and $C_{CO2} = 10^{-4}$, the pr1 dissolution and subsequent formation of pr2 is terminated at the point where pr1 is totally depleted. At $C_0 = 10^{-2}$ and $C_{CO2} = 10^{-4}$, the dissolution of pr1 and formation of pr2 is stopped at the point where the solubility product (K_{sp}) for pr1 is crossed. The dissolution of pr1, accompanied by pH–changes, is an interesting example of a dynamic process similar to the coulometric generation of a reagent. In this case, the dissolution of pr1 can be realised at (practically) constant volume of the two–phase system.

The changes in speciation and in the solubility

$$s = [Mg^{+2}] + [MgOH^{+1}] + [MgH_2PO_4^{+1}] + [MgHPO_4] + [MgPO_4^{-1}] + [MgNH_3^{+2}] + [Mg(NH_3)_2^{+2}] + [Mg(NH_3)_3^{+2}] (+ [MgHCO_3^{+1}] + [MgCO_3]) \quad (6)$$

of pr1 during the dissolution process were registered at different C_0 and C_{CO2} values.

Complex nature of the phenomena occurred, with side effects resulting from presence of carbonate species, can be explained by equilibrium analysis, made with use of all attainable physicochemical data involved. The optimising procedure, based on the set of equations expressed by charge and concentration balances, is referred to *quasistatic* isothermal process [7].

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GENERALISED EQUIVALENCE MASS (GEM) CONCEPT AND ITS KEY ROLE IN QUANTITATIVE INFERENCES

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Education in area of general and analytical chemistry should be realised with extended use of computer techniques involved in didactic process; it particularly concerns ionic equilibria in aqueous systems. Instead, in a common contemporary practice, the calculations based immediately on a chemical reaction notation are still the basis for quantitative inferences. This problem can be discussed in close relevance to the equivalence mass (EM) concept playing a key role in all calculations referred to titrimetric analyses. Titration can be considered, after all, as a more sophisticated manner of mixing the solutions, realised in classical, qualitative analysis. In this context, the qualitative analysis can be presented in quantitative manner.

In context with EM, we refer to the place and role of chemical reaction notation. We state that the chemical reaction principle should be limited only to the role of a ‘carrier’ of the related equilibrium constants. It is obvious that any ambiguities in reaction notation provide a sufficient reason disqualifying the chemical reaction notation as a potential source of quantitative inferences. One should take into account that (1) the number of linear combinations of two or more chemical reactions is infinite; (2) a particular reaction notation involves only a part of species of the system considered; (3) the obligatory definition of EM requires a choice of a particular reaction as one ‘responsible’ for all phenomena occurred in the system.

The EM concept, still recommended and advocated by IUPAC, is formulated for a defined system a posteriori, separately for all four kinds of elementary (acid–base, redox, complexation and precipitation) reactions. On the contrary, the generalised equivalence mass (GEM) concept, suggested by Michałowski [1,2], is formulated a priori, with none relevance to stoichiometries of particular reactions and involves all attainable and pre–selected physicochemical knowledge about the system considered. GEM is adaptable for equilibrium and metastable systems where quasistatic processes take place under isothermal conditions. In GEM, all kinds of elementary reactions may occur simultaneously and/or sequentially in mono– and polyphase (also: liquid–liquid extraction [3,4]) systems.

The fundamental question: has the reaction notation to be necessarily considered as a carrier of quantitative information? – will be answered disapprovingly, for the reasons specified below in the following points, related to quantitative aspects of phenomena occurred in a system tested.

1. Material balances. The set of material balances, consisting of charge balance, p concentration balances and electron balance, involves all species really existing in a system in question. Particularly, the generalised electron balance concept, devised by Michałowski [5], completes the set of balances referred to redox systems.
2. Equilibrium constants are related to a linearly independent set of chemical reaction notations. Any particular reaction is characterised by an equilibrium constant value. The reactions not involved in expression for equilibrium constants are thus omitted in considerations. Note that e.g. the equilibrium constant for $Na^{+1} + Cl^{-1} = NaCl$ equals zero. This omission enables to avoid indeterminate expressions of 0/0 type. The qualitative (speciation) and quantitative (equilibrium constants) data should be pre–selected carefully. A reaction notation commonly applied for simple stoichiometric calculations can be considered only as a kind of 'dummy' [7].
3. Calculations related to complex systems are usually made with use of iterative computer programs (e.g. MATLAB, MINUIT), referred – generally – to a set of non–linear equations. In the simplest case of acid–base systems, the functional relationships are obtainable [1,8].
4. Optimisation procedure requires to write the material balances (p.1) in the form of equations $f_i(x) = 0$ ($i = 1,..., k$), where k equals p+1 for non-redox and p+2 for redox systems; p – number of concentration balances; $x = [x_1, ..., x_n]^T$ is the vector consisting of fundamental (scalar) variables x_i [8]. It is advised to take $pX_i = -\log[X_i]$ as fundamental variables, $x_i = pX_i$; it enables to avoid negative values for concentrations ($[X_i] = 10^{-pXi}$) in the course of the iterative optimisation procedure. None simplifying assumptions are needed and any analytical prescription can be imitated.
5. Batch and dynamic system can be described with use of the optimisation procedure. An example of calculation in batch system is the calculation of pH and potential E in Br_2 solution [5]. Another kind of batch system refers to dissolution of a solid phase in aqueous media [9]. An example of dynamic system is the titration of Br_2 solution with NaOH [3]. A more complex dynamic system is exemplified by pH–static titration [10]. Another examples of complex electrolytic systems are presented in [1–3,5,6,8–11].
6. Phase composition. The simulations refer to mono- and poly-phase, batch and dynamic systems. Argentometric titration of cyanide, made according to a modified Liebig–Deniges method [8], is an example of a dynamic process realised (partially) in one and two-phase systems.
7. Visualisation of the data obtained from calculations is particularly applicable for dynamic systems. It concerns, in particular, individual species and/or a group of species, e.g. ones entering the expression for solubility (s, mole/L) in two–phase system.

The simulating procedures enable to see all that is invisible in real, experimental procedures, e.g. the speciation changes in dynamic processes. All the inferences are based on firm, mathematical (algebraic) foundations, not on a fragile chemical notation that is only an imitation of a true, algebraic notation.

It is noteworthy that the knowledge of algebra involved requires – from formal viewpoint – only the capabilities involved with an arrangement of the corresponding material balances and formulation of relationships based on the principle of mass action law.

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THE INFLUENCE OF COMPUTER-ASSISTED EDUCATION ON GLOBALIZATON KNOWLEDGE AND AWARENESS

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Globalization, being one of the most important subjects of today's world takes its' place in the curriculum programs of the departments of the Faculty of Economics and Administrative Sciences. The students attending the educational departments that do not have these subjects in their curriculum program can gain this knowledge through the Internet. The industrialized society, occurred in 20th century, not only increased industrialism in the world, but also the use of energy and resources. The increasing production and consumption led to environmental problems on a global level. Therefore, in order to provide global environmental protection, the concepts that were caused by globalism such as industrial overproduction and unconscientious consumption should be well understood. In order for these concepts to get under control on the global level, global environmental protection awareness should be constructed. The success of this program depends on the development of an educational system that takes globalism into consideration. Thus, in higher education, there has to be educational curricular programs, which involve globalism as a subject, construct global environmental awareness and to use these teaching technologies. In the study, the "Globalization Knowledge Test" and "Globalization Awareness Scale" were developed first. In order to investigate the affect of computer-based education on globalization, the students attending Hacettepe University, Faculty of Economic and Administrative Sciences that have these subjects in their curriculum program and the students attending Hacettepe University, Faculty of Economic and Department of Chemistry Education that do not have these subjects in their curriculum program were compared. The increase of the students' knowledge and awareness were determined with pre- and post test applications. The results of the researches show that the educational processes using technology affects the student success whether it is in the curriculum or not. The similar studies related with environment and usage of technology in chemistry education shows the increase of student success (Morgil vd.2004, Morgil vd, 2005).

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TOWARDS STUDENT-CENTRED PRACTICALS

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Traditional chemistry practicals in the UK have used the 'recipe' style, essentially a list of instructions as to what to do, preceded by some (brief) theory, perhaps even a mention of the purpose of the practical. The expected outcome would be mentioned at the end and the student's practical skill would be assessed by how close to the student's achievement was to the stated outcome.

This approach has been satisfactory for mainstream chemistry students who were motivated and could understand the context and relevance of the practical (and might even like doing it). However, this approach has been strongly criticised in recent years since, among other faults, it does not require the student to be intellectually engaged with the procedure being followed.

The several criticisms have been addressed by the use of practicals in which planning is required, or an open-ended task is set so that the student must make his or her own conclusions.

Such approaches may be useful in engaging students who have a good grounding in chemistry but there is now a large contingent or cohort of non-chemistry students who need to be acquainted with chemistry laboratories skills but who lack the background and motivation to derive much benefit from 'exploratory' practicals. The situation is exacerbated by the need to introduce (very) sophisticated procedures and instrumentation to (very) inexperienced students. An additional problem is that the cohort is very likely to contain a wide range of student ability and appreciation. Some may find a recipe incomprehensible while others may find it 'insults their intelligence'. All will need detailed instruction where instrumentation is introduced.

In an attempt to deal with several of these challenges I have adapted some practicals by identifying sub-sections of the overall procedure which could be short, self-contained exercises in themselves. These are generally at different levels of sophistication. The student has details for all of them but may pick and choose which he or she does, and in what order. The student is expected to ask him/herself "What do I want to get out of this practical?" and to do some preliminary work to inform his/her choice. During the procedure the student is expected to evaluate his / her results for the step just completed and to decide what is the next logical step to undertake. This may include repeating previous work when results seem unreliable or inconsistent.

Analytical practicals, particularly, lend themselves to splitting up into several reasonably self-contained exercises or procedures (setting up, calibration, measurement of unknowns etc.). Depending on their prior experience and knowledge, students can choose for themselves which exercise to start with and, depending on their results for that exercise, choose a suitable exercise to follow and so on. There would be no requirement to achieve a particular result - only to carry out work that improves the student's laboratory expertise and aids the learning of background material. It is hoped that such a flexible approach would enable the student to get what s/he wanted from the practical to best complement his/her appreciation of the topic or method at the time. Assessment of the work would be via an on-line 'pre-lab' test, self-monitoring of results during t he laboratory work *via* dedicated spreadsheets and a report (marked traditionally) which shows what was done, how the results were interpreted and how that influenced what was done next.

I have now tried using this approach with about 50 students doing four practicals. I have not collected statistical results but have some overall impressions. There are several snags in the implementation which must be addressed. Students will have to be introduced to the approach much more definitively; some students do not like having such a choice or find it confusing when compared with more traditional practicals; preparation for the practical must be done and so the pre-lab test must carry some marks (but deciding how to allocate them is tricky). An appropriate evaluation must be devised if I am to determine whether the student learning experience for a particular practical is enhanced.

The poster will outline this approach and emphasise the key features. It will be accompanied by examples of the student instruction material.

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NEW ROLE OF THE UNIVERSITY IN TRANSITION COUNTRIES: BETTER COOPERATION WITH SECONDARY SCHOOLS

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After graduation at the Faculty of Chemistry of the University of Belgrade, most of students are employed as teachers in secondary schools (about 50%) while others get job in industry (40%) research institutes and university (10). More than 15 years ago, Department of Chemical Education at the Faculty of Chemistry launched a well designed long range project for permanent education of secondary school teachers. Unfortunately there was no support for such project from the Ministry of Education and schools were reluctant to send their teachers for one week seminars. After the democratic changes in 2000, the situation was changed, so that revised and improved project started three years ago. Beside regular seminars which took part each year, efforts were also made to produce educational material which would be relevant and interesting for both, teachers and secondary school students. Such materials were produced within postgraduate studies in chemical education (specialization or M. Sc. degree) or independently. They were distributed to colleagues in schools on various occasions and used for mutual interest and benefit. There was the greatest interest for educational materials in environmental chemistry due to the shortage of such materials and to the interest for environment and environmental education expressed by media, various ministry, schools and general public. Therefore, four education packages were recently produced for environmental chemistry. Some of them were based on real events. The themes were: Bioremediation I: Cleaning up Alaskan oil spill after the disaster of oil tanker Exxon Valdez [1,2], Bioremediation II: Cleaning of the soil from a waste lagoon in petroleum refinery in Czechowice (Poland) [2,3], Eutrophication, DDT and pesticides.

All packages were intended for the use in upper secondary schools (the last four grades, age of students15-18) preferably for older students as all materials demanded a lot of knowledge, problem solving and intellectual capabilities. Each package required minimum 90 minutes for the use in the classroom (two ”school hours” of 45 minutes, preferably in a block). The package consisted of the short instruction for the teacher, information sheet and test for students. It was distributed to teachers as ready for use (teachers had make photocopies for their students and, of course, to study the material in order to find the optimal way for the use in his/her classroom). The general idea for the use of such package was that each student will receive the same information sheet, read it and then individually write answers on the questions in the test. All students received the same test and the use of textbook was not allowed. Various types of questions were included in the test. Some required the knowledge from previous lessons, some application of that knowledge and some combination of previous knowledge with data from information sheet. Open ended questions were also included. After finishing the test, a general discussion was organized focusing on the most difficult and/or the most interesting questions. All tests were later evaluated by the teacher and each student got the mark for it.

In this paper the package Bioremediation I: Cleaning up Alaskan oil spill after the disaster of oil tanker Exxon Valdez, will be discussed. It was used in the way described above in eight classes. The total number of students was 109 and they were all from the general type secondary school (Gymnasium), class 3 (age about 17; after the class 4 students can go to the University).

Information sheet was one page and the test consisted of 20 questions. One of them, which required good understanding of the main theme, was:

"The most important chemical reaction in the bioremediation is

$$C_xH_y \rightarrow CO_2 + H_2O.$$

What is missing (the word "bacteria" was written above the arrow)? Complete the reaction".

About half of students (52.8%) answered correctly that the oxygen is missing, but only 37% included it in the reaction. 18.5% of students tried to balance the reaction but only one of them was successful (0.9%).

In another question students were asked to discuss "the controlled burning" as the possible method for cleaning of oil spills.

The marks of students in chemistry were correlated with their total scores in the test as well as with partial scores (for tasks requiring knowledge, application of knowledge, combinatorial and problem solving capabilities).

Alternative scenario for the same package was also developed and tested. It included distribution of information sheets to students, discussion within the class moderated by the teacher, solving some selected questions from the test (individual work of students which are evaluated later) and general discussion at the end (including the analysis of possible answers on the questions in the test).

This package is translated to English and it will be offered for use in other countries with intention to make the international network of teachers with similar interest.

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TEACHING OF CHEMISTRY FOR STUDENTS OF SCIENCES AT WARSAW UNIVERSITY

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The author for ten years has dealt with teaching of organic chemistry at Inter-Faculty Studies in Environmental Protection, Warsaw University. Specific to these studies are interdisciplinary character of education and curriculum of the studies going beyond frames' programme of the single faculty. In order to be accepted on first year of studies, the candidates have to pass two exams. Chemistry is one of five obligatory objects which they have to choose. Usually one of eight - ten applicants, obtaining the highest scores, is accepted. Beginners represent however the very diverse level of chemistry acquaintance. This makes up the serious difficulties during constructing the programme of teaching and conducting exercises as well.

The programme of teaching chemistry for the first year students comprises now lectures: General and Analytical Chemistry and Organic Chemistry (I semester, 30 hrs each), and classes: basic organic chemistry (I semester) and analytical chemistry (II semester; 45 hrs each).

In order to overcome the above-mentioned difficulties the programme has been changed during the period of ten years as to the time frame and the scope of knowledge to be taught. The paper describes in details the programme itself and the changes introduced to it as a result of an interactive dialog among teacher and student.

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EDUCATIONAL SKILLS OF PROSPECTIVE CHEMISTRY TEACHERS

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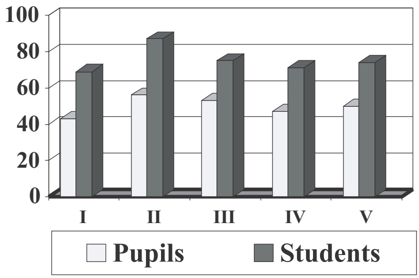
Increasing importance of education in school practice from the chemistry teacher formation of the situation in the teaching process in which pupils can shape their attitudes and behaviour along with acquiring knowledge. To establish the course of educational aims realization in the teaching chemistry process and its effects, some research consisting of three stages, was undertaken in the Chemistry Education Department. Teachers and junior secondary school pupils participated in the first and second stages but in the third one students – prospective chemistry teachers. Before starting the research, there were determined five groups of educational aims which should be achieved in teaching chemistry.

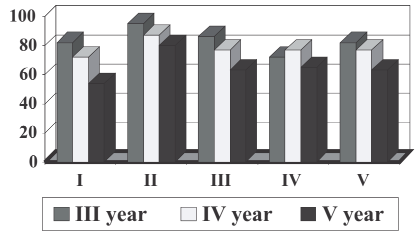
I. *Stimulating and developing pupils' interest in the processes occurring in the closest surrounding in nature;*
II. Showing the importance of chemical knowledge in development of civilization;
III. Making it aware that man is an element of nature and showing the effect of his activity on the processes occurring in nature;
IV. Making it possible for pupils to get to know themselves and to manage development of their own personality;
V. Developing the attitudes preparing pupils for life in the society.

The results of investigations made in junior secondary schools showed that frequency of didactic situations favourable for realization of educational aims in teaching chemistry depends on choice and arrangement of teaching contents and teacher's skills. *The more distinctly humanistic values of this subject and practical importance of knowledge are shown by the choice of teaching contents, the greater is frequency of situations favourable for combination of teaching and shaping attitudes and behaviour oreated by the teacher* [1]. However, frequency of these situations depends on the fact to which extent the teacher can notice and use these contents in teaching. Their rare occurrence has influence on educational aims realization manifested in pupils' attitudes and behaviour. That causes concern as according to the research, only about 50% pupils represented the expected attitudes [2].

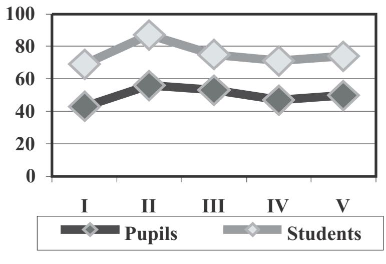
Therefore the aim of the third stage research was to answer the question: *What behaviours and attitudes are represented by students - prospective chemistry teachers?* 90 students were subjected to investigations. As a research tool, there was used the same test as that for junior secondary school pupils



assuming that students will disclose attitudes and behaviours more consistent with expectations than junior secondary school pupils. The test incuded 31 multiple choice tasks, the content of which presented the description of situation in which a pupil (student) can find himself or herself in everyday life. Four tasks described his or her different behaviours, possibible in this situation. One of them was accepted as the expected [2]. According to the assumptions, the results obtained by most students under investigations are much better than those obtained by pupils (see diagram). On the average 78% students are characterized by the attitudes consistent with the expected which can be accounted for by their greater chemical knowledge and greater maturity.



However, the results obtained by the students in individual groups, i.e. III, IV, V year chemistry students are significantly distinct. On the average 87% III year students, 78% IV year students and only 67% V year students of chemistry showed the expected attitudes and behaviours in different everyday life situations. Particularly alarming are poor results in I group aims i.e. *stimulating and developing pupils' interests in the processes occurring in nature* and in IV group aims i.e. *making it possible for pupils to get to know and manage development of one's own personality.* Both these aims are the resultant of combination of chemical knowledge acquisition and attitude formation. The frist one shows the essence of this knowledge and the other one its educational effects. The disturbing fact is that with the progress of university education of chemistry teachers, there is observed a decrease in the number of students presenting the attitudes consistent with the expected ones, the more so it takes place just before their starting werk at school. Comparing the results of pupils and students, some regularity can be observed as shown in the diagram. The results concerning individual groups of educational aims both in the groups of students and



pupils are approximately prpportional. In I and IV groups of aims , the smallest groups of both students and pupils were characterized by the attitudes expected from them.

As follows from the studies, one of the basic activities affecting the realization of educational aims in teaching chemistry is improvement of university methods of chemistry teachers education.Then the awareness of combining teaching and education should come into being in prospective teachers. This awareness should be formed along with acquiring basic skills indispensable in doing teacher's job. One of them is the ability to analyze chemistry teaching contents in order to bring out contents of educational value with their simultaneous application in didactic situation formation which may take place.

Such an approach to teacher training inspired modernization of chemistry education classes in the Chemistry Education Laboratory. In the elaborated curriculum one of the classes is devoted to educational aims in teaching chemistry. During classes students do various tasks and experiments, playing roles of both teachers and pupils, which are analyzed then. One of the tasks is examination of sulfur effect on plants. Therefore students make the experiment placing some parts of green plant in a vessel with sulfur dioxide and observe the changes taking place after a few minutes. Then they point to the attitudes and features of character formed by pupils examining the effect of sulfur dioxide on plants.Based on it they formulate educational aims. However, as shown by the studies only one class dealing with educational aspects in teaching chemistry is insufficient to achieve the full aim completely. Olso during other classes there should be given problems to solve which disclose possibilities chemistry provides in combining teaching and forming pupils' attitudes and behaviour. These are, above all, complementary and equiponderant areas in teacher's job.

Studies carried out on the group of students – prospective teachers aimed at getting to know already formed attitudes and behaviour in chemistry education. However, they did not provide information about the reasons for decrease in the number of students presenting the expected attitudes with age. These surprising results should promote further research to establish the reasons of such state. This will enable more effective improvement of teacher education methods.

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GRATE*: A MODEL FOR INTERNATIONAL INITIATIVE FOR TRANSDISCPLINARY EDUCATION IN ENVIRONMENTAL SCIENCE

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Since 2001, three educational centers in Poland, Romania and Germany initiated a pilot project establishing a model study for transdiscplinary education in environmental science. The main aim of this project is to prevent a “brain drain” of the best master and Ph.D. students from the Eastern Europe. Within a course of the GRATE initiative it is planned to complete curricula of all partners for better compatibility with modern trends of education in Europe. There are several proposed methodologies undertaken in order to obtain this tasks. First of all, outlines and general framework for attractive model of a trans-disciplinary education in graduate and postgraduate levels are proposed. Transdisciplinarity is gained through compilation of basic sciences, applied sciences and engineering to achieve a better insight into environmental problems faced in transforming Europe. Since modernization of curricula requires appropriate teaching faculty a process for advanced teachers’ training has been initiated. Therefore, the first summerschool undertaken within the frames of GRATE projects was organized solely for teaching staff members of participating universitities. Extensive teacher training was undertaken, within which planning for the next summerschool with participation of students was organized. Summerschools are planned in the way of case study related to environmental problems of the region it is organized in. Within the network of participating academic institutions, exchange programme of teachers and students has been initiated. The developing programme consist of guest lecturing, student modular courses and inter-refeering of master thesis. Romanian partner has already completed adjustments of the curricula towards compatibility to European educational standards. These changes already allowed to host well recognized scientists who already emigrated from Romania to join the project by offering guest lectures. This was in fact one of the main objectives of the GRATE project.

*GRATE –**Gra**duate and Postgraduate Study of **T**ransdisciplinary **E**nvironmental Science

SIMULATION OF pH–STATIC TITRATION

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This communication aims to introduce the students into details of the simulated titration realised according to pH–static mode [1], with iterative computer program, written in DELPHI language. The principle of this procedure is illustrated by the modified Liebig–Denigès method [2–4] of cyanide determination.

The simulated pH–static titration realises the following analytical prescription.

V_{KCN} mL of C_{KCN}* mole/L KCN solution is sampled and treated, successively, with portions: V_{DEA} mL of C_{DEA}* mole/L diethanolamine (DEA) and V_{KI} mL of C_{KI}* mole/L KI. After dilution in the flask (volume V_F mL), we have: $C_{KCN} = C_{KCN}*V_{KCN}/V_F$, $C_{DEA} = C_{DEA}*V_{DEA}/V_F$, $C_{KI} = C_{KI}*V_{KI}/V_F$.

Then V_D mL of the solution ($V_D \; V_F$), named later as titrand (D), has been taken for analysis. The pre-assumed pH_0 value was adjusted (AD) by titration, with V_{AD} mL of C_{AD} mole/L NaOH or with V_{AD} mL of C_{AD} mole/L H_2SO_4. The D+AD solution thus obtained, with volume $V_{DAD} = V_D + V_{AD}$ mL, is treated first with a portion V_{P1} mL of C_P mole/L $AgNO_3$, named as the primary titrant (PT). The resulting solution, with $pH_1 = pH_0 – pH_1$, is returned to the initial pH_0 value with V_{A1} mL of C_A mole/L NaOH, named as auxiliary titrant (AT), added according to (normal) titrimetric mode. Further portions of PT and AT are added repeatedly and alternately. After addition of j–th pair (j = 1,...,N) of the titrants, total volumes of PT and AT added are equal $V_{Pj} = {}_{i=1}^{j} V_{Pi}$ and $V_{Aj} = {}_{i=1}^{j} V_{Ai}$, respectively. Equal portions $V_{Pi} = V_{P1} = V_P$ of PT are assumed and then $V_{Pj} = jV_P$.

The points (V_{Pj}, V_{Aj}), j = 1,...,N, plotted in co–ordinates (V_P, V_A), are arranged along a line consisting of (or containing) nearly linear segments. The abscissa corresponding to the point of intersection of rectilinear parts is considered as the end (e) point, $V_P = V_e$. At the end point, the solubility product for AgI precipitate is crossed. If pH_0 value is chosen properly, the end point coincides with the equivalence (eq) point, i.e. $V_e \; V_{eq}$.

The system where H_2SO_4 is used for pH_0 adjusting is named as S–system. The system with NaOH as the adjusting solution is named as $ system.

The data related to the system consist of: (a) physicochemical (equilibrium constants), (b) analytical (concentrations and volumes) data and (c) fundamental (basic) variables.

The simulating procedure consists of three stages, namely: (1) Calculation of starting pH–value; (2) Simulated "classical" titration with adjusting (AD) solution, up to a pre–assumed pH_0–value; (3) Simulated pH–static titration.

The number of 26 (in mono–phase S–system) or 27 (in two–phase S–system) species are fully described by n = 6 independent (fundamental) variables:

$-\log[CN^-]$, $-\log[DEA]$, pH, $-\log[SO_4^{2-}]$, $-\log[I^-]$, $-\log[Ag(CN)_2^-]$

All the data and variables, potentially needed in the system, are introduced in the program. The program extracts automatically the variables needed for simulated titration. If H_2SO_4 does not enter the system ($ system), the void window for $-\log[SO_4^{2-}]$ does not stop the simulating procedure, i.e. the window with $-\log[SO_4^{2-}]$ is inactive this time.

The results are visualised after choosing between options: (a) V_A vs V_P or (b) pH vs V_P+V_A. In the case (b), the pH_j values are visualised in all points of the related titration curve; it enables to evaluate the resolution of the method.

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GETTING STARTED WITH MACROMEDIA FLASH

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Simple animations, videos and good diagrams can greatly increase the quality of teaching and learning. They can be used in lecture situations, they can be included in self-paced learning packages and they can be used to improve accessibility for students with learning difficulties. They also have significant potential for interactive applications.

Macromedia *FLASH* is an ideal tool for producing computer-based animations. It is already extensively used by web designers and the '*FLASH* reader' can be downloaded free from the web.

There are already a wealth of FLASH animations, JPEG and other diagrams, and videos available for downloading from a range of web sites. There are, however, a number of problems:

- Most of the material is subject to copyright
- Most of the material is not exactly suitable for another institution's learning situations without some modification
- All the material, and especially the *FLASH* software, is in the form of .flw files with no explanation of how these were produced. The original flash source files (.fla) are hardly ever available.

For the scientific community, there are two additional difficulties with *FLASH*. Firstly, there is the need to learn how to use it and secondly there is the lack of available help which is simple and directly related to scientific ideas. Even the examples which accompany *FLASH* software are complicated and have no scientific content and most books on *FLASH* have similar limitations.

In this paper a series of simple flash animations with detailed documentation on the methods used will be described. The animations produced by the project team will be available for use or modification by other workers. The documentation will provide end users with the methodology to develop their own ideas. Animations will be both qualitative and quantitative, e.g. producing data which can be used in further work, and will have interactive features. Examples include:

- The effect of pressure on the volume of an ideal gas
- The effect of temperature on the volume of an ideal gas
- The effect of temperature on the pressure of an ideal gas
- Electronic structure and the development of the periodic table
- The nature of solids, liquids and gases
- Vapour pressure

- Diffusion
- Atomic orbitals
- Thin layer chromatography separations
- Gas chromatography separations

Dissemination of the results of this work will take place in a number of ways:

- Documentation and animations produced in the project will be available for downloading from the ETGT web site (www.soton.ac.uk/~ecchemed/etgt/).
- Documentation and animations produced in the project will be available on a CDROM
- The work will be demonstrated at a ‘Variety in Chemistry’ meeting
- DB and AR will be available to run workshops at selected sites
- A paper will be written for CERP

LABORATORY OF FORENSIC CHEMISTRY — DO IT YOURSELF !

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Teaching students from the forensic chemistry course is the one of the most important task of the Laboratory for Forensic Chemistry (LFC) at Jagiellonian University. By this moment LFC provides several exercises in the laboratory course and a seminar preparing for writing master's theses.

Willing to spread our education offer, Laboratory's Team prepared a workshop combining analytical skills, essential in forensic chemistry, with facility designing, economy and public relation – domains usually being untouched by forensic experts. Presented workshop is based on the plot of "Pilgrim Pharmaceuticals" by dr Tony Curtis from Keele University, UK [1] and this adaptation is a part of the master's theses of two students from the forensic chemistry specialization.

The effectiveness of teaching depends on students commitments because even a very curious and fascinating topic might become boring, and it is wherethrough untransferable. Good way to make teaching and learning attractive is to introduce the interaction between students and discussed material [2]. Good example of classes, which students actively participate in is a workshop. This paper describe a scheme and materials for a workshop, which is conducted for students of forensic chemistry.

Initially, ten students divide themselves into two groups at the beginning. Each group has to design the new laboratory for forensic chemistry. The first group work by an order of the insurance company "Sagittarius". They are asked to design the laboratory adapted for the identification of car paints applying FT-IR and GC-MS. While the second group projects the laboratory working for the centre of drug addicted treatment. These lab is responsible for: detection of drugs of abuse in urine using the screening tests, as well as the determination of these drugs (mainly heroin) in hair with the GC-MS method.

Workshop includes several stages. After each stage, students present their projects as a "portfolio". In first stage students receive the scheme of analyses. Working on the given scheme students have to choose required equipment and

reagents, which are necessary to realize desired analyses. In the next stage students are given a chart of the room (about 8m x 6m), where they have to organize a new laboratory. The functionality is essential: there has to be enough space for all equipment, fume hoods, tables, cupboard, bins, disposal etc.
The important fact is that students designing the laboratory have to take into account not only the necessary equipment, but also the care about safety in a workplace. This involves the next students' task, namely risk estimation related from reagents, instruments and diposals.

The rise of the new laboratory arouses often many controversies. For that reason the preparation of Public Relation strategy becomes necessary and is proposed as the fourth stage. Students have to convince local residents that the newly formed laboratory is not the state of emergency for their health and will not disturb their everyday life.

The costs estimation of project is the next important part of workshop. This task shows to students that the price of instruments is not a total cost. It reminds about other expenses, such as costs of adaptation and maintenance of laboratory, reagents and utilization of wastes and finally funding related to employment, PR and advertisements. Students have to convince their employers that project is profitable. Besides, their job is not only to find potential customers but they also have to answer, whether or not it is possible to extend the offer of laboratory by some small investments.

Presented workshop shows many educational values. It improves the ability of decision making and also the expectation of its after-effects. Workshop helps in teaching skills of organization of workplace and allows to know how the laboratory for forensic chemistry works. Then it demonstrates an inseparable relation between chemistry - the laboratory work and economy, the protection of natural environment and interaction with the local community. Students have to show their knowledge about analyses made in the lab. They solve problems individually so they better assimilate with the questions connected to presented analytical methods as well as with working in the laboratory.

Finally, it cannot be neglected that these practices show that laboratory is not only a place, where chemists do experiments but it also is a commercial firm. So, it should function well, bring income, be competitive on market and realize the quality norms and protect the environment. In the framework of that workshop students have an opportunity to develop transferable skills which are necessary on the labour market.

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THE ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS (OPCW)

The Organisation for the Prohibition of Chemical Weapons (OPCW) is the international organisation that was established in 1997 by the countries that have joined the Chemical Weapons Convention (CWC) to make sure that the Convention works effectively and achieves its purpose.

Under the terms of the Convention, the OPCW undertakes many activities all over the world, including:

- working to convince those countries in the world that have not yet done so to join the Convention;
- checking and confirming the destruction of existing chemical weapons;
- monitoring certain activities in the chemical industry to reduce the risk of commercial chemicals being misused for weapons purposes by;
- providing assistance and protection to member countries if they are attacked or threatened with attack by chemical weapons, including by terrorists; and
- promoting international cooperation for the peaceful uses of chemistry.

The OPCW plays an important role in limiting the methods of war by getting rid of one of the most horrible weapons and working towards the complete elimination of an entire category of weapons of mass destruction.

The OPCW is an independent international organisation, working in the interests of its Member States. The OPCW cooperates with the United Nations and has a staff of about 500 people, representing around 66 nationalities. Like the United Nations, the six official languages of the OPCW are Arabic, Chinese, English, French, Russian, and Spanish.

Currently, the OPCW spends just over 60 million Euros per year. All 167 member countries (as at 19 November 2004) contribute to the budget each year. Their payments are determined by the size of their economies. Big, rich countries pay the most, while some smaller and/or poorer countries pay as little as one thousandth of one percent of the budget.

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We are cooperating with many companies from all over the world, for instance from; France, Spain, Germany, Ukraine, Hungary, Romania, Great Britain, Taiwan. Our balances are professional products of high technological quality. This quality has been proved by European Certificates (NMI, GUM, CMI) and positive reactions of our customers.

Our products

RADWAG produces scales and balances with very high accuracy (d = 0,01 mg, Max = 110 g) as well as high capacities like vehicle scales (d = 10 kg, Max = 60000 kg).

It also offers complex solutions for weighing systems and non typical constructions. RADWAG is the only company on Polish market with such wide range of assortment. This causes RADWAG to be very competitive on Polish and European market, and At the same time creates high expectations for maintaining high level of production and service.

Positive side of such wide assortment, either for RADWAG, and for its clients, is the possibility of complex service and selling in many branches of industry in Poland, European Union and in the world.

The assortment of RADWAG products consists of several groups of products of high importance, and outstanding quality and competitiveness. This include especially the series of analytical balances with graphic display WAX and WAS (similar products are manufactured by only three companies in the world.

Quality of those products is confirmed by our clients and Polish certificates from GUM and European ones from OIML (NMI).

Each of those balances is equipped with system of internal automatic calibration. It operates with relation to changes of temperature and time, which guaranties reliability and accuracy of measures. These balances are equipped with numerous functions, which makes them very universal for different applications. The functions are: counting pieces, % deviation in relation to calibration mass, dosing, filling, density determination of solids and liquids and recipes.

Control procedures GLP are realized by reports from calibration or by freely adjustable printouts. The printouts are composed by inscribing characters or ready to use patterns.

The second group of products, highly promoted by RADWAG, is industrial weighing systems, comprehended as typical and non typical solutions operating with such additional instruments as:

- Computers,
- Drivers or
- Appliances operating directly with other devices like feeders, dosing machines and valves, etc.

This group of products recently gave RADWAG a lot of success. As standard solutions, I can present to you:

- Data collecting systems – net of scales
- Control of packaged goods
- System of dosing of several ingredients
- Silo weighing
- Dynamic checkweighters installed in production lines.

Apart from these two types of products, RADWAG offer includes also average pallet scales with high protection level of IP 67. this platforms are equipped with single point and four point load cells. This is quite numerous group of scales applied in different kinds of industry (food, chemist, agricultural and metallurgical industry).

One more group of products are moisture analyzers used for Fast determination of humidity in small samples of materials. The moisture content is determined according to difference in masses of product before after drying process. RADWAG offers two solutions for moistures:

- With LED display and
- With graphic display.
- The first model is fairly simple construction manufactured for several years. The second solution is a new product, with extender possibilities, like data base of 99 procedures of drying, four profile sof drying, sample declaration, reports from drying, visualization of drying process on the display.

Strategies of development

Perfection of our activity is the background of constant development of the company. We base on:

- Running extended and developed marketing – meeting the requirements of the customers and their satisfaction;
- Looking ahead on the innovations – competitive products, inventions, technical progress,
- Personnel involvement with high qualifications and big experience,
- Designing and exploitation of Quality managing System according to ISO 9001-2000, equal to managing of the company.

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We are proud that our high-quality Merck products are to be found in virtually every laboratory throughout the world.

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With our commercial-grade solvents and high-purity solvents, we supply products for a variety of applications, e.g., DNA synthesis, gas chromatography and liquid chromatography.

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We also offer standard biochemicals, such as buffers, amino acids, enzymes and reagents for molecular biology and, through EMD Biosciences, highly innovative kits for sample preparation in protein analysis.

Food and Environmental Analytics

We supply a comprehensive range for food and environmental analytics: Merckoquant, pH indicator papers and strips, visual color tests such as Aquaquant, Aquamerck and Microquant, products for photometry under the brand name Spectroquant, and quantitative tests under the brand name Reflectoquant.

Microbiology/Hygiene/Microscopy

Our product portfolio includes culture and enrichment media, products for hygiene monitoring, rapid tests for water analysis, for example, and more than 250 innovative products for cell diagnostics.

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PPG INDUSTRIES

PPG Industries is a leading global supplier of coatings, fiberglass, glass and chemicals. The company has approximately 170 production facilities worldwide and employs about 33,000 people. In the year 2000 sales reached over 8.6 billion dollars.

PPG Industries Poland sp. z o.o. belongs to PPG Industrial Coatings which includes Packaging, Automotive OEM, Automotive Refinish, Aerospace and Architectural Coatings.

On both European and Polish market PPG is present mainly as the outsourcing company in the automotive industry. Typically, PPG is responsible for chemical processes in the entire car-plant. Because of that our company continuously seeks for well-educated, responsible young chemists. We offer challenging job together with top class professionals.

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See you on **www.edukacja-mikolow.pl** is our pleasance.

In this special issue for **European Variety in Chemistry Education - 2005** let's take a minute for presentation

M&C Lab Ball-and-Stick Molecular & Crystal Lattices Models

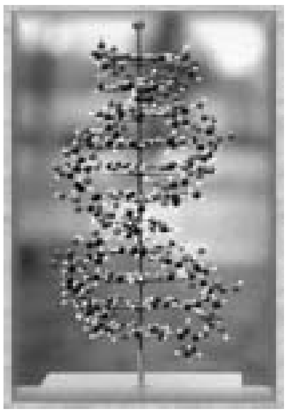
M&C Lab ball-and-stick molecular and crystal lattices models especialy suited for demonstration the general aspects of space relationships building of matter. The simple and intuitive analogy to real object makes it very usefull for every level of chemistry teaching.

The basic ideas for constructing ball-and-stick molecular models are just from VSEPR theory. Metal roads and plastic tubes represents chemical bonds. Plastic ball with properly distributed rods can represent "atom in molecule" as it was L. Pauling sugested.

Some of these models are present below and some of them you can find on Web Site www.edukacja-mikolow.pl. On the Web Site there are 3D representation to compare selected small molecules models: space filling vs ball-and-stick vs skeletal.

Let's take a brief of some basic M&C Lab models and kits of structual elements for molecular modeling.

The DNA model is assembled using ball-and-stick elements. The model is offered as 1 or 1.5 period height, 75 or 110 cm respectivly. The helix z-direction length 54 or 81cm. Models are mouted on wooden plate 40x40cm.



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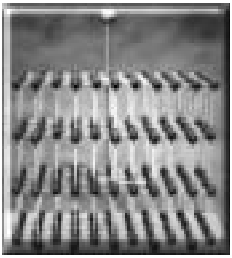
Structural elements set for molecular modeling. The kit Uni-2 consists of 182 different radius balls that represents atoms in molecule.

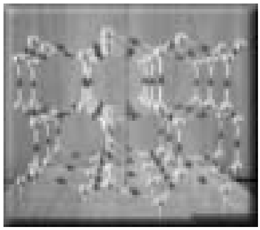
There are 12 plastic plates and 6 connectors for orbital concepts of chemical bonding introducing. 675 plastic tubes of different length which are use as connectors for balls to create chemical bonding. The manual on CD with 3D animation is attached.

Another structural elements kits are presented on Web Site www.edukacja-mikolow.pl

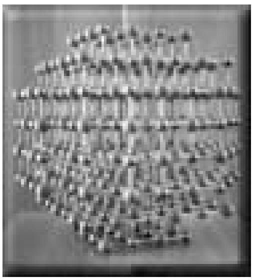
The examples of crystal lattices - graphite, ice, halite - and model of fullerene are presented below. The models are mounted on wooden plate of 40x40cm for crystal lattices and 30x30cm for fullerene. These models, like DNA models, are assembled.



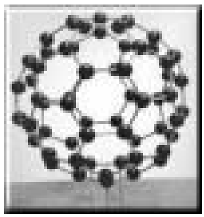
Graphite



Ice



Halite



Fullerene

If you can imagine the roads connecting atoms together not as chemical bonds, but rather as direction in enviromental space where chemical bonds are forming, you can find these models very useful for today. These are not contrary to quantum theory so long as you look it for spatial distribution of atoms in molecule, not for how atoms are building.

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