6th Eurovariety in Chemistry Education 2015

Chemistry Education for

Responsible Citizenship

and Employability

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Tartu, Estonia

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Dear Participants,

On behalf of the University of Tartu and its Faculty of Science and Technology, may I welcome you to Tartu, the second largest and University town of_Estonia, where we have the pleasure to host the Eurovariety 2015 conference.

Teaching in Universities is nowadays more challenging than ever - the proportion of youth entering universities is growing, the amount of information available in electronic form is literally overwhelming and the knowledge and motivation of students is not what it used to be (or so they have been telling us for thousands of years!). It is clear that the old teaching style, based on classical lectures, cannot be allowed to survive and new ways of providing higher education need to, and are, emerging. I hope this conference can help us all to advance our understanding of how to create a more fruitful and instructive environment for our current students and future colleagues.

On behalf of the University as the Estonian host, I wish this conference Estonia provides new opportunities to realise the scientific potential of university graduates in the region, create new grounds for scientific collaboration and enhance personal contacts in the chemistry and chemistry education fields. The organisers are making strong efforts to provide you with an attractive scientific and social programme.

I wish you all a fruitful and pleasant Estonian experience from your participation in the Eurovariety 2015 conference.

Thank you.

Professor Peeter Burk

Dean of the Faculty of Science and Technology

Dear Participants,

It gives me great pleasure to welcome all participants to the 6th 2015 Eurovariety conference on Chemistry Education.

This conference is taking place at a very special time when the world of science education is heavily emphasising, besides solid knowledge and skills in science, the need for promoting 21th century, cross-disciplinary skills among the young generation. Moreover, this is seen as the target of life-long learning and therefore promoting those skills becomes a bridge between different levels of education, between the younger generation needs and also the demands for a knowledge-based society.

Chemistry education, or as we in the Centre for Science Education like to say, education through chemistry, plays a strong role here. This bridge between chemistry and education will be strong and everlasting when school chemistry teachers, teacher educators, university chemistry lecturers, professors, chemists in research groups and also those in industry understand, acknowledge and support the need for a paradigm shift. This is needed towards more interdisciplinary and context-based teaching, expanding the meaning of inquiry-based chemistry teaching from laboratory-based practical activities to problem-based learning, using more ICT and smart technologies. In addition, there is the need to promote greater career awareness and employability skills. These components of the paradigm shift are packed into the conference presentations. Our task as participants is to notice, comment and if needed argue with this!

The conference brings together delegates from 23 countries, giving presentations covering the major conference themes and providing input into a mutual understanding about best practices for tertiary level chemistry education across Europe, Australia, USA and South Africa.

The conference organisers have also prepared a programme for all participants to introduce the historical surroundings of the University of Tartu and South-East Estonia, to admire the untouched landscape of Estonia and lake Peipsi, which forms the border of the European Union.

On behalf of the Eurovariety organisers, I wish all of you a pleasant stay in Tartu and in Estonia, and hope you can take advantage of our long daylight hours, so special for the Estonian summer. I hope this Eurovariety conference gives to everybody new ideas, new friends and willingness to come back again to our Estonia.

Thank you.

Professor Miia Rannikmäe

Conference chair

Conference program

Tuesday, 30th of June

14.00-14.30 Opening: **Miia Rannikmäe, Peeter Burk, Iwona Maciejowska**

14.30-15.30 Keynote 1 – **Reiner Salzer** (introduced by Iwona Maciejowska)

Education and Careers of Chemists in the Higher Education Sector in Europe

15.30-16.00 Coffee break

16.00-18.00 Parallel sessions

Room A

Theme: Training School chemistry teachers (chair Jack Holbrook)

1. **Dragica Trivic & Vesna Milanovic (Serbia)**

Development of chemistry teachers' competencies related to assessment of scientific reasoning

2. **Jack Holbrook & Miia Rannikmäe (Estonia)**

Interdisciplinary chemistry – pre and in service teacher education approach

3. **Iwona Maciejowska, Mustafa Sözbilir & Anthony Smith (Poland)**

Towards Excellence in School Teaching – One of the Goals for European Chemistry and Chemical Engineering Education Network

4. **Insa Melle, Sandra Anus & Inga Kallweit (Germany)**

Individualised teaching in schools, in seminars for students at university and in in-service teacher training

Room B

Theme: Training university chemistry lecturers (chair Julie Hyde)

1. **Pat O' Malley & Odilla Finlayson (Ireland)**

Implementation and Evaluation of a Laboratory Tutor Training Programme

2. **Natasa Brouwer, Bill Byers, Iwona Maciejowska & Anthony Smith (Netherlands)**

An On-line Platform for Sharing Expertise and Good Practice in University Chemistry Teaching

3. **Ria Dolfing & Jan Apotheker (Netherlands)**

Strategies in developing and implementing protocols in quality assurance and improve educational development in tertiary education

4. **Julie Hyde (UK)**

Can you teach University Chemistry Abroad?

18.00-18.30 Poster session and soft drinks (chair Katrin Vaino)

1. **Hanne Rautenstrauch & Maike Busker (Germany)**

Academic Language and Subject Specific Language Abilities of Future Chemistry Teachers

2. **Katrin Vaino, Toomas Vaino, Miia Rannikmäe & Jack Holbrook (Estonia)**

Supporting in-service chemistry teachers' professional development through ESTABLISH modules

3. **Elena Vysotskaya, Svetlana Khrebtova & Iya Rekhtman (Russia)**

Feel the concept origin: Engaging pre-service teachers into design research of a learner-centered chemistry course for middle-school students

4. **Apostolos J. Maroulis, Constantina P. Hadjiantoniou-Maroulis & Lemonia D. Antonoglou (Greece)**

Green Chemistry and Sustainability as an Innovative Educational Tool for Future Chemistry Teachers in Greece

5. **Ave Vitsut (Estonia)**

Problem-based Learning as a Source of Inspiration for Teachers to Develop Curricula

6. **Anneli Vahesalu, Hille Eek, Malle Solnson & Katrin Vaino (Estonia)**

Innovative teaching and innovative thinking in chemistry classroom

7. **Klaara Kask & Miia Rannikmäe (Estonia)**

Gymnasium graduates knowledge in chemistry - preparation for tertiary chemistry programmes

8. **Inga Ploomipuu, Jack Holbrook & Miia Rannikmäe (Estonia)**

Bridging a secondary-tertiary gap through implementing context-based teaching-learning modules at the tertiary level

9. **Malle Solnson, Klaara Kask, Ana Valdmann, Katrin Vaino, Anne Laius & Miia Rannikmäe (Estonia)**

EU project PROFILES in-service provision towards ownership of the teaching optional course „Science – Technology – Society"

18.30-19.30 Keynote 2 – **Peter Childs** (introduced by Dragica Trivic)

'We're not in Kansas any more!': some challenges for teaching and learning third level (university) chemistry"

19.30 Buses to the reception venue (University History Museum)

20.00-21.30 Welcome reception

Wednesday, 1st of July

09.00-10.00 Keynote 3 – **Ivo Leito** (introduced by Peeter Burk)

Using MOOCs for teaching analytical chemistry: experiences at the University of Tartu

10.00-10.30 **Mart Noorma**

What is quality of teaching and learning in higher education and how can it be developed?

10.30-11.00 Coffee break

11.00-13.00 Parallel sessions

Room A

Theme: Chemistry and interdisciplinary science at first year of tertiary education (chair Lemonia Antonouglou)

1. **Chris Thompson Chris & Mary-Rose Carroll (Australia)**

Student-generated drawings of chemistry at the sub-micro scale in the undergraduate laboratory

2. **Aishling Flaherty, Anne O'Dwyer, Sibel Erduran & J. Leahy (Ireland)**

Informing the Advancement of General Chemistry Laboratory Teaching to Ensure Successful Engagement and Progression of First Year Students.

3. **Laura Rice, Kieran Nolan & Odilla Finlayson (Ireland)**

Creating More Meaningful Learning in Organic Chemistry

4. **Dieter Meissner, Enn Mellikov, Andres Öpik, Peeter Burk & Enn Lust (Estonia)**

Chemistry and Materials Science - High Level Learning via Research and Practical Training

Room B

Theme: School chemistry teachers training (chair Rachel Mamlok-Naaman)

1. **Jan Reguli (Slovakia)**

Equilibrium between chemical knowledge and teaching skills in pre service teachers' education

2. **Bernard Pawel, Iwona Maciejowska & Karol Dudek (Poland)**

IBSE and its assessment as a part of pre-service teacher training – a Polish case of SAILS project

3. **Maike Busker, Monika Budde & Hanne Rautenstrauch (Germany)**

Fostering of Cognitive Academic Language Acquisition in Chemistry – Consequences and Possibilities for Chemistry Teacher (Language) Training

4. **Rachel Mamlok-Naaman, Dvora Katchevich, Malka Yayon & Avi Hofstein (Israel)**

Teachers' reflective practice as a tool for following the development of their sense of ownership during a CPD workshop

13.00-14.00 Lunch

14.00-15.15 Keynote 4 - **Simon Lancaster** (introduced by Mariann Holmberg)

Facilitating Learning in the Lecture Theatre

15.15-15.45 **Philip Taylor (Belgium), Danuta Barałkiewicz (Poland), Ricardo Bettencourt da Silva (Portugal), Darinka Brodnjak Vončina (Slovenia), Ewa Bulska (Poland), Maria Filomena Camoes (Portugal), Sylvie Childs (France), Ryszard Dobrowolski (Belgium), Marc Elskens (Belgium), Vaidotas Gegevičius (Belgium), Ivo Leito (Estonia), Nineta H. Majcen (Belgium), Petko Mandjukov (Bulgaria), Josephine McCourt (Belgium), Jérôme Randon (France), Paavo Perämäki (Finland)**

A summer school where master students learn the skills needed to work in an accredited analytical laboratory

16.00-18.00 Parallel sessions

Room A

Theme: Context based teaching in chemistry education for promoting employability skills and developing skills that employers want in undergraduate chemistry degrees (chair Jan Reguli)

1. **Niina Ronkainen (USA)**

Teaching scientific process skills in a modern context in Analytical Chemistry courses at a private American university

2. **Saara Kaski & Jan Lundell (Finland)**

Developing specialist identity through first year chemistry education

3. **Matthew Almond (UK)**

Embedding Career Development Skills into the Chemistry Curriculum

4. Aivar Vinne (Estonia)

Is teaching chemistry really difficult and boring?

Room B

Theme: ICT and smart technologies in chemistry education (chair Pascal Mimero)

1. **Jomy Samuel (USA)**

Clustered Discussion Board: A Better Framework That Enhance Student Learning and Participation

2. **Petr Šmejkal, Hana Čtrnáctová, Václav Martínek & Luděk Míka (Czech Rep.)**

Stereoscopy in chemistry education - how we use it

3. **Pascal Mimero (France)**

Continuous Education training program in Chemistry and EChemTest®

4. Jaak Järv, Heli Väärtnõu-Järv (Estonia)

Multimedia in chemistry Education: need or fashion?

18.00 Buses to the Conference Dinner in Alatskivi

Thursday, 2nd of July

9.00-10.00 Workshop 1 **Simon Lancaster (UK)**

Questioning the question?

Workshop 2 **Dragica Trivic (Serbia)**

Development of scientific reasoning of future chemistry teachers – the activities from the chemistry didactics classroom

10.00-10.30 Coffee break

10.30-11.30 Parallel sessions

Room A

Theme: Problem-and inquiry-based teaching and learning in chemistry

(chair Hana Čtrnáctová)

1. **Liliana Mammino (South Africa)**

Students' understanding of the rate law, as highlighted by laboratory reports

2. **Hana Čtrnáctová, Milada Teplá, Lenka Čtrnáctová & Petr Šmejkal (Czech Rep.)**

IBSE as an important part of chemistry teachers‘ education

Room B

Theme: Problem-and inquiry-based teaching and learning in chemistry (chair Luca Szalay)

1. **Luca Szalay (Hungary)**

Using Inquiry-based Approaches in Traditional Practical Activities

2. **Anne O’Dwyer (Ireland)**

Scaffolding Inquiry in Introductory Chemistry with molecular models

11.30-12.15 **Jaak Arold & Taavo Romann (Estonia)**
An audiovisual presentation: Large-scale learning material package “100+ Experiments in Chemistry”

12.15 -12.45 Closing: **Miia Rannikmäe, Iwona Maciejowska**

12.45-13.45 Lunch

Extended abstracts

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Poster Presentations

Education and Careers of Chemists in the Higher Education Sector in Europe

Reiner Salzer[1], **Philip Taylor**[2]

[1]*ECTN and TU Dresden, Dept. Chemistry, 01062 Dresden, Germany*
[2]*European Commission, JRC, IRMM, Retieseweg 111, 2440 Geel, Belgium*
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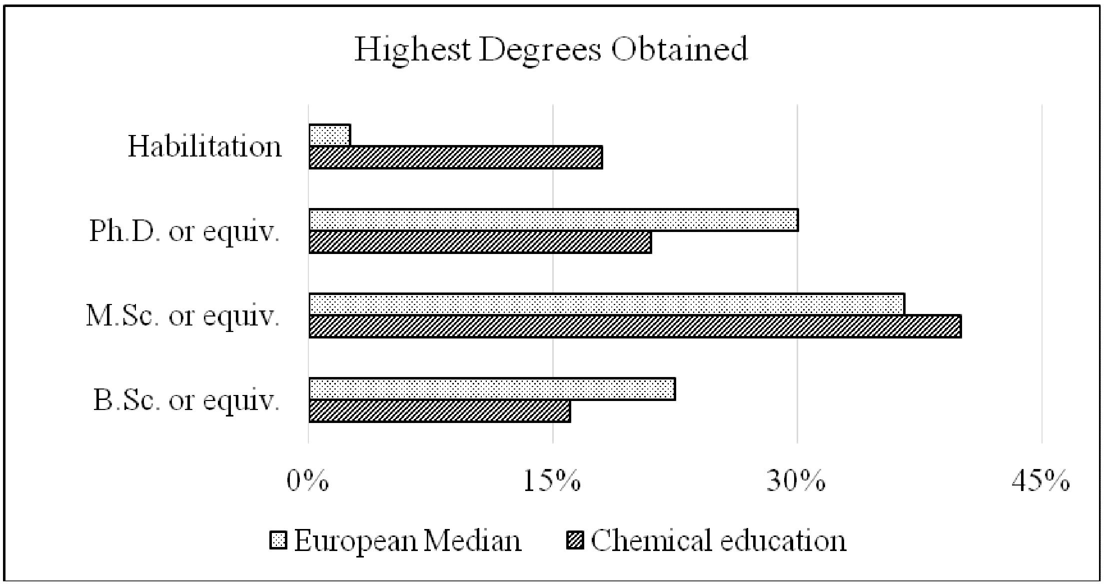
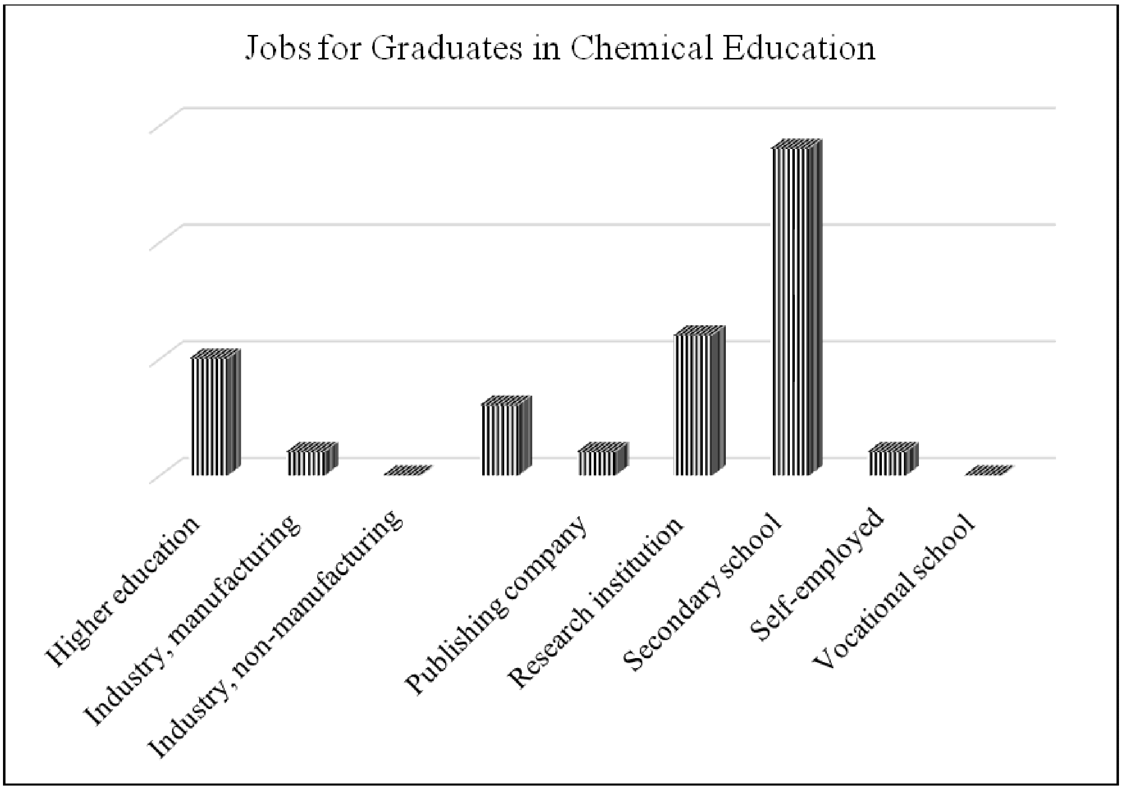
Which roles does chemical education play in the European labour force? Which employer sector offers most jobs for graduates in chemical education? Does higher education in chemistry in Europe provide appropriate specialization for their graduates? Reliable answers to these and other questions have been derived from the first European employment survey for chemists and chemical engineers in 2013.

The survey was initiated and executed by the European Chemistry Thematic Network Association (ECTN). The Joint Research Centre of the European Commission commissioned development of a questionnaire, its translation into 24 European languages, and the Web-based data collection. The European Association for Chemical and Molecular Sciences (EuCheMS) and the European Chemical Industry Council (CEFIC) actively supported the project. Some tasks were completed by the European Chemistry and Chemical Engineering Education Network (EC2E2N2).

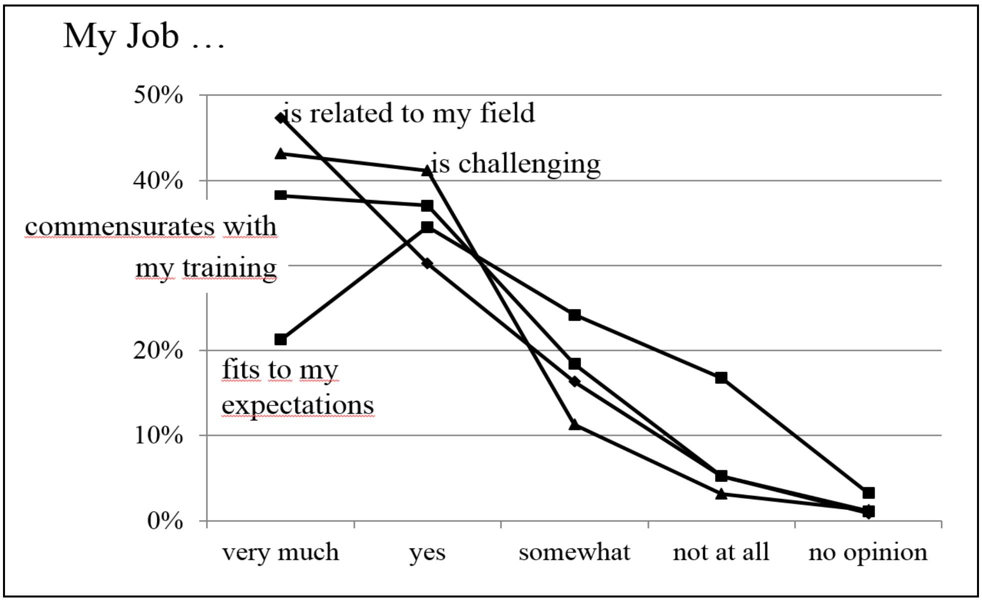
How well does the structure of the European higher education sector reflect the current needs in our societies? We analysed this situation for Europe as a whole and for individual countries. Such a detailed evaluation was only possible for countries with sufficiently large participation. It reveals unexpected differences in the content of chemical education, e.g. in the share of chemical disciplines in educational systems of European countries. Significant differences are also observed in the target qualification of the graduates in the different chemical disciplines in Europe:



During the last 15 years, every second graduate earned her/his highest certificate in one of the three top disciplines, chemical engineering or organic chemistry or analytical chemistry. During the same time, 1% of all graduates chose chemical education. Where do these graduates in chemical education find jobs?



The question about job satisfaction gave very interesting results. One describes the social situation in the European chemical workforce. More important in the current context is the answer, how the current job fits the expectation of the employee. This answer relates the image generated during the educational process to the real world situation:



'We're not in Kansas any more!': some challenges for teaching and learning third level (university) chemistry

Peter E. Childs

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I taught chemistry at third level (university) in Ireland from 1978 to 2010 and previously taught at the university in Uganda (1970-76). I am still involved in chemical education research (CER) aimed at improving the teaching and learning of chemistry at second and third level in Ireland. Based on 40 years of teaching chemistry at the University level, I want to talk about some of the contemporary challenges now facing those teaching chemistry at this level. These challenges and problems are common to most countries. In the talk I discuss, and suggest what we can do about the following factors, which impinge on and provide challenges for the teaching of third level science in 2015:

a) The second to third level, school to university, transition;
b) The chemistry background of first year university students;
c) The increasing diversity of modern university students;
d) The problems of language in teaching and learning science;
e) The mathematical competence of students;
f) The cognitive level of first year students;
g) The prevalence of students' scientific misconceptions;
h) The impact of IT on teaching, leaning and course delivery;
i) The relative lack of awareness and interest in science education research (SER) amongst academics.

Teaching ability is not usually a major factor in appointing or promoting university lecturers and often research is all that matters with teaching considered secondary. The nature of universities and their intake has changed and unless academics take these changes on board, adapt and make teaching a higher priority, then we will see more drop-outs from chemistry degree courses and more poorly-prepared chemistry graduates. A teaching philosophy whereby the lecturer says it, the students writes it down and then learns it for regurgitation in examinations, is no longer adequate in 2015. ***"We are not in Kansas any more!"***

Using MOOCs for teaching analytical chemistry: experience at the University of Tartu

Ivo Leito

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MOOCs (Massive Open Online Courses) are receiving much attention in higher education, including education in chemistry. MOOCs are intrinsically less suited for experimental sciences compared to e.g. web design, history or business, because it is impossible to offer the experimental/laboratory training via the Web.

This presentation outlines the experience of running a MOOC "Estimation of measurement uncertainty in chemical analysis" at the University of Tartu.[1] Teaching in the "MOOC mode" is compared to conventional university teaching as well as to short training courses for professionals.

Our experience with the MOOC on measurement uncertainty in analytical chemistry suggests that in the field of measurement uncertainty in chemistry (or in chemistry education in general), MOOCs are no real competitors for the conventional university degree programs. Instead they can rather be seen as useful add-ons. At the same time in the context of practitioner training, online courses can offer significant advantages over the conventional 1-3 days intensive course format. The on-line teaching materials of a MOOC can find many uses, e.g. as supporting materials for conventional university teaching.[1]

References

1. Using MOOCs for teaching analytical chemistry: experience at University of Tartu. I. Leito, I. Helm, L. Jalukse. *Anal. Bioanal. Chem.* **2015**, *407*, 1277-1281.

Facilitating learning in the lecture theatre

Simon Lancaster

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Intuitively we appreciate that we learn more when we are doing something. At the extreme we have the adage "The best way to learn something is to teach it." Now the quantitative evidence that active learning pedagogies are more effective than a traditional didactic lecture is overwhelming. However, chemists are busy people, often judged on their research impact rather than their teaching prowess. Prof Lancaster will present a pragmatic chemists vision of how we can facilely move towards a more active lecture theatre experience without unrealistic investment of academic time.

Prof Lancaster will illustrate the use of both the facilitating technology, in the form of clickers and the crucial scalable pedagogical innovation, peer instruction, to give the participants a student-eye view of the approach. Delegates will themselves engage in peer instruction. Prof Lancaster will pose challenging questions designed such that not all delegates will immediately be able to answer them. You will then be invited to discuss your answer with your peers. We will see how the nature of the question is key to the success of the pedagogical model.[i]

We will explore how students can be engaged as partners in the process to prepare interactive presentations, which we call student authored vignettes.[ii] Crowd-sourcing of potential questions from the student body will also be explored.

References

[i] http://www.rsc.org/Education/EiC/issues/2013september/flipped-classroom-inverting-lectures.asp
[ii] http://www.rsc.org/eic/2014/03/student-vignette-presentation

Development of chemistry teachers' competencies related to assessment of scientific reasoning

Dragica Trivic, Vesna Milanovic

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Scientific literacy was proposed as one of the key competencies of youth. According to that we were looking for the appropriate activities in the chemistry didactics course, which support the development of future chemistry teachers competencies associated with teaching and monitoring of learners' progress towards scientific literacy. We designed situations, which can contribute to the development of understanding of the nature of science and scientific work and, in the same time, serve as a model for assessment, which incorporates the process of learning. This approach to assessment requires dynamic combination of knowledge, skills and attitudes of future chemistry teachers in order to prepare them for a similar approach in different contexts in their future teaching practice. In addition, such situations are an integral part of learning of future chemistry teachers and guides them to improve their knowledge, skills and attitudes.

We started from the premise that content from the history of chemistry scientific work and reasoning of scientists can enhance the development of learners' reasoning in the field of chemistry. According to that we selected content about the *Law of conservation of mass,* since it is included in the curricula for both primary and secondary schools. This allowed us to form questions, which rely on:

1) the historical content that illustrate the experimental work and reasoning of scientists;
2) experimental work feasible to perform in the school laboratory;
3) experience from everyday life.

Texts were composed and included in the test, based on the results of a descriptive content analysis, of existing curricula materials on commonly known historical facts about the discovery of the *Law of conservation of mass* and on the work of three scientists. These are: the French scientist Lavoisier (Antoine Laurent Lavoisier), the Russian Lomonosov (Mihaíl Vasílьevič Lomonósov), and the German Landolt (Hans Heinrich Landolt. The texts about the work of the cited scientists were meant to be the basis for the student's reasoning and completing the questions. The test also contained additional texts with the descriptions and pictures of the experimental set-ups in the school lab. The test contains 11 questions, closed and open types, with 23 requirements. In order to monitor the student's comprehension, recognition and extraction of the information relevant for forming the answer, the students were asked to underline those parts of the text, on which they formulated their answers.

The follow-up step was to identify the indicators of reasoning, which would be monitored during the testing.

One group of 19 students was tested. After that, the obtained results and implication for future practice were considered. The results obtained offered a good opportunity for students, future chemistry teachers, to reconsider their understanding of the nature of science and scientific work.

This paper represents the result of working on the project "Theory and Practice of Science in Society: Multidisciplinary, Educational and Inter-generational Perspectives", Reg. No. 179048, the realisation of which is financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

Interdisciplinary chemistry – a pre-service & in service teacher education approach

Jack Holbrook, Miia Rannikmäe

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The issue

Students, in general, have little interest in topics that are perceived to be irrelevant to their lives and career aspirations (Osborne, Collins & Simon, 2003). Atomic structure and bonding are classical examples of this, and if that is not enough, what about the emphasis placed on the periodic table, which serves little purpose related to the vast majority of compounds known to chemists. Yet to move towards a more society-related approach, means recognising that a 'man-made' sub-division of science, such as chemistry, or even worse, inorganic, physical and organic chemistry, is not sufficient. A more interdisciplinary approach is needed, related to the real world and the scientific literacy aspects of a systems approach, non-routine problem solving, adaptability and self-development related to this (NRC, 2010). Thus for want of a better term, learning is seen as approached via context-based relevance and can be conceived as the initiator, driving the underlying chemistry conceptual ideas.

How to approach this?

An approach that has attracted attention is the initiation of the teaching of chemistry from the relevance perspective and is hence context-driven. Relevance in the eyes of students (Holbrook, 2008) is tackled by means of relating to an issue or concern, which, for the most part, can be considered as socio-scientific. The goal is to enhance students' intrinsic motivation and thus to promote self-determination (Ryan & Deci, 2000). And here a 3-stage model can be put forward which can be referred to as contextualisation, de-contextualisation, re-contextualisation (Holbrook & Rannikmae, 2010).

A start in this direction was actually initiated by the RSC some 20 years ago in developing materials for teachers. One such example reflected on which vehicle to use – battery power or diesel (RSC, 1993). This focuses on assessing the relative costs and evaluating issues, which surrounded their use, not least of which is the pollution concern. A major aim was to analyse data and to draw conclusions as well as to explore the chemical basis of electrically and diesel driven vehicles. The context-based focus was thus issue-based, in a real life environment rather than problem solving, solely related to chemistry ideas

Another example highlighting an issues-based consideration (here related to developing a new herbicide) is also published by the RSC (1994). As before, the initiation was by means of a scenario – in this case a concern that a weed, based on goosegrass, is devastating cereal crops. The approach is to be able to solve the weed problem by means of a marketable herbicide and in so doing facing the issues involved. The exercise leads to industrial awareness of the stages involved in developing a herbicide and with this a typical time line.

A more developed approach is to frame this in a 3-stages approach, in which both the chemistry and the interdisciplinary educational aspects promote relevant learning in a motivational frame.

The 1st stage reflects on a societal issue (or more specifically a socio-scientific issue - SSI) and the inherent advantages of this as an approach to chemistry teaching? Not only is it expected to provide a relevant focus, but it also allows discussions which draws on student background, giving an indicator of prior chemistry knowledge. It thus provides a student relevant base from which new, associated chemistry learning can build. It can also provide an induction to the need-to-know learning and from this, the determination of the scientific question (by students if appropriate), which drives the inquiry based, or problem-based, chemistry learning.

The second stage is thus the chemistry learning, moving from a specified scientific question through the planning, investigatory and interpretation stages as de-contextualised learning before being consolidated through well-formulating problem solutions. At the school level, the term inquiry-based learning is favoured (EC, 2007) although there is no suggestion this is a 'one size fits all' approach. Depending on prior learning, the teacher can focus on structured, guided, or open inquiry styles (Smith, building on ?, 2010) and suitably scaffolded in line with challenges facing students within their zone of proximal development (Vygotsky, 1978).

While new chemistry learning is the major focus at this stage. it is important that the chemistry acquired is not seen to be isolated from the goals of education related to nature of the subject, personal development (e.g employability attributes) and the gaining social attributes (responsible citizenship) (Holbrook & Rannikmae, 2007). Also the chemistry learning needs to go beyond inquiry-based learning and the problem based solution to the scientific question posed. The conceptual chemistry needs to be consolidated and interrelated to prior conceptual learning, such as through the use of concept maps (Novak, 1984).

But even this is not enough as the chemistry learning is de-contextualised and not related to the real world. A 3rd stage is needed in which the chemistry is related back to the initial concern, or issue. In the third, re-contextualised stage, the newly acquired learning, in association with previously acquired learning, is used to re-look at the initial scenario and to include this in the socio-scientific discussions (clearly in a conceptually correct manner) so that a well-reasoned decision can be made, in which the chemistry is meaningful and appropriately included. The 3rd stage is thus decision-making in a socio-scientific environment taking not of real life factors that are relevant e.g. risk assessment, sustainable development, environmental issues, the economic factor, political considerations or an entrepreneurial approach and not forgetting ethical and moral aspects.

In such a model, there is no suggestion that the emphasis or time allocation to each stage is equal. Nor is there any suggestion that only one chemistry conceptual area is studied from one scenario. But here is a requirement that the learning is seen in relation to the real world (having student relevant at a local, national or global level) and thus subject divisions, such as inorganic, physic or organic no longer play a role in the learning process as separate entities. And clearly, there is no expectation that theoretical aspects are acquired first and the application of these come second. This can have major implication for tertiary level teaching.

An example of a chemistry module, suitable at higher secondary level, is given (initially produced for the EU FP6 project, PARSEL and further developed in the EU FP7 project, PROFILES)

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Towards Excellence in School Teaching – One of the Goals for the European Chemistry and Chemical Engineering Education Network

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The ways of preparation for the teaching profession in Europe are very diverse: It ranges from 5-year university courses, for example "science education", leading to a master's degree in teaching science, to the situation where the issue of gaining knowledge and skills is left in the candidates' hands and only a qualifying examination is organized. However, the methods of preparing teachers for their future work largely determines how they will teach their students, and hence the effects of education until the pre-university level they promote.

Therefore, since 2003, the issue of contacting schools and teacher training has been inside the range of interests of the projects of ECTN (1-4) and EC_2E_2N (European Chemistry and Chemical Engineering Education Network 1&2). The working groups of particular projects have been, for example, dealing with:

- the rules of cooperation between universities and schools (ECTN-3, WG Links with schools, leader Ingo Eilks, http://ectn-assoc.cpe.fr/network/wg_pres/ECTN30n_LinksWithSchool.htm)

- the comparison of teacher training programmes in Europe and an attempt to identify common and promising goals, processes and indicators for a successful and sustainable teacher education (EC2E2N-1, WG **Towards European quality labels for teacher education programmes, leader Ilka Parchmann,** http://www.ec2e2n.net/1/wp12),

- supporting the education of future teachers through the publication of the best practice examples of important areas of chemistry teacher training, and preparation of a self-evaluation test for these areas (EC2E2N-2, WG Towards Excellence in School and University Teaching, leader Iwona Maciejowska, http://www.ec2e2n.net/2/wp01)

Individualised teaching in schools, in seminars for students at university and in in-service teacher training

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Individualised teaching in schools

In two studies we developed two different methods:

(a) The idea of individualised teaching was combined with the theory of self-regulated learning. Research reveals that methods of self-regulated learning lead to higher learning outcomes (e.g. Dignath & Büttner, 2008). In terms of the cyclical model of self-regulation according to Zimmerman (2002), a self-evaluation sheet was developed in order to help students to plan, monitor and reflect on their own learning process. The ability to evaluate one's performance is one of the best predictors for learning outcomes (Hattie, 2012). Furthermore, a learning unit was created, in which the work with the self-evaluation sheet was embedded. The self-evaluation group scored significantly higher than the control group ($t$pre-post(216) = 2.53, p = .012, d = 0.35). Additionally, the results of the analysis of the feedback questionnaire demonstrated that students' feelings towards the unit are more positive in the self-evaluation-group ($t$feedback(214) = 3.13, p = .002, d = 0.50, Kallweit & Melle, 2014).

(b) The combination of diagnosis via multiple-choice-tests (MC-Tests) and differentiated instruction in the construction of knowledge was analysed. The study tested the effectiveness of the differentiating instruction by comparing outcomes from students who received diagnose-based task assignment with outcomes from students who received a structured or chaotic task assignment. The analyses demonstrate that learners who receive individual, diagnostic-based task assignments show no significant higher knowledge gain compared to those receiving a structured or chaotic task assignment (cf. Bangert, Kulik & Kulik, 1983; Horak, 1981, Hattie, 2009). Also, these groups do not differ regarding the attitudes towards the unit and the assessment of motivational factors. However, further interaction analyses indicate that cognitively high- and low-performing students benefit from diagnosis and individualised instruction, whereas average students achieve higher learning outcomes when a structured or chaotic task assignment is used (Anus & Melle, 2014).

Individualised teaching in seminars for students at university

A seminar-unit (4*90 min) was conducted including the following aspects: Examples of individualised teaching, MC-Tests and self-evaluation-sheets as diagnostic tools, experiences with individualised teaching in other European countries (England, Sweden, Finland, Norway). Afterwards, the students ($N \approx 60$) felt significantly more competent concerning individualised teaching (strong effect size). Their attitude towards teaching was very high, even before joining the seminar and it did not change afterwards (Anus & Melle, 2013).

Individualised teaching in in-service teacher training

18 one-day teacher training sessions were conducted, which dealt with similar aspects as the seminar for students. A high number of teachers ($N \approx 250$) participated in the teacher training. This shows how important the issue is for their work. They evaluated the in-service teacher training, which was realized as a workshop, as worthwhile. After getting input during the first phase, they were quite competent in constructing MC-Tests and self-evaluation sheets, whereby constructing the latter seemed to be easier for them. For both instruments, it became clear that teamwork with other teachers can be helpful to create a greater number of diagnostic instruments.

Conclusion

The three levels are positively interdependent: On the one hand, the results of the school-study were discussed with the participants of the in-service teacher training. On the other hand, the experiences reported by the teachers influenced the construction of the leaning units, which were evaluated in the school-study.

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Implementation and Evaluation of a Laboratory Tutor Training Programme

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Undergraduate students develop much of their understanding and application of scientific concepts within the laboratory environment. Likewise Science undergraduates form many of their opinions about Science, including their career choice, in this learning environment. Therefore, ensuring this space is a most effective and engaging student-centred learning environment is paramount. While a wide variety of engaging and challenging experiments and activities helps to achieve this goal, the manner in which these activities are delivered is also an integral part of student engagement and learning. Thus the role of the laboratory tutor or demonstrator in assisting with this objective is pivotal.

The Chemistry Laboratory 'XG28' within the School of Chemical Sciences at Dublin City University facilitates up to 240 undergraduate Science students, with up to 90 students at any one time conducting their weekly Chemistry Lab. We aim to have a ratio of 8-12 undergraduate students to each lab tutor in order to ensure a most effective and safe learning environment. The lab tutors are postgraduate research students from a variety of Science disciplines, including Analytical, Pharmaceutical, Environmental, Science Education and Biotechnology.

This paper addresses the implementation of our tutor training programme which has been developed to assist postgraduates to prepare for their role as tutors in the undergraduate Chemistry laboratories, under the guidance of an academic lab supervisor. The aims of this tutor training programme include: defining the role of the tutor; allowing tutors to discuss the attributes of a good tutor; giving tutors a keen awareness of the teaching and learning environment, and ways in which they can fully engage with and deliver in this environment. The training programme is on-going in order to fully support the tutors in their tasks. This programme is also one of the DCU postgraduate accredited modules that complement the four year structured Ph.D programme.

The Chemistry Laboratory 'XG28' is a hub of teaching and learning and continues to strive to deliver the best educational experience to students while also enhancing postgraduate tutors' teaching skills; tutor training was one of the aspects of the XG28 lab activities that helped to ensure success at the recent Irish lab awards.

This paper also addresses an evaluation of this training programme, which includes findings based on end-of-year student questionnaires, tutor questionnaires, tutor journals and tutor interviews. The manner in which the training programme is developed to facilitate those lab tutors, who proceed into the second and third year of this tutoring module, are also explored.

An On-line Platform for Sharing Expertise and Good Practice in University Chemistry Teaching

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Only a fraction of teaching innovation is ever reported in the education research literature or presented at conferences on university chemistry teaching and learning. In fact, very few European lecturers establish any contact with colleagues from other institutions to discuss their approaches to teaching. A wealth of experience and expertise clearly exists, but tends never to be shared and remains in isolation. Sharing is surely important if we are to inspire lecturers to try new teaching methods, to improve knowledge about teaching thus improving the quality of university teaching, and last, but not least, it is crucial for supporting newly appointed lecturers in developing expertise in effective teaching.

Networks can, of course, play an important role in knowledge exchange. The European Chemistry Thematic Network (ECTN) was formed in 1996 with the aim of providing a forum for the development of university chemistry education and training in Europe and thereby to seek to improve quality over a European dimension (see ECTN web portal: http://www.ec2e2n.net/), as part of the European Community Socrates-Erasmus programme. ECTN, which evolved to incorporate chemical engineering in 2009 now, consists of some 120 universities and professional bodies, mainly from Europe, but also includes a number of institutions from other continents. A range of innovations, relating to the teaching dimension of university chemistry and the professional development of lecturers have been developed over the past 20 years through the work of over 40 multinational working groups. A wide range of knowledge and expertise has been widely shared and disseminated e.g. via ECTN publications and the ECTN web portal to help improve the quality of university teaching throughout Europe. However, much of the personal teaching experience and expertise possessed by individuals remains unshared.

In 2013 the Working Group 'Towards Excellence in School and University Teaching' (www.ec2e2n.net/2/wp01) decided to develop a database of 'Expertise in University Chemistry Teaching' to facilitate the sharing of knowledge and expertise about university chemistry teaching and to functionally connect expertise to the people having it. The working group identified 15 topics as particularly relevant to teaching and learning in university chemistry courses and further divided each of these into a number of sub-topics. Next, the working group started to collect brief descriptors for these topics and sub-topics and invited chemistry lecturers, not only those within the network but also those who are not members, to submit personal profiles and share their knowledge and expertise with this community. The database is hosted on the existing network knowledge platform Starfish, at the University of Amsterdam. Starfish is based on the TPACK model (Mishra and Koehler, 2006) which connects the technological, pedagogical and content knowledge that is needed for sound contemporary teaching design.

To date the database contains files for:

a) 69 university chemistry and chemical engineering educators (lecturers and other university teaching staff) who have added their personal profiles presenting details of their experience and areas of expertise in teaching and learning chemistry.
b) more than 40 short descriptors for topics considered important for the teaching and learning of chemistry and chemical engineering at university level, which can be accessed through the web site http://starfish.innovatievooronderwijs.nl/information/395/. The descriptions are all linked to lecturers with specific relevant expertise, who are willing to help others and answer questions about their own teaching practice, partake in discussions or even consider entering into advisory or cooperative arrangements.

The working group "Towards Excellence in School and University Teaching" has thus developed a core which can grow further to produce a strong university chemistry teaching knowledge-sharing network. All university chemistry educators are warmly invited to submit a personal profile and to join the Expertise in University Chemistry Teaching community by sharing their expertise and experiences in teaching and to discuss university chemistry teaching with peers. Visit the platform to learn or to get inspired whenever you wish.

The lecture will discuss and demonstrate the database.

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Strategies in developing and implementing protocols in quality assurance and improve educational development in tertiary education

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Due to changes in national law, Universities in the Netherlands are required to follow strict regulations regarding quality assurance of educational programmes. Usually these regulations lead to more protocols, rules and guidelines, and as such more paperwork for educational staff members. However, it seldom results in better education.

At the Faculty of Mathematics and Natural Sciences of the University of Groningen, an attempt was made to develop and implement new protocols in quality assurance to meet the regulations in quality assurance on the one hand and, at the same time, create conditions for further educational development. All lecturers needed to fill in a form to explain the design of the course and justify the assessment methods. Strategies were presented in developing and implementing this form in such a way that it benefitted professional development of staff members and curriculum development of study programmes.

A key strategy in developing the protocols was the introduction of the model of Constructive Alignment (Biggs, 1996). Using this model, instructions for lecturers covered about how to follow the protocols and fill in forms, supported them in rethinking the design of the course, formulate (new) learning objectives, improve the assessment quality and implement innovative teaching methods.

Implementing the protocols according to the model of Infrastructure, Authority and Consensus (IAC model, e.g. Havelock & Huberman, 1978) turned out to be a second key strategy to benefit the implementation of the protocols on a large scale in a short period. The Infrastructure of the developed protocols, the Authority of the accreditation committee, and the Consensus among the Faculty Board, directors, programme coordinators and lecturers about the implementation of the protocols resulted in the wide spread introduction of the concept of Constructive Alignment among lecturers (Biggs, 1996).

After implementing the protocols within educational programmes, it was found that staff members had a better overview about the courses in the programme, could explain why problems occur and started initiatives to improve the programme. For example, curriculum committees were installed to improve the programmes of Chemistry and Physics.

Besides rethinking their course design and sharing their experiences, lecturers were motivated to develop and implement innovative teaching methods and improve classroom practices. For example, a group of lecturers from Chemistry and Industrial Engineering, in collaboration with the student association, started to work together in developing video lectures, digital manuals for lab experiments and using modern communication technology and electronic devices in class.

In the course 'University Teaching Qualification', which is offered to educational staff members, one of the assignments was to describe the design of a course in terms of 'Constructive Alignment.' It was found that lecturers were more familiar with the basic levels in course design, for example in formulating learning objectives. That provided opportunities to discuss about course design, teaching methods, pedagogical approaches on a more complex level. This was seen as benefitting future professional development of staff members and educational development within the Faculty.

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Can you teach University Chemistry Abroad?

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This was a question asked to me when we offered a 3 + 1 degree to a group of Chinese students at Nanjing University of Technology (NJTech). The Chinese students from NJUT would have the opportunity to study for a BSc in Chemistry by taking all of the Sheffield University Chemistry degree modules from our level 1 and 2 years, but taught in China over 3 years. The Chinese students would study the modules in English and the course would be taught by lecturers from the University of Sheffield, who would travel to China, stop for 2 weeks and deliver the modules during this two week block. Although this would be a demanding way to study the course, it has been successful for the students to date. Currently the first intake of students are in their 3rd year and are preparing to go to Sheffield during the summer of 2014 for the final year of their BSc.

A chemistry degree must be supported with practical work so I was challenged with the opportunity to deliver our undergraduate laboratories at NTech in China. It was necessary to develop a programme to deliver a laboratory course over 3 years. The year 1 course in China would need to assume no practical experience, then develop their skills to be able to carry out the level 1 and 2 practical experiments from Sheffield.

A mixture of inorganic, organic and physical practicals were selected and chosen, so that the students gained quantitative skills, such as titration techniques. Volumetric skills were developed by carrying out an analysis of vinegar, the determination of copper in an unknown salt together with a potentiometric titration to determine the relative molecular mass of an unknown organic molecule. Organic synthetic skills were developed by carrying out a simple preparation of a derivative of an oxime and extraction of a natural product and the use of quickfit apparatus through steam distillation. Physical practical skills, such as use of a simple spectrophotometer were developed by the analysis of an indicator in different media such as acidic and neutral conditions. This also developed further quantitative analytical techniques and dilution skills. Recording data and use of the laboratory notebook, followed by simple write-ups of results in English, were also introduced. The year 1 was a good introduction to the practical skills and consolidation of techniques for students who did have some practical skills from previous chemistry courses.

The equipment and conditions in the laboratories in China, together with good technical support from NJTech, allowed successful delivery of the year 1 practicals. Year 2 and 3 practicals would be more challenging, but with meetings and discussions between myself, my Chinese colleagues, we were all clear what was required. After completing the course of the

17 practicals over 3 years, and successfully passing their exams, the Chinese students will earn a place to complete the final year of their BSc degree in Sheffield. This talk will describe the programme in more detail (Hyde, 2014a; 2014b).

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Student-generated drawings of chemistry at the sub-micro scale in the undergraduate laboratory

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Undergraduate chemistry laboratory classes are typically completed and assessed via a written report. Typically students will have interpreted chemistry observed at the macro-scale, and describe this using both written descriptions of what they have observed, and rationalised this via symbolic representations such chemical equations, molecular structures, calculations and graphs.

Arguably, these reports can still betray whether or not the student possesses a sound understanding of the processes occurring on an atomic scale. While teachers, textbooks and animations routinely use pictorial depictions of atoms and molecules, opportunities for students to sketch how they imagine atoms and molecules tend to be more limited.

This project sought to investigate whether student-generated drawings, which sit alongside laboratory activities (macro-scale), might improve their understanding of chemistry on the sub-micro scale, or perhaps vice versa. Over an eight-week laboratory curriculum, the student lab report for each exercise included several questions asking students to sketch a chosen feature of the chemistry, requiring them to imagine events at the sub-micro scale. Instructions typically asked students to consider the scale, ratio and intermolecular interactions of the participating particles.

Student evaluation of the exercise was conducted via three distinct approaches. Firstly, ten students participated in a narrative inquiry type activity, by keeping a diary every week to reflect on how the drawing activity impacted on their learning and understanding of the hands-on experiment. Secondly, a number of dynamic student interviews were conducted incorporating interactive whiteboards, to probe how students connected their sketches to their understanding of the chemistry. Finally, a questionnaire (n ~ 1000) was completed to provide Likert-scale metrics, and written qualitative feedback from the broader cohort. We report some of the findings here.

Informing the Advancement of General Chemistry Laboratory Teaching to Ensure Successful Engagement and Progression of First Year Students.

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Method

The attitudes and perceptions of undergraduate students (n=319) towards General Chemistry and towards the role of the Laboratory Demonstrator were investigated through the development and distribution of a questionnaire which was analysed both quantitatively and qualitatively.

The questionnaire was divided into two parts. Part A consisted of 22 statements which required participants to rank their level of agreement to each statement using a 5 point Likert scale that ranged from 1 : Strongly Agree to 5 : Strongly Disagree. Participants' responses were quantitatively analysed using SPSS software in terms of calculating the mean, median and standard deviation of their level of agreement to each statement.

Part B of the questionnaire consisted of 3 open-ended questions whereby participants' responses to each question were qualitatively analysed by theming and then coding the responses through the collaboration of the researchers involved in this study.

Results

Undergraduate students enrolled in General Chemistry strongly agreed with the statement "*Having a good understanding of chemistry at the end of first year is important*" yet students were in neutral agreement with the statement "*So far, I think I am learning effectively in this module*".

The findings of this study have revealed that students have some apprehension about completing laboratory sessions. They exhibited a neutral agreement to statements regarding their confidence level in the laboratory and the extent of which the laboratory practical work helps them to link the theory that is discussed in lectures. The issue, quality and appropriateness of feedback given to them on their performance in the laboratory, was also highlighted as being potentially problematic.

Students were in moderate agreement towards the effectiveness of a lot of the current features of the teaching and learning approach that is currently employed in General Chemistry laboratory sessions. One of the main features, with which they tended to exhibit concern of its effectiveness, was the role of the Laboratory Demonstrator. They were in moderate agreement towards aspects of this role, such as the demonstrators' concern for the students' learning, how prepared the demonstrators are to carry out their role and the quality of their explanation skills about apparatus or proceeding reactions.

Students also contributed their insights and opinions towards the following open-ended questions:

1. What do you feel is the most important reason for having a laboratory demonstrator in the laboratory during experiments?
2. Give one example of what you would do if you were in a laboratory demonstration position to help students learn and carry out experiments more effectively.
3. What one aspect of the teaching strategy employed in the laboratory would you change, if you could?

Discussion and Conclusion

Despite being aware of the importance of having a robust chemical understanding at the end of the first year, undergraduate students do not feel that they are learning effectively in General Chemistry. This calls for an intervention to the currently employed teaching and learning approach to be made if students are to engage and thus, progress with excellence throughout their undergraduate and postgraduate pursuits. An intervention to solve this problem is being explored by developing a Teacher Training module to advance the teaching skills and pedagogical mind-set of Laboratory Demonstrators.

Creating More Meaningful Learning in Organic Chemistry

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Organic chemistry forms core modules in many science-based programmes at third- level, from Environmental Science to Biotechnology to Analytical Science. In second-level teaching, this area of Chemistry is often reduced to simply the rote learning of functional groups, physical properties and their reactivity without development of understanding of the nature of these functional groups. Organic lecturers indicate that students need to understand the effect of different functional groups on the physical properties of molecules/compounds and to understand and work out mechanisms of complex reactions. An understanding of both the electron density distribution and the 3D nature of molecules is key for students to be able to do this. Therefore, students need to be introduced to organic chemistry in a more meaningful manner that enables them to look at organic molecules differently to the way they are currently being trained to.

Organic Chemistry through Visualisation (OCV) is a teaching methodology designed to enable students to inter-relate between 2D and 3D representations of organic molecules while predicting and comparing their physical properties and reactivity. The literature has identified a number of reasons for difficulties experienced by students when studying Organic Chemistry. Among these are the abstract nature of Chemistry and the multi-level thought required (Johnstone 1991), students' spatial ability (Pribyl & Boder (1987) and a lack of understanding of structural representations (Kieg and Rubba (1993), Arasasingham (2004), Bernholt et al (2012)). Kieg and Rubba (1993) reported difficulties in setting up structural formulae from molecular formulae; some students developed a code for the connections within the substance in the order of symbols, so that CH_2O was seen as carbon attached to water. They also reported some students directly derived the connections of the elements from the molecular formula, so that HNO_2 would be H-N-O-O. A similar observation was made by Arasasingham (2004), who reported students drawing structural formulae, like S-O-O for the molecular formula, SO_2. Bernholt et al (2012) detected student difficulties in identifying neighbouring constituents of a marked carbon atom in chemical formulae like CH_3-CH_2-Cl. Even when H_3C- was used instead of CH_3- in an effort to clarify bonding relations, students' performance did not improve.

Teaching through molecular models is a core value of the OCV programme. A number of studies have shown the use of molecular models to improve students' understanding of the three dimensional nature of molecules. Coppollo and Hounshell (1995) found that students experience difficulties in forming 3D mental images from 2D representations. In order to be successful at studying Organic Chemistry, students need to be able to move back and forth between 3D and 2D representations using physical models, illustrations and paper representations (Hassan *et al.* 2004). Learning through molecular models has been identified in the literature as a successful approach to help students create accurate mental models. The use of molecular models in teaching Organic Chemistry has been shown to help students to bridge from the sub-microscopic to the macroscopic representations (Tasker and Dalton 2006) and promote long-term retention of understanding (Copolo and Hounshell 1995).

The methodology has undergone a pilot and two iterations with approximately 130 5th Year (16-17 year old) students in total. Assessment of the methodology has been triangulated using data from three different sources; participating teachers, participating students and data collected by the researcher through observations of participating classes. Student understanding was further triangulated through analysis of student manuals, their final class assessment and structured interviews with students (N=50). The purpose of the structured interviews was to assess students' understanding of the three-dimensional nature of organic molecules and their ability to translate between symbolic and microscopic representations. The protocol for the interviews is similar to that undertaken by Nicoll (2003). Students were given the molecular structure of ethanal (CH_3CHO) and asked to draw this structure in 2-dimensions. Students were then presented with playdough of 4 different colours and a number of sticks of 3 different lengths and asked to construct an accurate 3-dimensional model of ethanal. Following the construction of their model, students were asked to explain various aspects of their drawings and models.

The results of the evaluation of this programme will impact on first year Chemistry teaching at third level. Results to date indicate a very positive attitude towards the approach from both teachers and students, with teachers identifying it as a 'more challenging and interesting approach' to teaching organic chemistry. Analysis of students' final class assessment indicates that students are able to inter-relate between 3D and 2D representations following completion of the OCV module. This paper will discuss these results in more detail, along with results from the structured interviews.

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Chemistry and Materials Science – High Level Learning *via* Research and Practical Training

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Materials science is a relatively new and broad field. It involves applications of different scientific disciplines that contribute to the creation of new materials. Chemists play an important role in materials science because chemistry provides information about the structure and composition of materials, as well as the processes to synthesize and use them. The most important task of materials science involves relating the microstructure of a material to its physical and chemical properties. By understanding and then changing the microstructure or defect structure, material scientists tailor the properties of materials to create new materials with specific properties for specific uses.

New educational topics that need to be addressed in Estonia, as well as in other countries, include the new boundary conditions for energy use. This is the fact that energy cost is becoming more and more a critical issue for all players in the energy business, due to increased worldwide consumption on the one hand, and the need to restrict the production of greenhouse gases, on the other hand. Especially in engineering, chemistry and materials science, this requires a fundamental change of the approaches taken and thereby the education given, a true ***change of paradigms***.

This is the idea for initiating in Estonia by both leading universities - Tallinn University of Technology and University of Tartu, a joint Master's level program "Materials and Processes for Sustainable Energetics".

Table 1. Study diagram of the joint Master level program "Materials and Processes for Sustainable Energetics".

Module name	***Content***	***Credit Points***
Module A: Basic Studies	**Estonian Language and Culture (2 CP), Fundamentals in Science and Engineering** (7 CP) i.e. obligatory for BSc. in Engineering: **Chemistry or** obligatory for BSc. in Science: **Engineering**	10
Module Y: General Studies	Law (International and Patent Law, European Directives) (3 CP) Scientific English (3 CP), Organization of Studies (1 CP), Social Skills and Ethics (1.5 CP)	10
Module V: Free Choice Courses	not specified	10

Module P: Core Studies	Fundamentals in Sustainable Energy Engineering (4 CP) Scientific working (3) (including homework: writing project proposals, scientific presentation), Project Management and Quality Control (3 CP)	10
Module E1: Sustainable Energetics	Applied Energy Engineering (3 CP), Thermodynamics (4 CP), Fundamentals of Materials Science (4 CP), Energy from Agriculture (4 CP)	15
Module E2: Research Project	Free choice: Industry or Research Labs in Tallinn or Tartu (3 terms, each 8 h/week = 15 CP), including project-seminar (3 times 1h/week = 3 CP)	15
Module E3 Elective 1 : Materials	Physico-chemical Properties of Materials, Materials Investigation and Characterization, Materials Technology, Applications of Materials, each	20
Module E3 Elective 2: Processes	Energy Saving and Conversion, Energy Management and Planning, Energy Storage, Wind Energy and Solar Energy Applications	20
Master Thesis	Industry or Research Labs in Tallinn or Tartu	30

The curriculum provides education in alternative energy materials science and engineering as well as in energy engineering in general at MSc level with a strong technology component oriented to solar cells and fuel cells. The curriculum offers an integrated approach towards current and long term materials and energy issues, focusing on technologies and concepts in sustainable development of industrial production and use of energy.

The aim of the new Master's curriculum is to educate engineers able to solve or minimize problems connected, first of all, with the utilization, but certainly also with the conversion, transport and storage of energy. At the same time, it aims at educating materials scientists able to design, develop and improve materials for sustainable energy systems, since the materials are seen as a key issue for improvements needed to extend the use of renewables in the future. Two main directions of the education are aimed at in parallel: on the one hand, site engineers leaving the academic environment to solve energy connected problems for consumers, buildings construction, energy consuming and providing industry, planning institutions, governments etc. On the other hand, scientists should be educated who will continue their studies in a PhD programme at one of the research institutions in Estonia or other countries. Development of scientific / engineering / technical fundamentals for efficient use of renewable energy technologies as well as on negative consequences for the environment and an efficient use of capital is here the main goal.

The basic idea of this high-technology study program is the interdisciplinary approach to the investigation of the materials preparation and description of the processes of energy usage as well as with optimizing the conversion and production of energy. Qualifying such people is a new need for all countries and all types of schools. One of the educational aims of this program is over the project base learning to develop the skills of the students.Being invited into the learning process by the specific and personal Research Project, students are invited to take responsibility for their learning, which leads to an increase in self-directed learning skills. The high level research laboratories of the Institute of Chemistry of the University of

Tartu, Department of Materials Science of Tallinn University of Technology and different leading companies of Estonia give for such approach – learning via research and practical training the best conditions.

Equilibrium between chemical knowledge and teaching skills in pre service teachers' education

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The aim of university education for future chemistry teachers' is to prepare specialists for teaching chemistry at primary and secondary schools. They need to master the basic knowledge of chemistry, as well as acquire appropriate teaching skills. In this sense, an equilibrium needs to be found between the degree of chemical knowledge and teaching skills. This contribution introduces the ways how this equilibrium is sought in study programmes on the *Teaching of chemistry* at the Faculty of Education of Trnava University, Slovakia.

Since 2005, undergraduate chemistry teachers' education is divided into two parts – bachelor's degree and master's degree. Bachelor's study is devoted mostly to basic chemical disciplines – General chemistry, Inorganic chemistry, Organic chemistry, Analytical chemistry, Physical chemistry, and Biochemistry. Further subjects are Toxicology, Mineralogy, Physics for chemists, and Mathematics for chemists.

Chemistry and the other subject of study (biology, mathematics, or English) form about 80% of all subjects of the three years of bachelor's study. The remaining 20% are devoted to basic pedagogy, psychology, and didactics.

Master's study comprises four terms (the last of them devoted to thesis writing) and its aim is to prepare teachers of chemistry (and another subject). The core subjects, therefore, are: Theory and practise of teaching chemistry and Technique and didactics of school chemical experiments. Chemical subjects involve Coordination chemistry, Chemical technology, Environmental chemistry, and Consumer chemistry. Optional subjects, devoted to development of appropriate teaching skills and acquiring of proper degree of scientific and chemical literacy, include Integrated science education, Science communication and English for chemistry teachers.

Undergraduate chemistry teachers' education at our faculty differs from other Slovak faculties, especially in two of the above-mentioned subjects.

The aim of ***Science communication*** is to acquaint students with the nature of science, concept of scientific and technological literacy and the importance and ways of mutual communication among scientists and the public. Students become acquainted with institutions of non-formal science education and gain skills in creation of interactive scientific exhibits, science toys and communication of scientific knowledge to the public, in an attractive and understandable way. Recently, academic debates on controversial socio-scientific issues have been involved. Students consider Science communication as a useful component of undergraduate chemistry teachers' education.

Science communication prepares chemistry teachers to be scientifically literate citizens, who are able to express their opinion on the problems associated with science and technology and make their own decisions in agreement with their position in everyday life. They should be able to support pupils' interest in life-long education, interest in science and technology and this way to contribute to a better attitude of the public to science and modern technologies.

Content of *Science communication*:

Science and technology and their role in society; Economic, social and ethical context of new discoveries; Risk/benefit analysis; Scientific and technological literacy, public understanding of science, public engagement in/with science and technology; Recent aims of science education; Science communication / Communicating science; Principles and methods of communication of scientists with the public; Non-formal science education of children and the public; Methods of hands-on presentation of science in science centres; Game as a form of education; Creation of interactive exhibits and science toys; Science demonstrations and shows; Chemical exhibitions in science centres; Application of new communication and educational technologies; Out of school education and work with gifted students in chemistry; Presentation of students' projects.

Consumer chemistry introduces application of chemistry and chemical technology in common life and in products for everyday use, especially materials with new properties. Chemically literate chemistry teachers will enhance pupils' interest in chemistry and new technologies and in this way contribute to a better attitude of the public towards chemistry.

Consumer chemistry comprises the following topics: Chemistry, chemicals, chemical literacy; Safety at work with household chemicals; Detergents; Cosmetics; Medicines and drugs; Food additives; Fertilizers and pesticides; Polymers and plastics; Energy sources – fossil and alternative fuels; Catalysis; New materials and new technologies in our life.

The appropriate balance between the degree of chemical knowledge and teaching skills depends on the school for which the future teachers are being prepared. Probably it is not good that teachers for basic and secondary schools are prepared together (the reason for this consists mainly associated with the non-attractiveness of the teacher profession in Slovakia). Generally, we may say that the teaching skills and the ability to engage and motivate pupils are of higher importance in primary schools. So didactics and methodology plays a greater role here than at secondary school.

At the secondary school, chemical knowledge of the teacher plays a more important role than the way he/she "delivers" new knowledge to students. But each teacher must understand everything he/she teaches and should be chemically literate i.e. be able to answer pupils' questions concerning chemistry and its application.

IBSE and its assessment as a part of pre-service teacher training – a Polish case of the SAILS project

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In Poland, chemistry students who want to be eligible to teach chemistry in secondary schools need to complete a subject education course successfully. Until 2012, pre-service chemistry teacher training didn't include methodology of using Inquiry-Based Science Education (IBSE). Based on the ESTABLISH and SAILS FP7 projects, a program of training in using this approach was developed and included as a compulsory element of training in Jagiellonian University. Later, the program was enriched with elements of assessment of inquiry-based education. During the course, a mixed approach of theoretical framework and practical IBSE workshops was used.

Workshops are held based on the following schedule:

- Workshop 1. Adaptation of the inquiry circle. Asking questions focused on various types of IBSE. Research on IBSE available resources.
- Workshop 2. Hands-on inquiry laboratory classes.
- Workshop 3. Design of inquiry-based lessons, including assessment of chosen skills.

Summary

Students participated in the training are ready-to-implement IBSE in school practice and their opinion was generally positive, albeit:

- Students had some doubts about using/applying IBSE in the Polish education, because the current curriculum is still heavily content, and external exams are insufficiently focused on checking inquiry skills.
- There was limited agreement and support from the school teaching staff as to what was visible when the opportunity to introduce students' new ideas into school practice (during internship) was given.

Fostering Cognitive Academic Language Acquisition in Chemistry – Consequences and Possibilities for Chemistry Teacher (Language) Training

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At present, the debate in education and politics concentrate on language diversity and the correlation between educational success and academic language proficiency. Empirical studies show that within a subject like chemistry there is high correlation between language and content learning (Becker-Mrotzek et al, 2013). National education programs in the natural sciences require the acquisition of (subject specific) communicative language abilities. During the last few years many approaches have been developed to support learners' achievement of academic language registers and to provide language as a cognitive tool. Also in the field of chemistry education, several approaches have been put forward, aiming at the acquisition of subject specific competencies in chemistry.

Within such approaches, chemistry teachers need to focus on cognitive academic language and subject specific language skills of their students. Consequently, there are different challenges for chemistry teachers. In fact, there are several instructions and information how to acquire subject-specific and cognitive academic language studies. But less is known about teachers' competencies in this field at present. Scholten-Akoun shows in his study, focussing on general language skills, that future teachers achieve poor results (Scholten-Akoun et al, 2012). Hence further results, especially about subject specific competencies of future chemistry teachers and a training of future teachers, is needed. Up to now, advanced teacher training courses have been developed and implemented. The training of chemistry teacher students,' right from the beginning of the teacher training program, has not yet been a focus.

In this contribution the program "Fach-ProSa" is presented, which is an interdisciplinary research project between educational studies of Chemistry and German Language. What makes the approach particular is the fact that "Fach-ProSa" is a curricular based approach for student teacher training at university, based on a theoretical model on teacher education in general. The program is implemented and evaluated within the teaching curricula of subjects, such as, for example, Chemistry and German Language. The program is based on the model of pedagogical content knowledge (*PCK*) by Park and Oliver (2008). By including the development of professional skills in linguistically supportive teaching with science teachers' *PCK*, each component in the *PCK* model for science teachers' training, is expanded by the factor 'language in science' (fig. 1). In the approach as well as in the program, various aspects of language, of language in the specific subjects and of language awareness, are areas of focus. One important component is Teacher Language Awareness, that refers to the awareness a teacher must have concerning his/her own language use and the role of language in learning settings (Andrews, 2007).

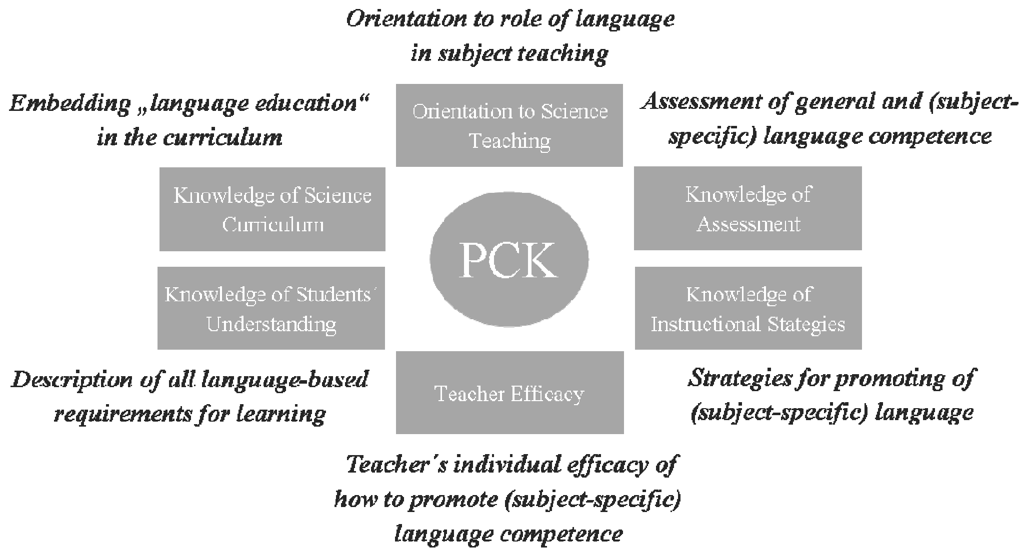

Figure 1: “Fach-Prosa”: a model for teacher training in developing professional skills for linguistically supportive teaching (Budde & Busker 2014: 511)

Especially in the subject Chemistry, subject specific language is of high relevance. Here highly standardized registers and chemical formulas are needed in scientific exchanges and in school learning settings as well, especially because they have to be transformed into language in communication settings. On the one hand the teacher trainees need to acquire a highly specialized academic language at university and on the other hand, they need to become aware of the importance of language in the subject of Chemistry and about the specific needs of their future students at school. The implementation of language related topics from the very beginning, into the degree schemes for prospective teachers, is a central aspect in the approach and is evaluated formatively. First results of a questionnaire study show that student teachers have a high perception of their own language-based competence, which, as shown elsewhere, may not correspond to their actual specialized language competence. The findings indicate that more attention must be given during teacher training courses to promoting subject-specific language acquisition in the particular subject. In the oral presentation, an overview of the program “Fach-ProSa”, first results of the empirical studies focusing the subject specific language skills and self-efficacy of future chemistry teachers are given and exemplary learning settings and materials are shown.

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Teachers' reflective practice as a tool for following the development of their sense of ownership during a CPD workshop

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A year long, continuous professional development workshop was conducted in Israel. It was conducted as part of an inquiry-based socio-scientific EU project: PROFILES (**P**rofessional **R**eflection-**O**riented **F**ocus on **I**nquiry-based **L**earning and **E**ducation through **S**cience). The key goal of this project is promote contemporary science education in order to enhance students' scientific literacy. The objectives of the CPD workshop were mainly to support teachers in: (1) gaining knowledge of different instructional approaches, (2) , teaching the inquiry skills, (3) decision making, and (4) reflection abilities. The CPD model that was used in this study was *"The teacher as [a] curriculum developer"* in which the teachers that participated in the CPD were intensively involved in the development and implementation of learning modules, while reflecting on the process which they underwent. It is suggested, that providing teachers with an opportunity to reflect on their experiences during a CPD workshop and during the related science classroom implementation may serve as a tool for following the development of teachers' ownership regarding a new program. It was found (based on several methods of reflection both orally and written) that the PROFILES CPD workshop, with the emphasis on teachers' active involvement, served as a platform for the development of sense of ownership among the teachers.

A summer school where master students learn the skills needed to work in an accredited analytical laboratory

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Analytical and bio-analytical measurements play a crucial role in science and society at large and many students are taught basic understanding and practical skills in the curricula they follow. Today, when important decisions depend on such measurements (e.g. regulatory, trade, production …) often they can only be carried out in testing laboratories which must be accredited (according to the international standard ISO/IEC-17025) for these specific measurements. The intention of such accreditation by a third party is to reassure the customer that the laboratory performing the measurement is competent. Surprisingly, higher education curricula rarely teach the competences needed in this context. The Measurement Science in Chemistry International Master Programme was exactly created for this purpose in 2008. It has run an annual international summer school, which is a pivotal learning activity for the consortium. This paper describes which competences the students learn, the methodology used in terms of course delivery and assessment and the actual programme. The school is unique in the sense that it is currently the only one focused on teaching master students in chemistry what it is to perform analysis in an accredited laboratory.

In a recent article in this journal, R. Salzer questioned whether academic study programmes sufficiently follow the rapid changes in society, whether they sufficiently prepare young people for new challenges so as to increase their employability[1]. He argued that although a strong foundation in the fundamentals and a diverse knowledge of cutting-edge research are important, students can further differentiate themselves by developing their non-technical skills. Interdisciplinary knowledge and transferable skills seem to be very important in the employment market [2,3,4].

Have such concerns been taken into account in the process of changing university curricula? The need for change in higher education structures in the face of globalisation was addressed in the Bologna Process, dealing with issues such as public responsibility, governance and social dimension, promoting student mobility and attracting non-Europeans to study and/or work in Europe. Some might argue that the emphasis of this reform was rather on administrative reorganisation than on modernising learning outcomes or adapting them to external requirements.

As for changes in external requirements, what have been major changes in the world of analytical sciences and analytical laboratories during the past decades? Apart from the rapid technological developments, the requirements of quality assurance of analytical results and laboratory accreditation (according to ISO/IEC-17025) have proven to have had a very influencing role all across the world. The importance of accreditation has risen to the level that without it laboratories can often go out of business. Have university curricula adapted themselves correspondingly to better prepare students for the job market where analytical chemists find employment? By and large, this has rarely happened. Students are often taught analytical techniques in their science or engineering education from the perspective of continuing a career in research, rarely addressing the knowledge and skills required in the context of an accredited laboratory. Thus it seems that genuine market needs are not so easily taken on board when changes to educational curricula are considered, although a qualifications framework and employability are intimately linked [5], as depicted in Figure 1 taken from this reference.

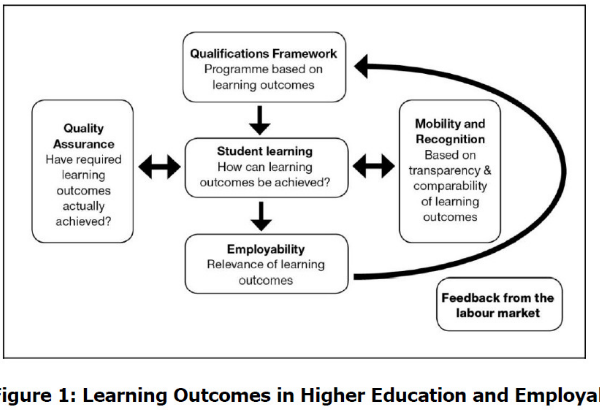

Figure 1. Learning Outcomes in Higher Education and Employability

This paper describes a summer school organised in the context of an International Master programme (Measurement Science in Chemistry-MSC) currently involving nine partner universities, which was specifically set up in 2007 to address a qualification framework required by many employers, namely to have graduates with knowledge and competences required to work in an accredited laboratory. The development of this programme [6,7] started in 2005, when the European Commission Joint Research Centre assembled a group of analytical chemistry lecturers in a workshop in Rogaška Slatina, Slovenia [8]. They addressed the need for introducing curriculum changes as described above. The findings were supported by many European stakeholders in a Rogaška Declaration [9]. In a follow up meeting in Wieliczka in 2007, a consortium was created which set up a programme, later submitted to the Label Committee of the European Chemistry Thematic Network [10]. It is this programme which received the Euromaster quality label in 2008. The requirements for the Euromaster label are that Euromaster graduates will develop learning skills which will allow them to continue to study in a manner which may be largely self-directed or autonomous, and to take responsibility for their own professional development.

This master programme attracts approximately the best 10% fraction of the master students of each of the consortium partners. For organisational and cost reasons, these students follow the bulk of their curriculum at their home university. However, these selected students then participate in a crucially important learning activity in the context of the MSC master programme, i.e. the international summer school. To the best of the authors' knowledge, it is currently the only summer school worldwide which enables students to develop expertise and skills directly related to working in an accredited laboratory. Organising the first summer school was critical in demonstrating its feasibility. It was held in Celje (Slovenia) in 2008 [11]. To demonstrate its European aspect as well as to spread the challenge of organisation across the partners, the school was subsequently held in Blagoevgrad (2009), Lepanina (2010), Poznań (2011), Fátima (2012), Lyon (2013) and Casablanca (2014).

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Teaching scientific process skills in a modern context in Analytical Chemistry courses at a private American university

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Teaching scientific process skills in a modern context that is stimulating and relevant to students' lives is an effective pedagogical approach, which is well suited for Analytical Chemistry due to its highly interdisciplinary nature. Analytical Chemistry has been defined as the study of fundamental and practical applications of how one measures important chemical parameters such as concentrations, rate constants, lifetimes, and other chemically relevant parameters [1]. In addition, Analytical Chemistry has continued to prosper, in part because it continuously adapts to changes in the chemical sciences and advances in modern technology [1]. Over the past decade, I have continuously revised the Analytical Chemistry lecture and laboratory courses, and developed an advanced undergraduate course in Bioanalytical Chemistry & Chemical Sensors at a private American university. The relatively small class sizes at our institution have provided me with many opportunities to explore various pedagogical approaches, including different types of assigned work with the goal of gradually improving the student's process skills. Pre-class assignments, class discussions, data analysis, student presentations, peer-reviews, literature assignments, context-based problems, and multi-method analyses of actual samples in the laboratory are a few examples of activities designed to help students develop a deeper understanding of the underlying scientific principles relevant to Analytical Chemistry, as well as develop critical thinking and reasoning skills, improve their literacy and communication skills. Furthermore, my students are expected to describe experiments and results, identify advantages and limitations of a technique, design sampling plans, carry out error analysis, scientifically justify their conclusions, devise experiments to optimize a new method, and consider practical aspects such as cost, ruggedness, ease of operation, and waste generated by the new method. Open-ended and context-based test questions, which require students to draw upon knowledge gained from multiple methods or course units, are included in the course examinations.

An increasing number of employers of recent university graduates in today's competitive labor market are stating that they do not care about the discipline specific knowledge students gained during their university studies, because such knowledge would be out-of-date soon after they graduate [2]. Instead, employers care more about whether their new employees can continue to learn over time, locate and evaluate information, communicate effectively and solve complex problems [2]. The ultimate goal of the revisions I have made in our Analytical Chemistry curriculum is to produce university graduates in Chemistry, Biochemistry, and Clinical Laboratory Science who, in addition to having essential content knowledge, are capable of critical thinking, analytical reasoning, and communicating like professionals. These non-discipline specific skills are highly transferable and therefore may also be of benefit in daily life. It is no surprise that specific skills such as complex reasoning, data interpretation, oral communication, scientific writing, error analysis, gathering information, and critical analysis of primary literature are highly valued by employers in chemical industry. Indeed, the same skills certainly benefit students who opt to pursue graduate-level studies in their discipline. My presentation describes how the incorporation of course assignments, activities, and experiments throughout an Analytical Course curriculum helps students strengthen their process skills.

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Developing a specialist identity in first year chemistry education

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Experts can be described as persons who are able to construct meaningful patterns of information and flexibly apply their knowledge to varying problems based on their deep substance knowledge (Brandsford *et al.,* 2000). University students should start developing their professional identity already in the early stage of their studies in order to acquire skills and expertise needed for the working life. Therefore, first year chemistry students should begin, from the first day of studies, to become acquainted with content-knowledge, competences and working life skills in order to act, think and perform as chemistry experts (Talanquer & Pollard, 2010)

At the University of Jyväskylä, the course "Chemistry of living environment (4 ects)" is employed simultaneously with two other main chemistry courses dealing with principles of chemistry and basic laboratory work. The combination of laboratory exercises and general chemistry follows the philosophy of the modified Johnstone model of Mahaffy, highlighting the role of human presence within the three-level representation of matter (Mahaffy 2006). Leading students into the world of chemistry in conjunction with its impact on society is directing the focus into the importance and need of chemistry in the living environment, as well as with a view seeing chemistry as a modern field of industry.

The aim of the course is to enable the student to make connection between chemical reactions and phenomena, and everyday life. The course emphasizes the development of an expert in chemistry by building up both the content-based knowledge and the skills to support their learning and studying at the university. The familiar topics are from media and news: chemistry of life, water, air, soil and energy. The students are expected *e.g.* to be able to describe and discuss for example about the role of chemistry in society and offer experts' solution to an environmental issue. Besides employing interactive, discussion-driven lessons, the course takes advantage of a virtual learning environment (VLE, here MOODLE) with varying learning assessments and as a platform for collaborative and group work. The students are also taught to formulate an expert's opinion with writing tasks, based on current research results published in academic journals. As writing is known to develop thinking to become more structured (Sherwood & Kovac, 1999), such task enhances deeper understanding of chemistry, which clearly is a required professional skill for the future.

In order to study the development of a specialist identity, all natural science students attending the course in the year 2014 (N=102) were asked to write down their conception of their learning. The answers from the chemistry major students in the group (N=40) were thereafter qualitatively compared with those of senior undergraduate students (who have studied at the university more than one year, most of them having chemistry as a minor subject). For example, the principles of teamwork were shortly introduced in VLE before starting two separate collaborative writing tasks, where students can act as experts in their field. The students at the beginning of the course were asked to consider whether team work skills (along with a few other studying skill topics) would be useful also for working life. The majority named team work as important tool for the future, which thus offered motivation for accomplishing the team work tasks on the course. It would direct the focus of the studies towards the working life and generate a starting point for the development of an expert identity. The success of such approach could be seen in the course feedback with several positive comments especially naming the team work tasks, when the students considered their accomplishment related to the learning outcome "student is able to act as a member of an expert team".

Once the development of the specialist identity is started at one the first courses in chemistry, the students are expected to be more prone to understand the essential connection between the non-substance skills learned at the university and work and life.

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Embedding Career Development Skills into the Chemistry Curriculum

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This extended abstract gives some more detail of the abstract for the above talk. One of my major principles in delivering university-level teaching in chemistry is that Teaching and Learning and Research must interact and must be seen to interact by the students. We also have a duty to prepare students for research careers – not just in academia but in industry. As such we need to teach the "soft" research skills – teamworking, oral and written presentation, planning a project *etc.* alongside the obvious discipline-related specific research skills e.g. labwork. These "soft" skills have sometimes been rather overlooked in university degree programmes. This work has recently been presented (September 2011) at the "Variety in Chemistry Education, University of York – organised by HEA) and University of Reading, Faculty of Life Sciences Teaching and Learning Showcase.

The *Chemical Education Group* (CEG) within the Department of Chemistry has developed a "Skills Training" programme as listed in Table 1.

Table 1. Skills training in Department of Chemistry showing role of Dr Matthew Almond

Part of Programme	**Skills Addressed**	**Where is this addressed and who is responsible?**
Part 1	General Skills	Module CH1CC developed by Drs Elizabeth Page and **Matthew Almond** and now convened by Elizabeth Page. Input from members of CEG.
Part 2	Employability Skills	Module CH2CC tied in with Career Management Skills (CMS) provision developed by Drs Elizabeth Page and Joanne Elliott.
Part 3 and 4	Research Skills	Within various modules as listed below. Many developed by **Matthew Almond.**

A particular feature is the introduction of a generic skills module (CH1CC) at part 1. I have worked closely with Dr Elizabeth Page to develop this. It is designed to teach skills in oral and written presentation, numeracy, teamworking, time management and IT. The module is designed to link into more specific chemistry teaching at Part 1 and is designed around a series of challenges as listed in Table 2.

Table 2. Skills addressed through "challenges" in module CH1CC showing role of Dr Matthew Almond.

Challenge	What is done?	Skills Addressed	Who is responsible?
General Challenge	Students work on unseen open-ended problems e.g. what is the concentration of a needle in a haystack?	Teamworking, Library skills, oral presentation, numeracy, problem solving.	**Matthew Almond** and Elizabeth Page.
Inorganic Challenge	Students given an application e.g. "non-stick surfaces" and asked to research properties and structures of compounds that would be useful for this.	Teamworking, Library skills, oral presentation, research, problem solving.	**Matthew Almond** and Elizabeth Page.
Organic Challenge	Students work on a problem in preparative chemistry.	Guided research, problem solving, synoptic work – combining information from rage of sources.	John McKendrick and Andy Russell.
Physical Challenge	Students use spectroscopic data to calculate bond lengths and force constants.	Numeracy, IT, data handling, team work.	**Matthew Almond** and David Nutt.

At Parts 3 and 4 specific research skills are addressed as listed in Table 3.

Table 3. Research skills addressed at parts 3 and 4 of chemistry programme showing role of Dr Matthew Almond.

Skill Addressed	Where is it Addressed?	How is it addressed?	Who addresses it?
Oral Presentation	Module CH4I2 (Catalysis)	Students give short presentations (3 minutes) after reading scientific paper of their choice on specific topic of matrix isolation.	**Matthew Almond**
Teamworking	Module CH3FA2 (Forensic Analysis 2)	Mini-projects as discussed in section **2.1.1**	**Matthew Almond**
Listening to research colloquia and deriving information from these.	Modules CH4CR (Current Topics in Chemistry Research) and CH4SK	Students attend colloquia given by academic or industrial experts from outside the university and write reports.	**Matthew Almond**, David Nutt and John McKendrick.

Is teaching chemistry really difficult and boring?

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The leading role in raising interest for chemistry rests with chemistry teachers and with universities that educate new teachers.

Teaching should be as closely related to daily life as possible. Students have often asked my advice on how to respond to their students' question: why do we need chemistry? A good example on this issue is the problem that occurred in Tartu County Gymnasium. In the new section of the building, the air smells really awful. Why is this?

In the article in „Postimees“ only ethylhexanol is mentioned, although the studies conducted by Professor Kallavus from Tallinn University of Technology found that, in addition to releasing from the floor was 2-ethyl-1-hexanol, 2-methyl-1-octanol, isooctanole, 3,7-dimethyl-1-octanol, 1-nonanol, 2-nonanol, 6-methyl-1-octanol, and 2- (2-butoxyethoxy) ethanol. As a chemist, I would open cans of all those substances only in the laboratory fume-hood.

Based on this article, I talk about how important it is to know the properties of substances and their effects on humans. I explain the safety requirements needed.

I have let the students explore complex equations and their agents to explain the basis of its physical and chemical properties. Students using their logic to solve the task within their competence in chemistry. Solving such a task gives students knowledge that in life one does not need to memorize everything. People should not be afraid of the complex titles of chemicals.

However, students should have a basic knowledge of chemistry so that they are not liable to be tricked. Is Dihydrogen Monoxide really a very toxic substance, as suggested by several members of parliament?

Based on these articles, you can show students that knowledge of chemistry is required in almost every field of study.

An example of good teaching materials for chemistry are faulty food supplement presentations, like happened to me with cod-liver oil capsules.

Teaching should be possible to do yourself and do the practical work in a laboratory outside study rooms (outdoor education). In chemistry, for example, the use of natural indicators of river water pH determination.

Games are of interest to students of all kinds (races). Chemicals and other substances could be used in teaching, for example, the chemical elements of Sudoku tutorial.

Success in teaching and learning for all of us!

Clustered Discussion Board: A Better Framework That Enhance Student Learning and Participation

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Discussion board is a common online tool used in blended and online courses. Peer-to-peer written interactions through online platforms like discussion board is known to enhance learner understanding and contribute positively to the learning environment.[1], [2], [3] Although research has shown that discussion boards can greatly enhance chemistry education, it is not widely used in chemistry curriculum.[4] The traditional online discussion board starts with one initial post based on the discussion topic. The discussion then moves horizontally with the participants expressing their analysis, opinion and feedback on the original topic and contributing additional content. Science courses are based on facts, not viewpoints, and hence does not lend itself to long horizontal discussion threads. Furthermore, information gets lost in the hundreds of posts and threads that the students have to click through. As a result, the traditional discussion board often does not lead to concrete learning outcomes and discourages student participation.

I will be presenting a new framework for online discussion board based on "clustered discussions" as an alternative to the "traditional horizontal discussions" (Figure 1). The key feature that defines a clustered discussion board is that the discussion topic will have a "multiplier effect". In other words, the discussion topic is framed in such a way that it allows each student to have their own unique sub-topic resulting in the "vertical movement" of the threads. Students are also given clear instructions on what is expected within the content of the initial sub-topic post. This helps the student formulate quality discussion posts and achive specific learning goals.

The horizontal movement of the discussion threads start from these sub-topics and progresses with students adding new content and interracting with the goal of helping each other achieve their learning goals. Specific instructions are provided to the students on "possible graded responses". This guides the student in having a productive discourse. In order to do the response post, the student will not only need to read through the posts by their classmates, but will also need to work through the problems. This exercise forces them to practice, research, analyze and gain a deeper understanding of the concept. When responding to the incorrect posts and explaining how they arrived at their conclusions, the student is forced to formulate an explanation in their own words. This further reinforces their reasoning ability and teaches them how to communicate and collaborate effectively. The instructor can also use the "possible graded responses" instructions to connect multiple concepts which further helps students in their learning goals.

All these conversations, although independent, have the main discussion topic as their common element. Thus, in a class of 30 students, there will be 30 sub-topics and as many simultaneous discussions ongoing at any given time. Since the posts and threads are automatically organized and categorized with well defined sub-topics, students can easily find and follow discussions, which keeps them engaged. It also ensures increased student-student interaction and better learning outcome. This framework inherently overcomes the challenge of data mining in the traditional discussion board. Since the focus of the clustered discussion board is student-student interaction, this framework is also less taxing on the instructor.

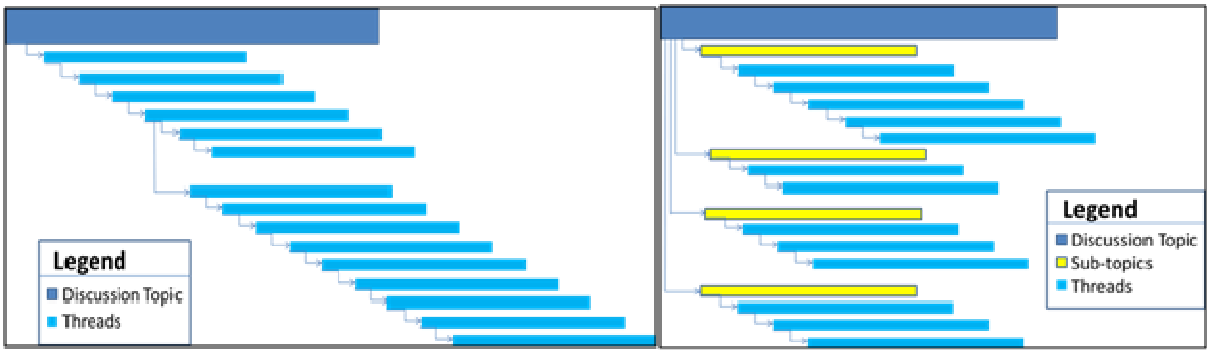

Figure 1: Schematic representation of "Traditional Discussion Board" versus "Clustered Discussion Board"

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Stereoscopy in chemistry education – how we use it

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Stereoscopic projection is a method of three-dimensional (3D) imaging on a two dimensional (2D) plane. Human vision uses several cues to perceive relative depth in scene in front of him. One of the most important is stereopsis, a binocular cue, i.e. such, where use of both, the left and right eye, is necessary. Binocular vision of a scene creates two different images of the scene, one by the left and one by the right eye, depending on different angles given by position of eyes on the head. Consequently, the brain composes the images together and forms a 3D image with depth information. Stereoscopy uses the corresponding strategy to induce a 3D vision and presents two offset images separately to the left and right eye of a spectator. Of course, the stereoscopic projection has a potential to be employed in education, especially in technical subjects, or in cases where "more believable" effect of projection needs to be evoked.

In this contribution, we present ways of using stereoscopy in our department courses. Unfortunately, implementation of stereoscopy is not as simple as just projecting 2D videos. Corresponding presentation equipment, as well as software, is necessary with respect to the particular purpose. Hence, 3D projection brings some advantages as well as limitation, which have to be taken in account. For example, we use active stereoscopic systems, where shutter glasses are synchronized with a projector. Nevertheless, in this case, some people can complain about health issues. Another example of possible problems is concerned with technical aspects. Mostly, our courses focus on the presentation of structures of molecules and discussion of corresponding properties of these molecules. With respect to that, we are mostly using Biovia (formerly Accelrys) Discovery Studio software, allowing very simple presentation of 3D models of (complex) molecules at very user-friendly control of the software, with many presentation style possibilities. On the other hand, the limitation is only "in-window" presentation and only with a limited choice of graphic cards, which can be used for stereoscopic presentation. Mentioning these, as well as other issues and (possible) solutions, are discussed in our contribution.

To estimate a potential of implementation of stereoscopy in chemistry education, we made an orientation inquiry using a questionnaire and knowledge test. The results of the survey indicate that stereoscopy has some potential in better visualization of the chemical objects, as well as that its implementation into secondary school education is supported by the majority of students and teachers.

Keywords: Stereoscopy, Stereoscopic projection, chemistry education
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Continuous Education training program in Chemistry and EChemTest®

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CPE Lyon [1], one of the Grandes Ecoles, known as the Engineering School with 3 Nobel Laureates, is a French Higher Education Institution, member of the Gay Lussac Federation [2]. After a successful completion of a two years preparatory cycle, it offers to students training programmes to prepare one of the 3 Masters' degrees (Chemistry and chemical engineering; Electronics, telecommunications and computer science; Computer science and communication networks).

CPE is having a Continuous Education Department (CED) [3], proposing a great number of sessions per year, covering a large number of areas, allowing professionals to come back to school for 1 to 5 days period, delivering modules from beginners up to highly advanced expertises. The catalogue is made available (printed and online version), to training managers, human resources managers and employees from all chemical and related industries.

Fields covered at CPE Lyon CED are in chemical engineering, analytical sciences, organic chemistry, polymers, biotechnologies, environment, safety, quality, …

Modules are delivered in two contexts:

- "inter-entreprise" sessions (most common modality, mixing companies); modules taken from the catalogue, with predefined approaches (entry level, learning outcomes).
- "intra-entreprise" sessions (most specific modality, one single company); modules taken from the catalogue, but we are often requested to create or re-engineer the content (learning outcomes, training frame).

Professional bodies are representing by a broad diversity of industries / companies / plants: chemical transformation, pharmaceutical, petroleum – petrochemical – refinery, cosmetics, painting, coating, conservation sciences, fertilizers, biocides, detergents, soaps, tars, mineral transformation, …

Our attendees are:

- coming from different structures: production lines (reactions, BMP, sampling, …), industrialization (scale-up, by-products characterization), quality control and analytical laboratories (BLP, normative methodologies, technologies, techniques), research & development (green chemistry principles, recyclability, …), regional and public administrations (environmental and safety controls), regulatory affairs (ministry regulation), etc …

- having different backgrounds (technicians, engineers, doctors) and needs (refreshing or updating the “school knowledge”, acquiring or developing an expertise, new employees “beginners”, career conversion and mobility).

My commitments in a number of programmes (*) gave me the opportunity to evaluate some of the assessments proposed by ECTN [4], using the frame of EChemTest® (European Chemistry Test) [5] via the Test Center at CPE Lyon [6]. To illustrate it, we will focus on 3 tests delivered in French language (General Chemistry 2[(a)], Organic Chemistry 3[(b)], Analytical Chemistry 3[(c)]), in both “inter” and “intra” sessions, to show how it can be used, what are the constraints, and the perspectives. Such a valuable experience enlightens the fact that those tests are easily usable in continuous education context, with a great diversity of students’ profiles.

(*) Training programmes

- Analytical Sciences: ***(c) wet chemistry***, potentiometric techniques, …
- Organic Chemistry: stereochemistry, ***(b) reactions & mechanisms***, nomenclature, solvent influence, retrosynthesis,
- Polymers: introduction, nomenclature
- Generic modules: introduction to chemistry, ***(a) fundamentals in chemistry***, functions and reactivity

Acknowledgements: to ECTN, for granting the use EChemTest®; to CPE Lyon CED, for allowing me to use EChemTest® in a professional context, and the attendees who positively participated.

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Multimedia in chemistry education: need or fashion?

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A chemical property becomes evident through change of chemical identity of the material or more precisely, through a chemical reaction. Sometimes this change of chemical identity is accompanied with changes in physical properties of the material that can be directly observed on a *macroscopic level* and these observations can be further used to draw conclusions about the chemical events taking place in the background, representing the *molecular level*. But in most cases suggestions about chemical properties cannot be drawn by using phenomena which are experienced by senses, but need application of sophisticated analytical methods and theoretical concepts, based on understanding of chemical structure at the molecular level. These circumstances have put chemistry into a unique position, where it needs to operate with "abstract" concepts and "models", which can be presented on different level of complexity. The most common list of these models includes atoms, ions and molecules, described in terms of mathematical functions, or presented in the visual mode as 2D graphs and diagrams or as material or virtual 3D molecular models. Finally, to describe transitions between chemical structures i.e. characterize the chemical properties, a *symbolic level* needs to be introduced. These three levels (*macroscopic, molecular and symbolic*) are well-known cornerstones of representational systems of chemistry education, and the main question associated with different approaches and curricula is related to their mutual relevance and the list of teaching/learning tools selected.

As the concept of chemical structure is explicitly developed in organic chemistry, it can be proposed that the "molecular" level should be used as the major focus of this curriculum component, together with explanations of the basic principles of organic mechanisms and an introduction to principles of structure-reactivity relationships. In other words, the primary target of introductory course in organic chemistry should be demonstrating that all chemical and physical properties of organic compounds depend on their molecular structure, or more specifically, on structural fragments, which are the constituent parts of the molecule. Originating from this idea, a digital organic chemistry resource for high school students and for introductory organic chemistry course of university has been compiled and is freely available at: www.orgaanilinekeemia.ee

This resource includes an extensive database of molecular models of organic compounds, and, more importantly, includes a toolkit for compilation of molecular models by students themselves. Related exercises are given in attached worksheets.

With this material, we expect to demonstrate that application of multimedia in chemistry education is a fashionable need.

Students' understanding of the rate law, as highlighted by laboratory reports

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Physical chemistry is an area that students find particularly challenging, largely because of the extensive presence of mathematics and of the all-pervasiveness of conceptual reflection [1]. It is also a domain in which the interconnections between conceptual and experimental components are broadly present and which often demands a considerable degree of articulation. All these factors require learners' active engagement for successful learning. The challenges in physical chemistry teaching/learning increase sharply in underprivileged contexts in which tertiary students' epistemological access is restricted by inadequate development of essential skills at pre-university level and by acquired passive attitudes towards learning [2]. Many aspects of physical chemistry university courses can be chosen to document and illustrate the challenges. Aspects which involve specific experiments within a course are particularly suitable because they can also highlight the mutual interdependence between conceptual understanding and the ability to analyse and interpret experimental results. This paper focuses on the rate law and presents the results of a 17-year investigation at the University of Venda (UNIVEN) – a historically black university located in an underprivileged rural area in South Africa.

The rate law plays a key role in chemical kinetics and is given fundamental importance at teaching and interaction levels. An experiment utilising the isolation method to determine the reaction order with respect to a selected reactant is also performed during the course at UNIVEN, and detailed guidelines to the lab-report are provided to stimulate students to identify and utilise connections among theoretical aspects, observations and treatment of results. Their lab-reports enable interesting insights into students' understanding of the meaning and implications of the rate law. In particular, they highlight a variety of dichotomies, as if the in-class work and the work in the laboratory – or the theory and the treatment of experimental observations – had little or no connections. Similar dichotomies are diagnosed when a question on the isolation method is proposed in an in-class work. Most dichotomies and errors can be traced back to the identified components of the general difficulties determined by (or associated with) inadequate epistemological access, such as language-related difficulties (having dominant impact, as they also condition all the other aspects), poor familiarity with the descriptive role of mathematics and poor familiarity with the utilisation of visualisation as a description and communication tool [2]. The impact of the associated tendency to passive attitudes is also evident in many cases.

Students' work within physical chemistry courses at UNIVEN have been systematically analysed over the last 17 years. The analysis has the major aim of providing information on the details and roots of students' difficulties, viewing this information as essential to the design of teaching approaches attempting to address identified difficulties, at least to the extent to which addressing is possible under existent circumstances. Although it is not possible to address the roots and impacts of general problems deriving from the entire pre-university instruction within an individual course, it is possible to foster the development of basic epistemological skills and to stimulate active engagement, by designing options specifically tailored to respond to identified problems and to the characteristics of a given group of students.

The paper presents an overview of diagnosed difficulties, provides ample illustration through an adequate number of concrete examples, and analyses relationships with identified epistemological-access inadequacies. It also outlines the main options designed to try and address diagnosed difficulties and the way in which the options have evolved in response both to students' responses and to the changing characteristics of incoming students throughout the years considered. The impacts of the designed options are also discussed.

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IBSE as an important part of chemistry teachers‘ education

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Science is currently one of the most important disciplines and the further development of society is unimaginable without it. Chemistry, as a part of science, is solving many current tasks. Some of the most important ones are the synthesis of new materials and research of their properties, guaranteeing adequate food supply through increasing soil fertility and eradication of weeds and pests or better food conservation, environmental purity control, research of the chemical basis of the composition and functions of organisms, the causes of diseases and the search for substances that would allow to make new and more effective medicines, etc. However, international and national research performed since the 1990s show that the student knowledge of science is often merely formal and short-lived, based on memorization, lacking deeper understanding and the ability to apply the knowledge in practice [1]. Because of that, there is a search for the reason for this state and more effective ways to teach science subjects. IBSE is one of the approaches that seem to be suitable for improving the current situation [2]. IBSE is an educational approach based on one's own inquiry that uses many activating methods. It is a process of problem diagnostics, experimenting, alternative recognition, research planning, hypothesis creation and verification, information search, model creation, discussion with colleagues and argumentation. It is found that the way scientists perform research can be shown as an inquiry cycle and analogically, inquiry-based teaching can be shown using models, which can be considered variations of the so-called "learning cycle". The most often used model is the five-stage learning cycle 5E [3].

However, in order to use IBSE in a given country, at least four basic conditions must be satisfied. It is clear that the valid curricular documents must create space for such teaching, and simultaneously, there must be valid themes for it in the individual subjects; the students must be able to accept this way of teaching, and most importantly, the teachers must be able and willing to teach in such a way.

The 2000-2010 curricular reform in the Czech Republic was already in concordance with the EU programme and set new demands about the expected education results, especially in the area of competencies and follow-up skills. As for the teaching of the subject of chemistry, many suitable materials applicable to the IBSE approach were processed [4, 5]. As a part of a project by the Grant Agency of the Czech Republic, we focused on determining and verifying the students' science skills required for IBSE at lower and upper secondary schools, and found that they have acquired these skills at a reasonably high level [6].

Therefore, the main problem was still with the ability and willingness of the teachers to accept this kind of teaching into their own practice. As a part of the ESTABLISH project in the 7th FP EU [4] and also as a part of the national project GAČR, we performed extensive questionnaire surveys to find out if teachers had encountered the IBSE method and whether they consider it suitable for chemistry teaching at school. For this reason, we focused on the preparation and realization of a training system for in-service and pre-service teachers, using support from the European project TEMI.

The TEMI project (Teaching Enquiry with Mysteries Incorporated) whose main solver is Queen Mary University of London (with Charles University in Prague – Faculty of Science being one of the co-solvers) started in 2013 as part of the 7th FP EU program. TEMI is a science education project meant for teachers of upper and lower secondary schools. Its main goal is to prepare and carry out teacher training, focused on inquiry-based education that leads to the change of science and mathematics teaching across Europe. In-service and pre-service teacher training is provided to teachers with new knowledge and skills, which allows greater connection with their students, exciting new resources and extensive support necessary for the effective introduction of this method of teaching into their classrooms [7].

The goal of our activity is to train around 100 teachers in the Czech Republic. The training is for two days with 10-15 science teachers participating in each. The preparation and realization of the training is based on the identification of a scientific "mystery" and the active work of the teachers connected to the experience of inquiry and discovery as such. It is this exact way of working with teachers which proves to be very effective. The questionnaire survey performed before the training and afterwards shows that the training gives most teachers a positive opinion about IBSE [8]. However, much more important is the fact that they incorporate the IBSE tasks into their teaching and/or create their own tasks. Only the teaching of IBSE as such and the conviction that it's more successful than the traditional forms of teaching can lead to a genuine change in chemistry teaching and its greater success.

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Using Inquiry-based Approaches in Traditional Practical Activities

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The 2006 PISA (PISA, 2006) analysis suggests that Hungarian students' should develop a wider range of scientific skills, such as devising scientific investigations and evaluating data gathered. Introducing the theoretical and practical aspects of inquiry-based education (IBSE) in the pre-service training of chemistry teachers and in CPD courses for in-service chemistry teachers can help to address these challenges. However, when promoting IBSE, some people can be sceptical, especially practicing teachers. They argue that the requirements of the curriculum do not allow sufficient time for unguided inquiry and only topics that are closely connected to the curriculum could be covered.

Advantages and disadvantages of inquiry-based instructional practices have been widely discussed in the literature. Researchers supporting IBSE argue that teaching strategies which actively engage students in the learning process (applying active thinking and drawing conclusions from data) are more likely to increase conceptual understanding (Minner at al., 2010) and developing higher order cognitive skills (Tomperi and Aksela, 2014), than are strategies that rely on more passive techniques. However, Kirschner, Sweller, and Clark (2006) warn that minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process. They add that there is also evidence that it may have negative results, with students developing misconceptions or incomplete or disorganized knowledge. As an answer to the doubts described above, Hmelo-Silver, Duncan and Chinn (2007) stress that not only learning content but also learning "softer skills" such as epistemic practices, self-directed learning, and collaboration are important learning outcomes. Therefore, according to them, it is worth investigating under what circumstances guided inquiry approaches work, what kinds of outcomes are for which they are effective, what kinds of valued practices they promote, and what kinds of support and scaffolding are needed for different populations and learning goals.

Considering all of these and our earlier experiences about promoting IBSE in Hungary described in a paper submitted for publication in the journal LUMAT – Research and Practice in Math, Science and Technology Education (Szalay, submitted 2015), our view is that IBSE should be introduced gradually. Furthermore, teachers might find it easier to handle the situation if an inquiry-based activity originates from an established and widely used step-by-step practical that is adapted, at least in part, to inquiry tasks, by asking students, working in teams, to design one or two experiments and reviewing and discussing the results obtained. The question is, whether a few occasions when students do this kind of partially inquiry-based activities, make a difference when it comes to their scientific way of thinking and attitude toward chemistry.

There are insufficient data at present for a critical statistical analysis and evidence-based evaluation of piloting IBSE in Hungary. Therefore empirical research on this subject, led by the author was started in May 2014 and ended April 2015. It is part of a national project, which aims to develop teaching materials to help initial and in-service teacher training. It includes a brief pilot consisting of three chemistry lessons about reaction kinetics that is organised in 12 schools involving 16 teachers and more than 800 students. Pre- and post-tests, as well as control groups, are applied to investigate and evaluate the possible effects of using IBSE on the development on the students' scientific skills, knowledge in chemistry, as well as their attitude toward chemistry and their learning environment.

The topics of the three lessons in the pilot are as follows:

Lesson 1: Rate of reaction

Lesson 2: Chemical equilibrium

Lesson 3: Factors that affect the chemical equilibrium

In case of lesson 1 and lesson 3, traditional step-by-step student practical activities, in which full instructions are provided, are used by the control groups. Students in the other groups (the experimental groups) have to think about and plan how some steps should be carried out. In other words, part of the activity is guided inquiry. There is no other difference between the lesson plans of the experimental and the control groups. While doing the practical activities, students work in teams in both the experimental and in the control groups.

Research questions:

1. Do students in the experimental groups achieve significantly different scores on the tasks measuring the ability of designing experiments on the post-test than on the pre-test? If yes, is there any correlation between the previous knowledge in chemistry measured by the pre-test and the change of ability designing the experiments measured?

2. Do students in the experimental groups achieve significantly different scores on the post-test than the students of the control groups, considering the tasks measuring the factual knowledge obtained at the three lessons?

3. Is there any significant change in the attitude of students toward chemistry in general and toward their learning environment in the experimental group and in the control group? If yes, is there any difference between the changes measured in the experimental group and in the control group?

The oral presentation will give answers to these questions, based on the statistical evaluation of all data collected at the time of the pilot.

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Scaffolding Inquiry in Introductory Chemistry with molecular models

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Introduction

The main reason that chemistry is perceived as difficult by many learners, and by those teaching it, is due to the abstract nature of the subject (Johnstone, 2000). Many misconceptions in chemistry stem from an inability to visualise structures and processes at the sub-microscopic (or molecular) level of Chemistry. (Tasker & Dalton, 2006). Organic chemistry is one of the most visual sciences and the need to foster metacognitive and learning strategies for organic chemistry has been outlined as an area for future research (Graulich, 2015). Learners need to move backwards and forwards between two-dimensional and three-dimensional representations. Previous research carried out at second-level in Ireland (O' Dwyer & Childs, 2014) has credited the use of molecular models in facilitating learners' understanding. Given this success, the researcher was interested in exploring the potential impact of the use of molecular models with a different group of learners in a different educational setting, but teaching the same topic.

Visualisation as a learning tool

There is evidence in recent CER (Briggs & Bodner, 2007; Kozma & Russell, 2007) about the value of visualisation in learning Chemistry. This exploratory research involves the use of molecular models with a group of mature students who are learning introductory level organic chemistry. According to Piaget's age predictions - it would be assumed that many of these learners have reached the formal stage of cognitive development. Previous research has outlined that formal thinkers revert to concrete operational processing when faced with a challenge in a new area (G. M. Bodner, 1986). Previous research has shown that learners' understanding of molecular representations are best developed with the use of concrete types of representations (Ferk, Vrtacnik, Blejec, & Gril, 2003).

Methodology

This study uses the Purdue Visualisations of Rotations Test (PVRT) (G. Bodner & Guay, 1997) to assess the mature learners' development in spatial thinking. A modified PVRT was completed by the learners before and after their use of the molecular models in their learning of organic chemistry. The learners' scores in the pre and post PVRT will be compared as well as qualitative data collected about the learners' experience of the PVRT and using the models to facilitate visualisation will be detailed in the oral presentation.

Implications for future teaching

Learners revert to concrete operational or pre-operational thought whenever they encounter a new area (G. M. Bodner, 1986). There is evidence that deliberate facilitation and development of cognitive skills has been beneficial for learners in previous projects (Barke, Harsch, & Schmid, 2012; O' Dwyer & Childs, 2014). Many programmes designed to facilitate cognitive development have been effective with second-level and university-age learners. However, there is scope to explore the application of different visualisation tools and resources with more diverse groups of learners.

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Large-scale package of audiovisual learning materials: “100+ Experiments in Chemistry“

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The problem of chemistry and chemistry teaching is that the subject is considered to be boring, unpopular or difficult. Nevertheless, it is possible to demonstrate didactic, interesting, effective and simply beautiful experiments, which make the matter more interesting and more attractive for students and might be a source of additional knowledge.

Under the leadership of chemistry teachers and lecturers at Tartu University, an initial version of a collection of chemistry videos "100+ Experiments in Chemistry" has been created. This is a capacious audio-visual teaching (or learning) material, which is now freely available in via internet:

www://chemicum.com

Recently, the tables of contents (9 broad themes) and the titles of experiments are provided with English and Russian translations. Some videos (about 1/3) have, additionally, complete English translations.
The videos can be used for independent learning as well as in chemistry lessons and/or lectures by being shown on a big screen.

What is the idea of creating such visual aids?

- Textbooks give lots of descriptions, drawings or photos of chemistry experiments. From the cognitive point of view, there is a remarkable difference whether you only look at the pictures in a textbook, or you can see the whole ongoing process.
- And although the best way, of course, is to watch the experiment together in a live show and then the teacher (or lecturer) can make comments, but reality sets it`s limits.
- Carrying out the experiments commonly needs expensive equipment, chemicals, safe laboratory conditions as well as the preparation time and experiences from the lector. Time is also needed for the purification and washing the equipment.

Here we see the use of audiovisual teaching material as one possible solution. Thus, audio-video material "100+ Experiments in Chemistry" is trying to fulfill this gap in chemistry education.

To date, there are totally 120 experimental topics (and more than 250 individual experiments) in the videos.
In addition to ordinary school material, the package consists of many different interesting and effective experiments, which do not belong to the official program, but are attractive and will educate the viewer more widely (like technology videos-see: ELECTROCHEMISTRY).
The video-material is provided with the comments, explanations and equations of chemical reactions, therefore the special attention has been paid to the safety of experiments.

Academic Language and Subject Specific Language Abilities of Future Chemistry Teachers

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In chemistry lessons, subject specific language is of high relevance. Students need to deal with chemical formulas, technical terms (e.g. oxidation, chemical reaction) and specific textual forms (e.g. lab report). Empirical studies show that there is a high correlation between language and content learning. In Germany, different education programs require the acquisition of subject specific language abilities and general language abilities in all school lessons. Hence chemistry teachers need to diagnose the language learning difficulties of their students and choose appropriate kinds of support. Future teachers need to become aware of the importance of language in the subject, Chemistry. A study of Scholten-Akoun that focusses on general language skills shows that future teachers achieve poor results. Up to now, less is known about future teachers´ subject specific language competencies and about general language competencies of future chemistry teachers.

The empirical analysis of academic language and subject-specific language abilities of future chemistry teachers is part of the project „Fach-ProSa“, which is an interdisciplinary research project between the educational studies of Chemistry and the German Language. The study was carried out at 10 universities in Germany. The tests focus on abilities of reception and production of written texts and also on general language and subject-specific language abilities e.g. a reading ability test according to PISA is used. A C-test and a text production test focusing on chemistry specific language has been developed. The results of these tests are used in the project "Fach-ProSa" for the development of exemplary learning settings and materials.

In the poster the different test instruments and exemplary results of the study are presented and discussed.

Supporting in-service chemistry teachers' professional development through ESTABLISH modules

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According to different reports and studies (High Level Group on Science Education, 2007; Henno, 2010; Business Europe, 2011), there is a serious decrease in young people's interest in science and technology (S&T) related studies and careers.

In order to address students' lack of interest in S&T studies and careers, design-based science learning approach (DBSL) is put forward in the current study. DBSL combines the elements of engineering design within inquiry learning, engaging students in scientific reasoning while solving authentic design problems including stages such as:

(1) defining the problem and identifying the need;
(2) searching information;
(3) considering alternative solutions;
(4) choosing an optimal solution;
(5) designing and constructing a prototype, and
(6) evaluating the prototype (Apedoe & Schunn, 2013; Gomez Puente, van Eijck, & Jochems, 2013).

In DBSL, a trigger for students to promote further science learning, is a design-project in which students are expected to develop a technological solution to a problem (Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004; Apedoe & Schunn, 2013).

In order to help in-service chemistry teachers to update their knowledge and skills for supporting gymnasium students' interests in science (more particularly in chemistry) and technology related studies and careers, a continuous professional development programme was carried out. Within a two-year project, a group of Estonian chemistry teachers (N=10) was introduced to the teaching approach and learning modules provided by the EU FP7 project ESTABLISH (European Science and Technology in Action: Building Links with Industry, Schools and Home). For that purpose, three learning units (Greenhouses on Mars?!, Chitosan – fat magnet?, Why to make home-made cosmetics?) were adapted and modified by the research team for the current, DBSL approach and taught by the participating teachers within optional (8 schools) as well as compulsory chemistry (1 school) courses. Throughout the project, the teachers participated in 5 in-service sessions and carried out adapted modules in their classrooms. Altogether, 314 students from grades 10-11, took part in the study.

The following research questions were posed:

1) Is there any change in students' science and technology related career interests through the implementation of specially designed modules?
2) What are chemistry teachers' opinions on the use of specially designed modules: what aspects supported and what aspects diminished its applicability in chemistry classroom?

Based on the results of the student questionnaire, the approach used played a role in increasing students' interests towards careers in science and technology. Moreover, the course helped to broaden students' understanding about the diversity of the field of technology and how science and technology are interrelated.

In chemistry teachers' opinion (based on teacher interview), the aspects that supported the use of the modules, were mainly related to:

- students' increased interest towards learning which, in turn, was related to the everyday life focus of the modules and possibility for students to have a tangible result (product) at the end of each module, and
- the support from the project team (research team and other participant teachers) was considered as highly important when implementing modules.

Aspects that counteracted the implementation of the modules were mainly related to teachers' lack of personal and lesson time plus, for some teachers, having too many students in the same classroom when carrying out experiments.

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Feel the concept origin: Engaging pre-service teachers into design research in a learner-centered chemistry course for middle-school students

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Engaging pre-service teachers in design research of learner-centered chemistry courses is considered as a promising way to support sustainable improvement in general chemistry education. To recruit chemistry teachers into our ongoing long-term design research experiment, we suggest a training program for pre-service teachers to counter the teacher-centered approach that has been assimilated over the years. In contrast, our local instruction theory supports students' learning initiatives and allows them to plan and carry out simple experiments to verify the predictions and modify them as needed. Therefore, a teacher is relieved from directly explaining a chemical concept to students; rather, they gradually construct it together, so its significant features and applications become obvious to students. The training program implies that trainee teachers enter into iterative micro-cycles of design, enactment, and analysis during the main phase of the design experiment. The process can be briefly described as follows:
(1) a trainee observes what and how the teacher and students act in the classroom;
(2) s/he helps students to carry out, in a safe manner, the experiments they have already planned;
(3) s/he joins in the work of a group of students as a peer to figure out how they think about solving a problem: what models students use, why they plan certain experiments, what they conclude and how they modify the model – it takes some time to become familiar with students' models and the ways of revising them;
(4) the trainee and the teacher plan a next lesson together;
(5) the trainee and the teacher exchange their roles in the classroom;
(6) they analyze the lesson conducted by the trainee and plan the next one, and so on.
Thus, trainee teachers learn to recognize students' ways of thinking, support students' learning initiative, and appreciate students' testable predictions, especially incorrect ones. Typically, this experience affects the trainee's choice of his/her thesis topic. In the course of our program, the trainee teachers discover for themselves that teaching and learning chemistry might be much more inspirational than they have thought before. They watch wide-eyed how well-known rules can be revealed and made understandable, what models stand behind the basic chemistry concepts, how tightly they are linked to ancient techniques and technologies, and how they coherently changed over the centuries. It makes the trainees respect chemistry as an important part of human culture and understand it much deeper.

Green Chemistry and Sustainability as an Innovative Educational Tool for Future Chemistry Teachers in Greece

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Chemistry teachers are considered as a key factor in influencing and encouraging students' interest and awareness in environmental and sustainable issues. Education of future citizens on the previous mentioned issues provides them with a wide-ranging and a long-lasting, positive, environmental impact on the world. However, a lack of teacher training is one of the largest stumbling blocks for thorough implementation of Education for Sustainable Development in Greece.

Hence, an innovating course on sustainable development, protection of the environment and resources preservation, through application of Green Chemistry in a master degree program, has been established since 2000 at the Aristotle University of Thessaloniki. The basic features of this course are i) interdisciplinary approaches, ii) engagement of teachers in Green Chemistry practices, iv) learning by design Context-Based educational material and lesson plans, and v) sharing of the educational material for Green Chemistry and Sustainability through an open access, Green Chemistry Online Library (http://www.gcex.gr/).

The Online Library is designed as a comprehensive resource, database and repository of educational material including chemistry lab experiments, lecture material, course syllabi and multimedia learning objects that illustrates chemical concepts important for Green Chemistry and Sustainability.

Among the plethora of topics we have covered are: Air Pollution and Green Solutions; The Green approach to Energy; Water Conservation; Soil Conservation; Climate Change and Green Chemistry; Green Chemistry in Cosmetics Industry; Green Anticancer Drugs; The Green approach to Food and Drinks; Green Agrochemicals; Green Chemistry in Arts; Nanotechnology and Green Chemistry; Catalysis as an important tool to Green Chemistry; Ionic solvents, Super Critical solvents, Biomass solvents and their applications; Green Oxidation; Chemical Waste and minimization by the use of Atom Economy; Monitoring and Characterization of the Polluting Industries of Thessaloniki; Hydrogen as multidimensional transfer Energy mean; The Green approach to Chemistry of Cleaning; Dry Cleaning with Supercritical Carbon Dioxide; Precious Green Greek National Products - Pharmaceuticals Plants.

Moreover, we have also covered some special topics in Green Chemistry: Green Chemistry and Interdisciplinary; Green Legislation; Life Cycle Assessment; The Precautionary Principle; Recycling and Reusing; Dangerous environmental pollutants (Hg, Cd, Cr and Mo); Supported Reagents in Green Chemistry; Lighting and Green Chemistry.

In addition, we have designed and distributed, within the Online Green Chemistry Library, prototype educational Green Chemistry Experiments, such as the following: Preparation of Biodiesel from Sunflowers seeds; Preparation of Biofuel and Bioethanol; Design, Construction and Application of a prototype apparatus for Micro-extraction by Supercritical Carbon Dioxide; Catalytic Oxidation of Cinnamaldehyde by Copper Acetate in the presence of Ammonia; Preparation of Polymeric Starch Film from Potato Starch for food packaging to avoid migration of Terephthalates to the foods; Synthesis and applications of Thermal Polyaspartic Ion; the Dual Nature of Tropospheric Ozone; Oxidation of Organic Pollutants in Aqueous Colloid Dispersions; Rare Earths. The Green Approach to Oxidation; Microwave Assisted Synthesis of Esters with Characteristic Odor of Fruit and Flowers; Microwave Synthesis of Biodegradable Polycaprolactone (PCL); Microwave Irradiated Polymerization of Galactic Acid; Green Chemistry approach for Biocatalytic Hydrolysis of Lactose; Microwave assisted Polymerization of Lactic Acid; Microwave Extraction of Alizarin from Natural Dye, Rubia Tinctorum.

The educational material in the Online Library is divided and organized on seven main grouping categories: Green Chemistry Seminar Material, Monographs, Green Chemistry Experiments, Lecture Presentations (Power Point slides), Posters, Articles (Publications in Green Chemistry and Educational Chemistry Conferences, Money Show, Municipalities and Environmental Education Centres), Green Chemistry Lesson Plans for Primary and Secondary Education. Each entry in the Green Chemistry Online Library includes a description of the content material and is text- searchable by any keyword or phrase found anywhere in the document.

In conclusion, the contribution of this innovative course in the long run, is to support Greek teachers to raise the environmental awareness of their students, aiming at improving the present and future state of the environment. We believe that the context based courses towards Green Chemistry and Sustainability provide to both teachers and students with the appropriate stimulus in order to develop critical skills and to cultivate an environmentally friendly way of thinking and acting.

Moreover, the involvement of graduate students with Green Chemistry and Sustainability could endorse their scientific and technological literacy and also support their preparation to play role as responsible citizens, future teachers, employees or employers in every workplace in the highly competitive new economical settings.

Problem-based Learning as a Source of Inspiration for In-service Teachers to Develop Curricula

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The in-service science teachers' working group in Viljandi Gymnasium, Estonia has during 3 years of its existence**, developed curricula** for chemistry, physics, biology and geography which include interdisciplinary technology courses and learning activities applying problem-based learning. An overview of the curriculum for special courses is given in table 1.

Learning modules, initially developed within the EU FP7 project PROFILES, are used in **technology courses**, adopting the learning materials according to the students' ideas and technological possibilities**. Following the PROFILES 3 stage approach**, the initial scenario themes focus on oil pollution, making paper, soil quality and its relationship with plants.

Practical courses in chemistry and biology deal with environmental problems, nature resources and health. The scenario themes are based on chemical parameters of water and human impact on water-bodies, different foods (milk, potato chips, coca-cola) and additional substances, conservation processes, cosmetic creams, extracting flavouring substances, making soap.

Student expeditions is one innovative application of problem-based learning. The activation level of students is much higher than on classical guided tours. The students take roles as science experts, tourist guides, teachers, environmental observers etc. They find information and make oral reports in advance, take measurements, samples and photographs, observe and describe different places of interest (such as hills of oilshale ash, mines, soils on different landscapes and water-bodies), and compile and present an analytical group report.

As an important part of competence-based curricula, several **projects** are carried out, in which the students teach the pupils in basic school and **attract learning about the natural sciences.** The projects involve designing and may include practiced learning expeditions in a national park. A second application are practical chemistry lessons given to basic school students.

A course on science-theatre has been a great success. In this, students develop a scenario, find attractive experiments and are guided to perform these safely. The shows are performed at schools, kindergartens, etc. The first Festival of School Science Theatres was organized in 2014.

Table 1. An Overview of the Curriculum – Special Courses

Branch / Year	Science	Maths and Physics	Social, Languages, Humanitarian, Arts, Economics	All Learning Branches
I	1 practical course in chemistry, 1 in biology, 1 in physics, 2 expeditions	1 technology course	Technology modules applied to state science curricula courses	Science theatre, performances, festival
II	1 practical course in chemistry and 1 in biology, 1 in physics, 2 expeditions, 1 technology course	Technology modules applied to state science curricula courses, 1 expedition	Technology modules applied to state science curricula courses, 1 expedition	
III	A joint course on applied biology and chemistry, 1 technology course, 1 practical course in physics, 1 expedition, practical lessons to basic school pupils	Technology modules applied to state science curricula courses	Technology modules applied to state science curricula courses	

Feedback from students:

„I like groupwork and making products with my own hands.“
„Practical experiments are the best part of science courses.“
„Now I understand that there are so many things to learn about nature. An expedition gave us much more than a usual tour. We learned about each other, from each other and got much more information.“
„I will not eat chips anymore and now I see why we’ve got to read the labels associated with products.“
„I didn’t imagine that there were so many plastics around us and that people were responsible for so much pollution.“
„I never thought that there were so many ways the atmosphere, soil and water were connected with human beings and other living creatures.“
„Incredible - this is my own handmade soap! I’m so proud!“
„The science-theatre students are so smart, though they are so young!“

Innovative teaching and innovative thinking in chemistry classroom

Innovative teaching and innovative thinking in chemistry classroom

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Introduction

Students today need to be prepared for a problem-oriented and technology-rich world. People work more and more in teams to create new ideas, products, and services and share these with various audiences. At the same time, society face problems that need to be addressed: poverty, deseases, pollution, global climate change, lack of energy, etc. Therefore, it is generally agreed, that main emphasis in education should be given to the development of students' creativity, critical thinking, communication and collaboration skills - known as XXI century skills (Binkley *et al*, 2010).

In order to address this challenge and develop students' creative and critical thinking, especially designed teaching-learning modules were implemented within the current study as a part of gymnasium students' compulsory as well as optional chemistry courses.

Learning materials

Four aspects were emphasised in the teaching-learning modules (Vaino, Vaino, & Rannikmäe, 2014):

- Design- and/or inquiry-based learning play an integral role in every module as both of these were seen as promising approaches for fostering students' creative, as well as critical thinking skills.
- Modules start from an authentic problem that would be personally relevant to students and would trigger them to learn science in depth (Holbrook & Rannikmäe, 2010).
- Science content is embedded in and related to technological applications demonstrating its potential usability.
- Within every module, technology related careers are introduced to students.

Two teaching-learning modules were introduced to students:

- Forensic science in classroom: Who killed Robert?
- Why make home-made cosmetics?

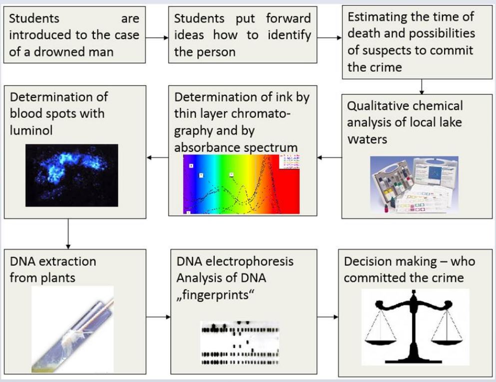

Figure 1. Flowchart of the module „Forensic science in classroom: Who killed Robert?"

Teacher in-service

Throughout the project, participants took part in 5 in-service sessions provided by the University of Tartu, Centre for Science Education. Sessions included:

- Lectures and workshops on design- and inquiry based learning
- Lectures on scientific, technological and industrial content knowledge related to the topics of the learning modules.
- Group-reflections on teachers' ongoing practices.

Throughout the school year, teachers implemented the modules in their chemistry classroom.

Figure 2. Students from Vinni-Pajusti Gymnasium extracting DNA

Conclusions

Based on students' and teachers' feedback:

- Students developed mainly positive attitudes towards the modules and slightly increased their interest in science (chemistry) and technology.
- Modules raised students' awareness of various careers in science and technology.
- Modules put high demand on teachers' skills to manage classroom and provide students with necessary equiptment.
- Participants got necessary support from the other project members as well as from researchers involved.

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Gymnasium graduates knowledge in chemistry - preparation for tertiary chemistry programmes

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Introduction

The Estonian gymnasium Chemistry course sets out to provide a foundation for further study in higher education in chemistry and related specialties, e.g. biology, medicine, agricultural chemistry. In this respect, the competence-based gymnasium chemistry curriculum recognises that the success of a person depends not so much on the acquisition of declarative knowledge, but on important applications of knowledge and skills connected with competences, including problem-solving. In fact, the European Commission has broadened the definition of educational goals from declarative knowledge to a definition based on competences (EC, 2004; 2007). However, the results of the international PISA study in Estonia demonstrated the poor level of students' problem solving competence among 15 year olds (OECD, 2007; 2013). Yet beyond this level in the gymnasium grades, it is assumed that developing students' high order skills has, or does, take place. This claim is confirmed by the Estonian chemistry curriculum, which stipulates that by completion of the gymnasium studies, students have acquired skills for solving problems as well as making informed decisions in domains related to science, technology and society (Estonian National Curriculum, 2010).

The main objective of the current study was to analyse students' differences in problem solving skills before and after studying in the mandatory four chemistry courses in gymnasium –that is in 10^{th} and 11^{th} grade students.

Table 1. Description of the problem solving model used in current study

Component	Interpretation in this study
Supportive competence	Application of knowledge in a subject context
	Application of knowledge in a interdisciplinary context
Problem solving skill (i) Problem Defining	Posing a scientific question
	Planning skill to solve the scientific question and choose variables (i.e. planning an investigation)
Problem solving skill (ii) Problem-solving procedure a) in the context of a scientific problem b) in the context of a socio-scientific issue	Making a relevant choice of procedure
	Giving relevant scientific explanations
	Giving relevant socio-scientific reasoning

Methodology

The sample was formed from grade 10 and grade 11 students, with the grade 10 students (being one year above the PISA sample tested - OECD, 2007) tested at the beginning of their gymnasium level studies, while the grade 11 students, tested at the end of the school year, completed all compulsory chemistry courses. *The 7-item instrument* used was based on solving an everyday problem, related to a sprained ankle and the use of a cold bag to reduce pain and oedema. Students were required to use problem solving competence (Table 1).

Content and construct validity of the instrument were determined by using expert opinions and an analysis of Estonian gymnasium science curriculum to ensure validity in terms of expected learning outcomes. The reliability was calculated using Cronbach alpha (0.634) and was considered acceptable.

Results

To compare the achievement of skills among 10th and 11th grade students, all responses were rated analogically on a scale 0 – 2, with 0- missing or wrong response, 1- a partially correct response, and 2- a correct response. Overview of problem solving achievement is given in table 2.

Table 2. Mean of skills included in problem solving in 10th and 11th grade

Competence	Class	Mean	S D	t	p
Applying knowledge acquired in basic school	10	1.926	0.261	0.233	0.816
	11	1.923	0.267		
Scientific explanation (chemistry-physics)	10	1.980	0.190	-0.651	0.507
	11	1.990	0.120		
Reasoning	10	1.425	0.500	-2.337	0.020
	11	1.512	0.500		
Posing a scientific question	10	1.422	0.497	-0.732	0.464
	11	1.443	0.497		
Planning an experiment	10	1.789	0.408	2.043	0.041
	11	1.738	0.440		
Applying knowledge acquired at the gymnasium level (LeChatelier's principle)	10	1.337	0.473	-3.303	0.001
	11	1.411	0.492		
Explanation (biology-physics)	10	1.203	0.403	-0.888	0.375
	11	1.235	0.432		

From the table it is clear that the only significant differences (at the 0.05 level) is related to reasoning, planning an experiment and knowledge acquired at the gymnasium level. This research was supported by ESF funded grant LoTeGüm.

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Bridging a secondary-tertiary gap through implementing context-based teaching-learning modules at the tertiary level

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Introduction

Lack of students' interest in learning chemistry topics and choosing a career path in science is a worldwide problem in chemistry education and this has been discussed in many science education-related articles. Potvin & Hasni (2014) found that decline in this area is a major concern of researchers almost worldwide. Teichmann & Kübarsepp (2008) showed that science and technology students have weak understanding in science subjects, such as chemistry, and lack psychosocial skills in the beginning of their studies. Professionals in the field of health care have to be able to understand complex characteristics human beings and their environment, to make decisions, think critically and solve problems. All those skills are related to chemistry learning and, more generally, to the promotion of scientific literacy (SL). Promoting such scientific literacy, whether in chemistry or any other health related learning, involves chemistry (scientific) knowledge, ways of thinking and problem solving, the ability to explain scientific phenomena, and socio-scientific decision-making (Holbrook & Rannikmäe, 2009; Choi *et al* 2011). In higher education, these abilities are important to build further knowledge and awareness of the specific subject and a more general context so that students can become competent specialists in their chosen career field. Biggs & Tang (2007) propose the SOLO (Structure of Observed Learning Outcomes) taxonomy to assess learning outcomes. This taxonomy, divided into 5 hierarchical levels of understanding: prestructural, unistructural, multistructural, relational and extended abstract, is used in this study,

The goals of the research are:

• To determine readiness of 1st year tertiary health care students for higher education, measured in terms of identified components of SL, especially chemistry related.

• Based on preliminary results, to develop a course to raise students' levels of chemistry related SL and to evaluate how these levels change after implementation of a specially designed course.

Methodology

Participants in the study were students who entered Tartu Health Care College (n=213). Components of SL were tested using an interdisciplinary instrument developed for the LoteGüm project (Rannikmäe *et al.,* 2014) and outcomes compared with the overall 12th grade students' results from the LoteGüm project (Rannikmäe *et al.,* 2014). A group of volunteer students (n=20) were chosen to undertake a course to develop the participants' SL and to evaluate the effect of the course using the same SL instrument. The course materials were composed in a module format that followed a three stage format (Holbrook & Rannikmae, 2010), and were context-based, teaching-learning modules developed in the framework of the EC FP7 project ESTABLISH (http://www.establish-fp7.eu). Modules were adapted to give more relevance to tertiary healthcare students according to their curriculum.

The results

The results showed that the question answered question was classified to be measuring the SOLO unistructural level and decision making skills. The question was about making a simple decision according to the information given in a text. The worst answered question was classified at the multistructural level and about problem solving skills. This required more specific background knowledge, understanding a process, choosing an approach, planning and decision making. Overall, results are not good. For most questions, less than 50% of respondents could give a correct or even partially correct answers. Comparing college students results against 12th grade students, it was determined that responses from the attendants of Tartu Health Care College are more similar to the results of students from schools who received lower scores in National Exams.

After the course, although summary test scores were significantly improved ($p<0,05$ t-test; $p<<0,05$ Wilcoxon Signed Rank Test), only answers to two questions were significantly improved ($p<0,05$; $p<<0,05$ Wilcoxon Signed Rank Test). One was at the relational level and on decision making skills while the other was also at the relational level but about problem solving. Interviews and feedback from the students show that the course modules are effective in motivating and encouraging students, for developing inquiry skills and directing students towards more independent studies.

In conclusion it can be said that students' SL levels in the components measured are low and after carrying out a course, summary test scores were improving, but only some skills improved significantly. It is suggested that the module-based course can be used for bridging the cap between secondary level education and tertiary level education.

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