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SALiS Special Issue

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Cover photo: **Participants in the SALiS workshops in Georgia (Photo: P.E. Childs)**

Editorial

The SALiS project

This issue of *Chemistry in Action!* is different in that it is mainly devoted to describing an EU-funded Tempus project – SALiS, Student Active Learning in Science. The University of Limerick (through Peter Childs and Sarah Hayes) was one of the EU partners, along with the University of Bremen, the Free University of Berlin, and the University of Plovdic, Bulgaria. These partners worked with others in the beneficiary countries outside the EU – in Georgia, Moldova and Israel. The aim of the project, which is to improve the way science is taught by increasing student activity and involvement through inquiry-based teaching and learning, is a common theme in today's science education and the focus of many other EU-funded projects. I hope this project will be of interest to readers of *Chemistry in Action!* This issue has been funded by the SALiS project as part of its dissemination.

LC results 2012

This year's LC results, which came out on August 15th, have created a stir and a massive debate in the media because of the 25 bonus points for honours mathematics. Anyone who took higher level mathematics, and got a D3 grade or above, was credited with 25 extra points: over 11,000 students were eligible for the bonus. Not surprisingly the number opting for higher level mathematics jumped by 35% to over 10,000 and there was concern that this would have a knock-on effect on CAO points for courses. The first round offers were published on August 20th. and showed some increases but not as much as was feared. Entries for science courses had gone up by 22% and this was reflected in the increase of points required for some omnibus Science to over 500. Simultaneously the mathematics syllabus and examination were changed with everyone doing one examination paper on Project Maths. The numbers doing higher level mathematics went up compared to 2011 and the failure rate dropped dramatically, despite the larger number of students switching from ordinary to higher level. In a classic example of poor experimental design, two factors have been changed at the same time so we cannot disentangle their effects! Is the increase in number doing higher level due to the bonus points (probably) or the introduction of Project Maths? Is the low failure rate due to the new mathematics course and/or a change in marking standards? Concern was expressed that the marks had been adjusted to reduce the failure rates, though this was denied by the State Examination Commission. All things being equal, one would have expected a similar or greater failure rate if a greater percentage of the age cohort took higher level mathematicss, but this is complicated by the change of syllabus. There has been a lively debate in the press for and against Project Maths.

Concerns were also expressed about the blanket nature of the mathematics bonus points – everyone got the same 25 points irrespective of the grade obtained or the third level course they wanted to do. There is an argument for only giving the bonus points for third level courses that need mathematics, and possibly also for having a sliding scale of bonus points. Also if given for mathematics, why not for chemistry and physics as well, subjects struggling to maintain numbers? The CAO estimated that bonus points would only affect about a quarter of the eligible students, as the CAO points score is based on the top six subjects, and mathematics even with bonus points, would not necessarily be included; also for courses where higher level maths was already a requirement there would be no real effect.

On the 21st August the heads of the universities came out with their report on university entry and they proposed several possible changes to the current system. A Task Force is to be set up to come up with concrete proposals by the end of the year.

Peter E. Childs,
Hon. Editor

Education News and Views

Rationalisation and merger of education colleges proposed

In a report on the *Structure of Initial Teacher Education Provision in Ireland* published in Sept.. (*Irish Times* 6/9/12) by an expert committee, proposed rationalising the provision of state-funded teacher education courses from 19 locations to 6 centres of excellence.

The report recommends the following mergers/integrations:

* Dublin City University with St Patrick's College, Drumcondra and Mater Dei Institute of Education; a new campus is to be located at St Patrick's. CICE is also involved in this process.
* Trinity College Dublin with Marino Institute of Education, University College Dublin and the National College of Art and Design. In a boost for Marino, the new institute could be based at its Griffith Avenue campus.
* The National University of Ireland Maynooth with Froebel College.
* University of Limerick with Mary Immaculate College and Limerick Institute of Technology; the campus may be located at MIC.
* University College Cork with Cork Institute of Technology at UCC.
* The National University of Ireland Galway with St Angela's College Sligo, to be based at NUI Galway.

This report has been submitted to the Minister of Education and Skills but no dates have been set for its implementation. This will have major implications for the institutions involved and it is hard to see how it will be practicable in some cases, particularly with resource-intensive concurrent post-primary education degrees like science, domestic science, woodwork and metalwork. There is a major difference in the resources needed for concurrent and consecutive (Higher Diplomas) courses. For the consecutive courses it is assumed that students have already done a first degree in their teaching subject: for the concurrent courses they are studying their teaching subjects and education together.

A background paper by Aine Hyland on Initial Teacher Education in Ireland can be found at http://www.hea.ie/files/AineHylandFinalReport.pdf

One thing is apparent from the Report is the importance of teacher education for a well-performing public education system and the importance of teacher education and teaching to be research-informed. *"..in order to advance further in its national teacher education system, Ireland needs to invest more in the continuous improvement of the quality of teaching, the role of research in teacher education, and international cooperation in all of its teacher education institutions."* (p.6)

The report gives statistics for the production of primary and post-primary teachers: in 2011 1,887 primary and 1,576 post-primary teachers were produced. These numbers far exceed the number of jobs available in the system. The report makes the important point that there is no proper planning in relation to the supply of teachers – the result is an over-production of teachers, most of whom cannot find employment.

"The Review Panel suggests that there should be a research culture in teacher education where staff are familiar with current research and are engaged in research on critical areas of teaching and teacher education: their own practice; teachers' professional learning; Irish and international education policy; and the fundamentals of teaching, learning and assessment. Student teachers should also be engaged in researching their practice, reflecting on it and improving their teaching accordingly." (p.21)

This is an important report and it will be interesting to see how much of it will be implemented in the future, as it represents a major shake-up of the sector.

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Reform of Selection and Entry to University in the Context of National Educational Policy

A report submitted to the Minister of Education and Skills in August 2012 by the Irish Universities Association. This report reviewed the issues and set up a Task Force to make specific recommendations, to report in December 2012. They made three recommendations:

1. Reduce Leaving Certificate Grading Scale from 14 to 8 Points

We have concluded that there is merit in reducing the current fourteen point grading scale to an eight point scale, i.e. A1, A2, B, C, D, E, F, NG. This will allow beneficial changes to how the leaving certificate is assessed and consequent changes in university selection methods.

2. Further move towards common entry

Much of the "heat" in the "points race" arises from those courses where places are most limited and thus points are highest. A move to greater common entry would be challenging but would significantly alter the dynamic of competition for university places. It is desirable that institutions progress towards greater common entry, while noting that there will continue to be a particular challenge regarding competition for entry into highly selective programmes such as the health professions and other similar areas.

3. Incentivise Strategically Important Subjects

Currently (with the exception of bonus points for maths) all subjects are treated equally for points purposes. There is scope to change this approach to create further incentives for students to study and achieve in specific, prioritised subjects.

You can read the report at: http://9thlevel.ie/wp-content/uploads/Reform_of_Entry_and_Selection_to_University_IUA_report_August2012.pdf

One of the advantages of the current grading system, unlike that in the UK, is the ability to distinguish between similar candidates. This would be lost if these proposals were accepted and there would likely to be more places allocated by lottery.

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Increase in length of ITE

From 2014 the Professional Diploma in Education for post-primary teachers will increase in length from 1 to 2 years (120 ECTS credits), and the 2013 entry will be the last entry to the 1 year course. Any concurrent teacher education programmes must last 4 years (240 ECTS credits), which will apply to some primary education courses.

One of the recommendations of the Report on Initial Teacher Education (see above) was a shift towards a Master's level teaching profession. Increasing the length of the postgraduate consecutive courses to 2 years would allow them to become a Master's programme. However, there is also a case to add 1 year to the concurrent degree programmes, making them 5 instead of 4 years, with the 5th. year being used for a Master's programme. As it is now someone going down the honours degree (4 years) and postgraduate diploma (2 years) from 2014 will take 6 years to become accredited as a teacher. The concurrent programmes currently take 4 years to deliver the same accreditation, a much more cost effective route.

Concurrent courses in science education to produce science teachers are now available at DCU, NUIM, UCC and UL.

At further education level, a teacher education qualification will be a requirement from 2013, and new programmes are currently being designed to meet the particular needs of that sector. Five new courses have been accredited to provide this qualification.
(www.teachingcouncil.ie)

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Student Active Learning in Science (SALiS) – An Introduction to the Special Issue

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TEMPUS: Innovations by establishing European partnerships in higher education

In 2009, a cooperation of the Ilia State University in Tbilisi, Georgia, and the University of Bremen, Germany, was launched to start the project initiative SALiS. SALiS stands for 'Student Active Learning in Science' and aims at innovations in science education via reforms in science teacher training.

The idea of the SALiS initiative was to apply in the TEMPUS IV call of the European Union. TEMPUS supports the modernisation of higher education and creates an area of co-operation with and within countries surrounding the EU. Established in 1990, the scheme of TEMPUS now covers 27 countries in the Western Balkans, Eastern Europe and Central Asia, North Africa and the Middle East. The latest phase of Tempus IV started in 2008 with an annual budget of around 50 million Euro. Individual projects receive funding of between 0.5 and 1.5 million Euro.

Led by the universities of Tbilisi and Bremen, with further partners from Bulgaria, Germany, Georgia, Ireland, Israel, and Moldova, an application for a reform network was submitted to the TEMPUS program in early 2010. The funding scheme selected was Joint Projects. Joint Projects within TEMPUS are partnerships between higher education institutions in the EU and TEMPUS partner countries. The partners apply jointly for developing, modernising and disseminating new curricula, teaching methods or materials, as well as boosting quality assurance and management of higher education institutions. Part of the funding is also designated towards modernising infrastructure within the partner country institutions.

Within this framework the SALiS consortium encompasses ten partners from six countries, of which Germany, Ireland and Bulgaria are the EU member countries and Georgia, Moldova and Israel are TEMPUS partner countries. The participating institutions are:

- Ilia State University, Tbilisi, Georgia
- University of Bremen, Germany
- Free University of Berlin, Germany
- University of Limerick, Ireland
- Paissi Hillendarski University, Plovdiv, Bulgaria
- Kutaisi Akaki Tsereteli State University, Kutaisi, Georgia
- University of the Academy of Sciences, Chisinau, Moldova
- Moldova Institute of Educational Sciences, Chisinau, Moldova
- The Academic Arab College of Education, Haifa, Israel
- Oranim College/University of Haifa, Israel

In summer 2010, the project was successfully approved by the European Union. The total budget of SALiS was approx. 800,000 €. SALiS started in October 2010 and had a duration of 24 months, finishing in early October 2012.

Focus and objectives of SALiS – Student Active Learning in Science

The central aims of SALiS are to make science education in the participating countries more motivating, more effective in the learning of subject matter and to raise its potential for the promotion of a broad range of cognitive and non-cognitive skills. Unfortunately, classroom practice in many countries of the world still seems to be dominated by a teacher-centred teaching paradigm, with low student-activity in both minds and hands. This can be also considered true in the participating partner countries within the SALiS project. That is why SALiS aims at promoting science teaching through a better inclusion of student-active and inquiry-based experimental learning in science classes. The project intends to promote inquiry-type lab-work, for example, as one of the foundations of modern science curricula and pedagogies, in order to raise motivation, to support development of higher order cognitive skills, to produce better learning of science concepts, and to promote a broad range of general educational skills.

Recognizing that the teachers are the heart of any innovation in educational settings, the project aims at innovating science teaching in the above mentioned sense by improving teacher training. For the purpose described, all participating institutions intended to innovate jointly curricula and materials for science teacher training. These curricula and materials were designed to enable pre- and in-service science teachers to strengthen hands- and minds-on student learning through innovative approaches to lab-work instruction, e.g. inquiry-type experiments, open lab tasks, or cooperative learning.

The SALiS consortion at the SALiS opening conference in Bremen in Febuary 2011

Outcomes of SALiS – A first overview

In the two years of SALiS several outcomes were reached, of which this special issue gives an overview. Among others the following gains were reached:

- SALiS strengthened the science teacher training infrastructure in the six beneficiary institutions through equipping science teacher training laboratories, including written guides that describe the usage of such laboratories in teacher training including questions of safety, logistics and maintenance issues.
- The SALiS consortium jointly developed teacher training modules, school teaching materials, and a concept of implementation of SALiS in schools via the use of low-cost lab equipment and microscale experiments for inclusion in respective pre- and in-service teacher trainings.
- The project created the foundation for upgrading science education in many schools in the beneficiary countries by the training of science teachers. Qualification of staff for in- and pre-service teacher training concerning the SALiS philosophy took place, experiences were shared during visits and placements between the partner institutions. Through a thorough implementation of the SALiS training modules and the staff training in all partner institutions, the dissemination became broad and sustainable.
- A lab guide for low-cost- and microscale-experimentation in science education was developed and translated in seven languages. A database of more than 200 experiments in different languages for low-cost- and microscale-

experimentation was made available via the SALiS website.
- The project collected and disseminated good practices from all partner countries and made them available to the other partners by translation and adoption.
- Different joint research projects in science education were launched, e.g. on student teachers' and experienced teachers' beliefs about suitable pedagogies in science education or on stakeholder views on the goals of science education in eastern European countries.
- Although the essential components and facilities of SALiS were already available in most of the EU partner institutions, the whole process also led to an improvement in the available teacher training modules in the EU partner institutions.

For more detailed information see the different contributions within this special issue of *Chemistry in Action!* or visit the SALiS website: www.salislab.org.

Project Timetable

- Initial planning meeting, Bremen, Germany, February 2011
- First training workshop, Tbilisi, Georgia, September 2011
- Second planning meeting, Limerick, Ireland, October 2011
- Second training workshop, Chisinau, Moldova, October 2011
- Third training workshop, Haifa, Israel, December 2011
- Teachers' Demonstration Workshop, Tbilisi, Georgia, May 2012
- Final planning meeting, Tbilisi, Georgia, August 2012
- Final conference, Tbilisi, Georgia, August 2012

The project has been disseminated by talks at international conferences in Ireland, USA, Germany and a symposium at the 22ICCE/11ECRICE in Rome.

Typical workshop timetable

Each workshop typically lasted four days, with a mixture of lectures and hands-on workshops. The idea was to give the science teacher trainers and science teachers in each country both a theoretical framework for student active learning in science i.e. inquiry based science education, and a practical appreciation of what this involves. There were also feedback and discussion sessions and opportunities for participants to relate what was being covered to their own situations. The typical programme is shown below, although this was adapted to suit the needs of each country. In this special issue we have tried to capture the content of the training workshops as a permanent record of what was done. More details of the practical workshops can be found on the project website (www.salislab.org., see p.).

Welcome	
Intro Lecture "Contemporary issues in Science Education"	Ingo Eilks
Activity "A reflection on Inquiry"	Silvija Markic
Lecture "Motivation and interest"	Claus Bolte
Public lecture with demonstrations "Inquiry learning in science classes"	Peter Childs and Sarah Hayes
Workshop on "Motivation and interest, cooperative learning and modern science curricula"	Ingo Eilks, Claus Bolte and Ani Epitropova
Workshop "Experiencing inquiry learning"	Sabine Streller and Sarah Hayes
Lab session "Low-cost-techniques in class"	Silvija Markic, Peter Childs and Marc Stuckey
Workshop "Planning and applying inquiry Learning"	Sabine Streller and Silvija Markic
Presentation and discussion of the results from Workshop "Planning and applying inquiry Learning"	Sabine Streller and Silvija Markic (coordination)
Ideas for implementation IBSE into teacher training programs	Ingo Eilks, Claus Bolte, Ani Epitropova
Reflection on the training (Outlook, further ideas, needs, …)	Ani Epitropova

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More Student Active Learning in Science (SALiS) – From a Theoretical Justification to Implications for Science Teaching

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Summary

Educational theory suggests understanding learning science in terms of social constructivism. Social constructivism asks for organizing the learning process in a student-active mode and characterizes effective teaching-learning scenarios by a high level of individual as well as collaborative and cooperative student activity. This paper sums up essential tenets from this theoretical justification for more student-active learning in science. It discusses a tool for reflectin on classroom practice, and based on the theoretical justification general strategies are derived that will allow for raising the degree of student-activity in the science classroom.

Justifying more Student Active Learning in Science

The pedagogy of teaching science in many classrooms all over the world can still be characterized as being a teacher-centred approach. In this approach, the teacher is presenting the content and – if laboratory work is embedded at all - is demonstrating experiments. Interaction with and among the students is limited to short periods of questions and answers. Within this teacher-centred practice, the teacher is pouring knowledge over and into the students and all the students are required to do is to absorb it. As a result, when we evaluate our teaching we all too often find that what we had taught and what our students had actually learned are very different. Our reaction is to try to explain better. The teachers hope that the better they will present the content the better their students will learn. This interpretation of learning is not in line with what educational theory suggests. It is not only the fact that many teachers are not always able to explain everything to others in a sufficiently comprehensible fashion. It is also that the students often fail to listen with sufficient care and attention. Sometimes they even lack the necessary cognitive abilities or previous knowledge to allow for instant understanding of the newly acquired information, but even this explanation is a shortcoming (Byers & Eilks, 2009).

The problem is deeper and involves understanding that learning is much more complex than merely listening, memorizing and repeating (Bodner, 1986). Educational theory suggests that knowledge cannot be transferred intact from the mind of one person into the mind of another. We know for a long time now that most information obtained simply by listening is forgotten very quickly, with only a small percentage ever reaching the long term memory (Peterson & Peterson, 1959). Sustainable learning asks for a broad spectrum of activity by the learner. Meaning and understanding can only be constructed actively by the mind of each individual learner (Wittrock, 1989). Meaningful learning is the active integration of new information with knowledge already possessed by the learner. The subsequent interpretation of this new information will then depend heavily on what the learner already knows and what cognitive processes will occur in the mind of the learner. This means that the quality of teaching should not be assessed in terms of the effort being put in by the teacher. The quantity and quality of learning is much more dependent on the effort being put in by the learner. Teaching science will become more efficient at the point where we apply methods where the students become more active, with both hands-on and minds-on.

The prevalent teacher-centred teaching paradigm in science education is based in the theory of behaviourism (Mills, 2000). Behaviouristic theory considers every action simply as a response to a stimulus; if the correct stimulus is provided the required behaviour will inevitably follow. In terms of learning a teacher wishes a student to learn something by simply providing the right stimulus, e.g. presenting the right pieces of information, in the right sequence, at the right moment. Behaviourism suggests that giving the right information to a student, will enable him to (a) store this information in his/her memory, (b) assign the intended meaning to this information, and (c) have this information readily available for future use. While behaviourism can certainly be helpful in understanding the simple issues associated with basic training processes, like memorisation of facts or training simple psychomotor skills, it has proved much less successful when it comes to understanding the important issues of learning with understanding.

Today, the understanding of effective science learning is generally referred to the theory of constructivism (Bodner, 1986). Constructivism suggests that science teaching should apply teaching methods which make the learner the active player. Constructivist pedagogies seek to encourage the learner to become cognitively engaged in developing understanding of the topic being taught. The more elaborated interpretations of constructivism not only seek to make students active thinkers, but to promote interaction between them. In the socio-constructivist interpretations of learning interpersonal communication and social interaction become essential for effective learning (Hodson & Hodson, 1998). This theory explains how sustainable learning does not take place only via the contemplation of content by an individual learner but by a process that mainly functions through cultural and social mediation about content (Driver & Oldham, 1986). Lazarowitz and Hertz-Lazarowitz (1998, p. 451) describe the the social component of constructivist learning as: *"…cognitive construction is facilitated through the following activities, all of which are based on peer-interaction: students present their own ideas by explaining them to other group members; they think and talk about their experiences; they suggest and try out new ideas; they reflect on changes in their ideas; they negotiate and aid other students to clarify their thoughts; and they move ideas forward by making sense of new ones. Indeed, constructivist theory brings to light the significance of social-cognitive interaction, cooperation and collaboration to the science teaching-learning context."*

Science education should apply methods fostering activity in the students' thinking about the content and also make science learning a collaborative and cooperative experience. Far more than a mere exchange of ideas can take place in such cooperative learning environments. Instead of studying the mental content of individual minds, collaborative and cooperative learning focuses on the processes of interaction, participation, discourse, and negotiation. Cooperative learning leads to co-constructing knowledge and to building up collaborative knowledge, where the group is able to attain a level of understanding that could not have been achieved through the mental processing of any one individual from within the group alone (Johnson & Johnson, 1999). This is true for the learning of pure subject matter knowledge as well as the learning within contexts; nevertheless the same can become true also for the learning initiated by practical work (Witteck & Eilks, 2005; 2006).

If collaborative and cooperative student active learning is considered and used, the classroom environment has high potential for effective learning, student motivation, and the development of skills beyond the learning of science topics and theories. Such non-cognitive skills include team working abilities, organising and structuring of projects, and negotiating of consensus following conflict within the group. Cooperative learning proofed to result in higher cognitive achievement, better development of higher-level thinking skills, increased student self-confidence and satisfaction and better attitudes towards subject matter (Lazarowitz & Hertz-Lazarowitz, 1998).

An Analytical Tool to Reflect Classroom Activity

In 1992, Hertz-Lazarowitz suggested the six-mirrors of the classroom (SMC) model as an analytical tool for reflecting on classroom activity. The model can serve as a reflective tool for analysing classroom situations in behavioural categories such as "on-task" and "off-task" behaviours, levels of cooperation in the interactions between students, and in aiding the social events that take place during learning. It can be used to design classroom environments and move from traditional teacher-centred instruction to more student-active and cooperative learning (Khalil, Lazarowitz & Hertz-Lazarowitz, 2009). The SMC model includes six aspects (mirrors) of the classroom: (1) organisation, (2) learning tasks, (3) instructional behaviours of the teacher, (4) communicative behaviours of the teacher, (5) academic performance of the students, and (6) social behaviours of the student. Each mirror is operated into five levels of complexity from simple to complex (Figure 1).

The potential of the SMC will be briefly explained by comparing two different examples of potential science classroom environments (Eilks, Prins & Lazarowitz, in press). One is the traditional teacher-centred classroom, where the teacher is presenting information and tries to directly transmit information towards the students, also called frontal or expository instruction; the second is based on cooperative learning. Within the teacher-centred classroom, in mirror 1 of the SMC, which examines the physical organisation of the classroom, there is a classroom with the class forming one group. This is perceived as a fixed classroom with little or no movement of students around the room. The learning tasks (mirror 2) are presented to the whole class and then each student tackled the learning task individually. The teacher uses centrally-controlled and strongly guided instruction with the class as a whole (mirror 3), with a high frequency of presenting information by lecturing, demonstrating experiments or using the blackboard (mirror 4). Students' activity is limited to individual action or short term interaction with the teacher (mirror 5). Students' social behaviour often is individualistic and competitive (mirror 6). In all the six mirrors, such a traditional teacher-centred approach will get low scores for a classroom environment with respect to its potential to support socio-constructivist learning.

In contrast, cooperative learning environments will receive higher scores by the SMC. Students work in small groups which do interact and are integrated with one another (mirror 1). Learning tasks (mirror 2) are divided horizontally or vertically and integrated. The learning tasks involve peer learning and peer teaching, were designed to increase interdependence and personal as well as collective responsibility, and thus form integrated tasks for all learners. The pattern of teacher's communication and instructional behaviours include communication with the whole class for a short period of time, then with each of the groups, as well as with individuals who need help. The teacher becomes the organiser and coordinator of the learning process (mirror 3). The teacher's communication (mirror 4) becomes multilateral, while moving between the groups and helping the students individually or within their groups. Students' communication has a multilateral perspective and their social behaviour is supported by the structured formation of the group; they become socially integrated within the group by feeling their individual accountability, together with their positive inter-dependence and the need for cooperation and communication (mirrors 5 and 6).

This model allows us to analyse and plan for more student-active learning in science classes. If it is analysed by means of a spider-web-diagram, the resulting graph will allow for consideration about the classrooms degree of student activity (Eilks *et al.*, in press).

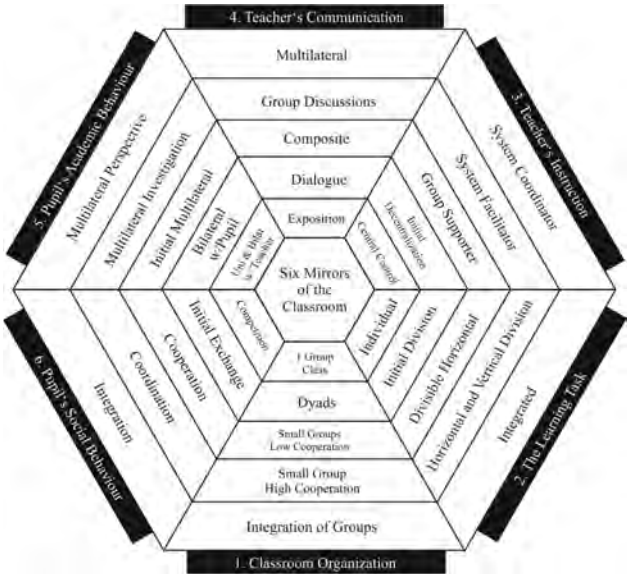

Figure 1: The Six-Mirrors of the Classroom (SMC) model (Hertz-Lazarowitz, 1992)

Making the Science Classroom Student-active

Coming from the theoretical framework briefly discussed above and the idea of the SMC model, we can allocate different domains where more student activation in the classroom will allow for more effective science learning.

Activating students' prior knowledge.
One of the basic assumptions of constructivist learning theory is that learning depends on the learner's prior knowledge. Neglecting students' prior knowledge and interests will lead to learning only in the form of rote memorization. The result will be memorization of isolated facts detached from their scientific origin, as well as inert knowledge with no chance to be applied. Putting the content into a context connected to the students' prior knowledge and interests is essential for any effective learning process. Student-active learning in science should start from issues relevant to students that embed the learning into a meaningful context. It should activate the prior-knowledge and associations a student might have with the topic. It should take prior-knowledge into consideration, should make prior-knowledge explicit and should make students aware about the potential discrepancy between pre-conceptions and scientific explanations, by using communicative processes of contrasting them (De Jong, *et* al., in press).

Activating students' minds.
Learning, beyond cold memorization, is never a passive diffusion of knowledge. Learning is an active process of the learner in the interaction with new information. Only actively-constructed knowledge will become applicable knowledge, transferrable to new situations. New information which challenges the prior understanding and cognition is accommodated, resulting in the assimilation of new knowledge. Student-active learning in science should activate the students' minds by challenging them and producing a cognitive conflict in the learner. New information should contradict and challenge prior conceptions that might be not scientifically reliable. Problems and tasks shall be used to challenge students' thinking and guide the learning process in an inquiry-based mode, especially in connection to the learning in the laboratory (Hofstein, *et al*., in press).

Activating hands.
Learning uses more channels than only the aural and visual channels. Not all students have priority for learning via the visual and aural senses; some are better at learning in combination with the manual sense. The more senses are activated the better is the chance for learning. Student-active learning in science should include hands-on student activity. Students' practical work is a unique chance to raise motivation and learning effectiveness (Hofstein *et al.,* in press). Microscale and low-cost-techniques can help making students' laboratory work available even with low budgets and bad equipment (Poppe *et al.,* 2011). Beyond laboratory work, other physical and social activities should be embedded into science teaching, e.g. work with physical models, operating ICT, using drama or role play (Eilks *et al.,* in press).

Activating cooperation.
At the heart of social constructivism is the idea that learning is making meaning in communication to others, preferably not only with the teacher. Learning is more effective if it is done in cooperation with others. Cooperative learning has been shown to offer a whole range of strategies for more effective and motivating learning in science education. Examples are the Jigsaw Classroom (Eilks, 2005) or the Learning Company Approach (Witteck & Eilks, 2006). Student-active learning in science should be organized in small cooperative groups. It requires the application of cooperative learning instead of

traditional, unstructured group work and requires forms of positive inter-dependence between students, and between students and the teacher.

Activating communication.
Social constructivism says that learning is making meaning which takes place in communication. Learning settings with only one-directional teacher-student communication have been shown to be ineffective for sustainable learning. Communication and negotiation between the learners provokes meaning making and the shaping of concepts in the mind. Student-active learning in science should include various forms of communication. It asks for multi-directional forms of communication, especially student-student communication. Effective communication needs to be learned and should be supported by the teacher. Pedagogies like the 1-2-4-All method can help students to organize meaning making by negotiation and cumulative communication (Witteck & Eilks, 2005); methods like the ball bearing can help to develop communication skills and reciprocal teaching (Witteck *et al*., 2004).

From all these areas there is hope that we can make science education more motivating, more effective in subject matter learning and to raise its potential for the promotion of a broad range of cognitive and non-cognitive skills.

References

Bodner, G. M. (1986). *Constructivism*: A theory of knowledge. *Journal of Chemical Education*, *63*, 873-878.

Byers, B., & Eilks, I. (2009). The need for innovation in higher chemistry education – A pedagogical justification. In I. Eilks & B. Byers (eds.), *Innovative methods for teaching and learning chemistry in higher education* (pp. 5-22). London: RSC Publishing.

De Jong, O., Blonder, R., & Oversby, J. (in press). How to balance chemistry education between observing phenomena and thinking in models. In I. Eilks & A. Hofstein (eds.), *Teaching* c*hemistry– A studybook*. Rotterdam: Sense.

Driver, R. & Oldham, V. (1986). A constructivist approach to curriculum development. *Studies in Science Education*, *13*, 22-105.

Eilks, I. (2005). Experiences and reflections about teaching atomic structure in a jigsaw classroom in lower secondary school chemistry lessons. *Journal of Chemical Education*, *82*, 313-320.

Eilks, I., Prins, G. T., & Lazarowitz, R. (in press). How to organize the classroom in a student-active mode. In I. Eilks & A. Hofstein (eds.), *Teaching* c*hemistry– A studybook*. Rotterdam: Sense.

Hertz-Lazarowitz, R. (1992). Understanding interactive behaviors: Looking at six mirrors of the classroom. In R. Hertz-Lazarowitz & N. Miller (eds.), *Interaction in cooperative groups: The theoretical anatomy of group learning* (pp. 71-101). Cambridge: Cambridge University.

Hodson, D. & Hodson, J. (1998). From constructivism to social constructivism: A Vygotskyan perspective on teaching and learning science. *School Science Review, 79* (289), 33-41.

Hofstein, A., Kipnis, M., & Abrahams, I. (in press). How to learn in from the chemistry laboratory. In I. Eilks & A. Hofstein (eds.), *Teaching* c*hemistry– A studybook*. Rotterdam: Sense.

Johnson, D. W., & Johnson, R. T. (1999). *Learning together and alone: Cooperative, competitive, and individualistic learning*. Boston: Allyn & Bacon.

Khalil, M., Lazarowitz, M., & Hertz-Lazarowitz, R. (2009). A conceptual model (The six mirrors of the classroom) and its' application to teaching and learning about microorganisms. *Journal of Science Education and Technology*, *18*, 85-100.

Lazarowitz, R., & Hertz-Lazarowitz, R (1998). Co-operative learning in the science curriculum. In B. J. Fraser & K. G. Tobin (eds.), *International handbook of science education* (pp. 449-470). Dordrecht: Kluwer.

Mills, J. A. (2000). *Control: A history of behavioral psychology.* New York: University Press.

Peterson, L. R. & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, *58*, 193-198.

Poppe, N., Markic, S., & Eilks, I. (2011). *Low-Cost-lab techniques for the science classroom.* Bremen: SALiS Project.

Witteck, T., & Eilks, I. (2005). Writing up an experiment cooperatively. *School Science Review*, *86* (317), 107-110.

Witteck, T., & Eilks, I. (2006). Max Sour Ltd. – Open experimentation and problem solving in a cooperative learning company. *School Science Review*, *88* (323), 95-102.

Witteck, T., Most, B., Leerhoff, G., & Eilks, I. (2004). Co-operative learning on the internet using the ball bearing method (Inside-Outside-Circle). *Science Education International*, *15*, 209-223.

Wittrock, M. C. (1989). Generative processes of comprehension. *Educational Psychologist*, *24*, 325-344.

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Note: The book *Teaching chemistry– A studybook*. I. Eilks & A. Hofstein (eds.), Rotterdam: Sense Publishers, mentioned above, is in press and will provide a sourcebook of relevant educational ideas for teaching chemistry, for both trainee teachers and for practising teachers.

Evaluating Students Active Learning in Science Courses

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Introduction

SALiS tries to promote "Students active Learning in Science Teaching" by offering inquiry based and every day context led learning environments (SALiS 2011). The following article reflects on a sequence of lessons situated within the context of weather, climate and climate change (Streller & Bolte, 2007; 2011) which is meant to facilitate access to this topic based on the everyday experiences of the students. The conception of this lessons plan spans a sequence of about 10 lessons which are devised for interdisciplinary introductory chemistry courses as well as for courses in the subject science. A wide range of connections to physical, biological and geographical aspects characterise our conception. Starting with an impressive weather phenomenon – the occurrence of tornados and their increasing frequency – the formation of tornados will be discussed. The composition of air as well as its change through natural and anthropological influences will also be dealt with in the lessons. The students will have the opportunity to carry out several experiments and to conduct their own research using new media.

This sequence of lessons was developed first in the framework of the PARSEL project (2007) and optimised and successfully tried out, amongst other trials, in a one-week school project in three grade 7 classes of a Berlin *Gymnasium* in the context of the PROFILES and SALiS project (2010; Bolte et al. 2011).

The evaluation of the project-week by means of the MoLE questionnaire, on which this article will focus mainly, gives evidence that the conception used by the FUB SALiS Working Group is applicable and highly successful either as part of a project-week or in regular science lessons. This can be stated because the students assessed our project-courses as relevant, popular and highly (intrinsically) motivational. But make up our own mind.

Objectives and Intentions

One objective of our work within the SALiS project was and still is to investigate, in a case study approach, how students are or can get (more) motivated to learn science, about science and about the nature of science if they take part in a special educational programme; in an educational programme which follows the recommendations of science education projects such as SALiS (2011), PARSEL (2007) or PROFILES (2010). Furthermore, we want to demonstrate to teachers and pre-service teacher students the impact of approaches like this as well as to convince them to use methods of systematic evaluation; like the usage of the MoLE instrument (Bolte, 1995; 2012, in press).

Evaluation of a Lesson Sequence based on SALiS by Means of the Motivational Learning Environment Questionnaire – A Case Study

Innovations in science education are often evaluated on the bases of personal experience and on (more or less) professional reflections of the teachers involved which are gained in the field trial. However, we should be aware of the fact that these impressions are subjective, that they are gathered unsystematically and therefore possibly deceiving and easily misleading; even more so since designer and evaluator are the same person. For this reason we have decided to systematically investigate the success and/or failure of our course sequence by means of conducting the MoLE Intrument. But before we will discuss the results of this evaluation we would like to introduce the MoLE Instrument and the design of our case study.

The Motivational Learning Environment Questionnaires

One method which in our opinion is particularly suited to ascertain to what extent the goals in general and the goals of the PARSEL project in particular have been reached is the analysis of the Motivational Learning Environment (MoLE) using the MoLE questionnaire in its different versions (Bolte 1995; 2008; 2012, in press). The questionnaires for the assessment of the Motivational Learning Environment are based on the pedagogical interest theory (Schiefele, 1998; Krapp, 2002; Häussler & Hofmann, 2002; Hoffmann et al., 1998; Gräber 1998), on the self-determination-theory (Deci and Ryan 1985; 2002), on theories of achievement motivation (Heckhausen 1991) and on reflections from the field of classroom and learning environment research (Fraser 1989). These various concepts of motivation and interest and the results of research on learning environment served as a basis for a "Motivational-Learning-Environment-Model" (Bolte, 2008; 2012, in press).

The different questionnaire versions are well proven, theoretically sound (Köller & Bolte 1994) and statistically of high quality (Bolte 2006) as well as versatile and universally applicable. Questioning the students using the MoLE questionnaires is not particularly time consuming.

Design of the Case Study

In the case study we are going to present in this publication, we have concentrated on two different MoLE questionnaire versions (the IDEAL and REAL version). The MoLE questionnaire in the REAL version collects data by focusing on the students' perceptions and assessment of the learning environment in their science classes in general. In the IDEAL version the students are asked to talk about their expectations in terms of how they would like the motivational learning environment in their science lessons to be. Both versions of the MoLE questionnaire allow data collections regarding the following seven "dimensions of the motivational learning environment" (Bolte 2006):

– satisfaction,
– comprehensibility/requirements,
– subject orientation,
– relevance of the topics,
– students' opportunities to participate,
– class cooperation, and
– individual students' willingness to participate.

Every dimension of a questionnaire version contains only two items. Each item is aimed at a certain instructional feature, which is to be assessed between two poles (and from two points of view; see item examples). There is a seven point rating scale to estimate the items. The statements which correspond to our ideas about a "good" science lesson are coded with high numerical values ("7" to "5"). Negative statements receive low numerical values (between "1" and "3"). The scale value "4" corresponds to a "neither - nor estimation", for example: "The topics in chemistry lessons are... very difficult for me to understand / very easy for me to understand." (REAL version) and "I wish the topics in chemistry lessons to be... very difficult for me to understand / very easy for me to understand." (IDEAL version).

In the past the MoLE questionnaire versions were applied to students in larger studies (Bolte 2006). Hence, we are now able to compare the findings from our 'case study' (n = 61) with results of another sample of students in grades 7 and 8 at a German *Gymnasium* (n = 648), who have experienced only regular (or as we want to call it "conventional") science lessons. This group serves as a control group and the 'case study sample' as the treatment group. Both groups of our sample were asked to fill in the REAL and IDEAL questionnaire versions.

Following this procedure, we are now able to assess the effects of the FUB treatment study from two perspectives: We are able to compare the findings from our treatment group with the findings from conventional science classes (control group) and we can compare the students' "reality" (findings from the REAL assessments) with their "wishes" (findings from the IDEAL assessments).

To allow further insight into this, we calculated – as we term – "Wish-to-Reality Differences" (WRD) by establishing the difference between the IDEAL assessment value and the REAL assessment value. The WRD score makes clear which aspect of the learning environment already fits to the students' expectations and which aspect is – regarding the students' opinion – in need of change.

Interests and Questions of Research

Regarding the SALiS project aims we are trying to answer the following questions:

– What do students in grades 7/8 at a German *Gymnasium* really assess as important concerning a "motivating" learning environment?
– How do students in grades 7/8 who have regular science classes on the one hand and those who took part in our treatment courses on the other hand assess their lessons in general?
– Which aspects of the Motivational Learning Environment in each of the different settings (treatment and non-treatment group) are really in keeping with the students' wishes and which aspects are – in the students' opinion – in the most urgent need of change?

Findings

Looking at the box plots in Figure 1, one can see that it is particularly important to students in grades 7 and 8 at *Gymnasium* to get opportunities to participate in science lessons (median: 6.5) and that they feel at ease in their lessons (median: 6.5). Understanding the topics of the lessons and the students' own willingness to participate are equally important to them (median: 6.0). That the topics covered in science lessons are of personal relevance to the students is important, though compared to the other aspects which have been mentioned it is only of secondary importance (median: 5.0). The same is true for appreciation of class cooperation in science lessons (median: 5.0). Furthermore, the students are comparatively indifferent towards their assessments regarding the importance of subject orientation in science lessons (median: 4.0).

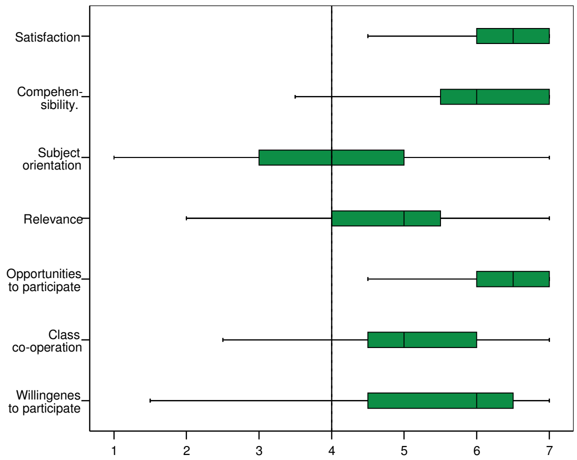

Figure 1: Box plots of the students' wish assessments (MoLE IDEAL version)

Moreover, it is striking that the students' general opinion concerning the dimensions "subject orientation", "willingness to participate" and "relevance" show particularly broad distributions. In this context it is noteworthy that a majority of the students is negatively biased towards specialized explanations and a smaller but still rather large proportion of the students indicate that they do not really want to make an effort in science lesson and do not want to participate in them.

Figure 2 gives an insight into the overall assessment of the Motivational Learning Environment in science classes and shows how students assessed the MoLE items regarding the FUB SALiS approach. First of all one can see that students of grades 7 and 8 assess their science lessons all together positively. The mean scores of six out of the seven dimensions of the learning environment are in part clearly above the theoretical mean value or rather the "neither-nor estimation" (theoretical mean: 4.0). It is only the "relevance" of the lessons' topics which tends to be assessed negatively (mean: 3.8). The following dimensions of the learning environment are assessed particularly favourably by the students: "opportunities to participate" (mean: 6.0), their "own willingness to participate" (mean: 5.3), "satisfaction" (mean: 5.2) and "comprehensibility of the topics" (mean: 5.1).

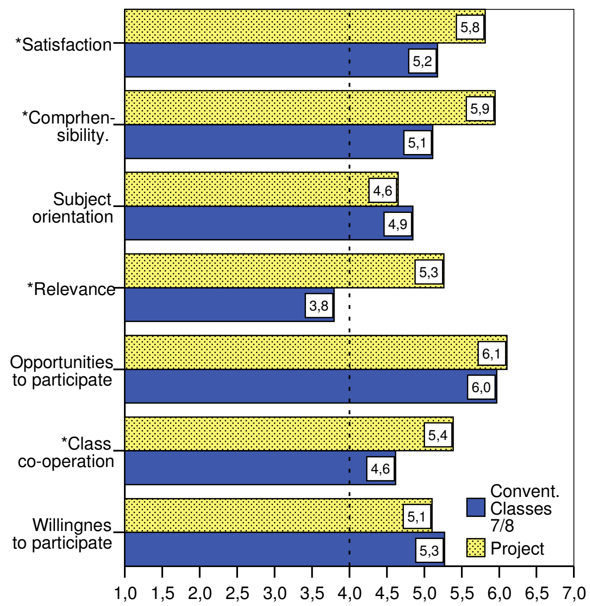

Figure 2: Mean scores of the students' MoLE assessments (MoLE REAL version)

However, looking at the statements of the students who participated in the SALiS Project it becomes clear that the assessment of the Motivational Learning Environment can be much more favourable. It seems this project was successful in making the students become aware of the relevance of the topics that were discussed in the lessons (mean: 5.3). This shift of focus was neither to the disadvantage of subject orientation (mean: 4.6) nor to the disadvantage of their opportunities to participate (mean: 6.1). According to the students, it was also possible to increase the comprehensibility of the topics that were discussed (mean: 5.9), which must have played a part in that the students were all together very satisfied with this project (mean: 5.8). In short, the assessment of the Motivational Learning Environment is considerably better following the FUB Project than following the assessment of conventional science lessons by students.

But, can we now simply sit back due to the overall positive – and in the case of the FUB Project even very positive – results? We do not think so, since the findings shown in Figure 3 reveal that there are in part considerable differences between desirable and "actually" experienced instruction. Conventional science instruction in grades 7 and 8 still shows large deficiencies with regard to the Motivational Learning Environment dimensions of satisfaction (WRD: 0.94), comprehensibility (WRD: 0.78) and relevance of the topics (WRD: 0.86).

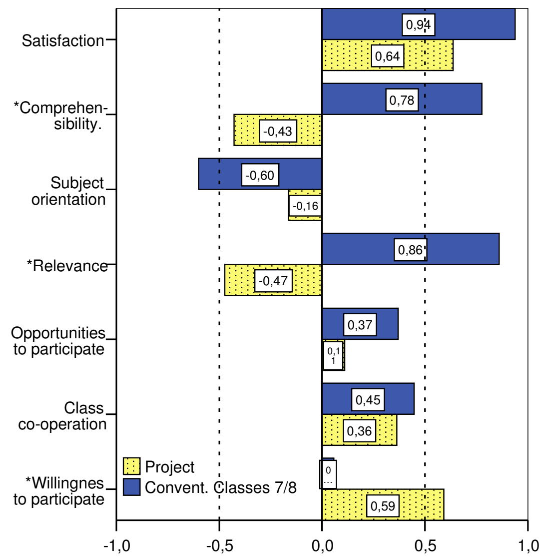

Figure 3: Calculated wish-to-reality difference of the students' MoLE assessments (MoLE WRD = MoLE IDEAL value – MoLE REAL value)

However, these deficiencies can be considerably reduced by choosing particular teaching methods, for example those which are recommended by the SALiS Consortium, as the results of our case study show. By means of the chosen treatment it was possible to reduce, in part considerably, the wish-to-reality differences in almost all areas. But we also have to admit that we were not wholly successful in the project in encouraging the students in their 'willingness to participate and in their willingness to make an effort – according to the students' statements (WRD: 0.59). Trying to explain this result, we suggest that this finding came about because it was subjectively much easier for the students to follow the lessons and to participate in them since they were adequately intrinsically motivated; and generally much more motivated by the topic and the teaching concept as such. From motivation and interest theory we know that students who are intrinsically motivated to learn, and those who are taught about topics that are interesting for them, may achieve a so called "flow-process". In our case flow means that these students do not realise how much effort they really made in a project. There is evidence to suggest that this happened to students who participated in our treatment courses.

Conclusion

One of our major aims of our course sequence and the combined case study was to make it clear to the students that scientific work not only includes conducting experiments, but also finding, working on and evaluating texts and other sources of information. Furthermore, the students should learn that science answers certain questions but cannot answer every question. We have evidence that this is a strength of the FUB course sequence.

The other major aim of the project was the motivating of students to learn science, about the sciences and about the nature of science by showing them how useful scientific knowledge is or can be to answer – for example socio scientific questions – and how strongly scientific inquiry and knowledge are related to our everyday life. The results of the Motivational Learning Environment analyses show how successful the FUB science teaching approach was, both in the eyes of those who developed and taught this project courses as well as – and this is in our opinion the most important point – in the eyes of the participating students.

References

Bolte, C. (2012, in press). How to analyse and assess Students motivation to learn Chemistry, SALiS Conference Book, 2012

Bolte, C., S. Streller, J. Holbrook, M. Rannikmae, R. Mamlok Naaman, A. Hofstein, F. Rauch (2011). PROFILES: Professional Reflection-Oriented Focus on Inquiry based Learning and Education through Science. *Proceedings of the European Science Educational Research Association (ESERA),* Lyon, France, September 2011. http://lsg.ucy.ac.cy/esera/e_book/base/ebook/strand5/ebook-esera2011_BOLTE_2-05.pdf (2012-05-31)

Bolte, C. (1995). Conception and application of a learning climate questionnaire based on motivational interest concepts for chemistry instruction at German schools. In D. L. Fisher (Ed.), *The study of learning environments* (Vol. 8, pp. 182-192). Perth, Australia: Curtin University.

Bolte, C. (2001). How to enhance students' motivation and ability to communicate in science class-discourse. In H. Behrendt, H. Dahncke, R. Duit, W. Gräber, M. Komorek, A. Kross et al. (Eds.), *Research in science education – past, present, and future* (pp. 277-282). London: Kluwer Academic Publishers.

Bolte, C. (2006). As good as it gets: The MoLE-instrument for the evaluation of science instruction. *Proc. Annual Meeting of the National Association for Research in Science Teaching (NARST)*. San Francisco, USA.

Bolte, C. (2007). Assessment for the adaptation of the PARSEL materials in practice – selected by the PARSEL group of Freie Universität Berlin. Retrieved December 22, 2007, from http://www.parsel.uni-kiel.de/cms/index.php?id=60

Bolte, C. (2008). A conceptual framework for the enhancement of popularity and relevance of science education for scientific literacy, based on stakeholders' views by means of a curricular Delphi study in chemistry. *Science Education International*, *19*(3), 331-350.

Deci, E., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Deci, E., & Ryan, R. (2002). *Handbook of self-determination research*. Rochester: University of Rochester.

Fraser, B. J. (1989). Twenty years of classroom climate work: progress and prospects. *Journal of Curriculum Studies*. 21, 307-327.

Gräber, W. (1998). Schooling for lifelong attention to chemistry issues: The role of interest and achievement. In L. Hoffmann, A. Krapp, A. Renninger, & J. Baumert (eds.), *Interest and learning* (pp. 290-300). Kiel: IPN.

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching*, 39, 870-888.

Heckhausen, H. (1991). *Motivation and action*. Heidelberg: Springer.

Hoffmann, L., Krapp, A., Renninger, A., & Baumert, J. (eds.) (1998). *Interest and learning*. Kiel: IPN.

Krapp, A. (2002). An Educational-psychological theory of interest and its relation to SDT. In E. Deci, R. Ryan (eds.), *Handbook of Self-Determination Research* (pp. 405-429). Rochester: University of Rochester.

Köller, O., & Bolte, C. (1994). Learning climate, satisfaction and grades in chemistry in German schools. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST)*. Anaheim, CA, USA. (Polyscript).

PARSEL (2008). Popularity And Relevance of Science Education for Scientific Literacy. http://www.parsel.eu

PROFILES (2010). Professional Oriented Focus on Inquiry based Learning and Education through Science. http://www.profiles-project.eu

Schiefele, U. (1998). Individual interest and learning. In L. Hoffmann, A. Krapp, A. Renninger, & J. Baumert (eds.), *Interest and learning* (pp. 91-104). Kiel: IPN.

SALiS (2011). Students Active Learning in Science. http://www.salis … (2012-05-31)

Streller, S., & Bolte, C. (2007; 2011). Junior climatologists required! – "How can we avoid global climate change? – Reflections on air pollution, tornados and global climate change" – A module for science instruction – especially chemistry – for grades 7 to 10. (2007): http://www.parsel.uni-kiel.de/cms/index.php?id =60 (2012-05-31) (2011): http://www.profiles-project.eu … (2012-05-31)

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Experiencing Inquiry Learning

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Summary

"*SALiS (Student Active Learning in Science) aims at innovating science teaching through a better inclusion of inquiry-based and student-active experimental learning in science classes*" (Kapanadze et al. 2011). One way to reach this aim is to train staff members of universities in the partner countries, who are responsible for the pre-an in-service teacher training in their own institutions. The SALiS-training in laboratory management and in innovative learning methods should help to support the personnel to implement SALiS-ideas in the partner countries successfully. In this paper we focus on inquiry-based learning approaches and present a workshop concept 'Experiencing inquiry learning', which was developed and carried out in collaboration with Sarah Hayes (University of Limerick) and Mario Hoffmann (FU Berlin).

Theoretical background

The literature shows a variety in using the term 'inquiry' regarding education and learning. So you can find inquiry-based learning (IBL), inquiry-based teaching (IBT) or inquiry-based science education (IBSE) (e. g. Rocard 2007, p. 2, 9; National Research Council 2004, p.173-174). What these terms have in common is 'inquiry'. In accordance to Harlen (2010, p. 45) by 'inquiry' we understand: "*... that students are developing their understanding through their own investigation, that they are gathering and using data to test ideas and find the ideas that best explain what is found. The source of data may be the direct manipulation of materials, observation of phenomena or use of secondary sources including books, the internet and people. The interpretation of the data to provide evidence to test ideas may involve debate with other students and their teacher and finding out what experts have concluded. Implicit in all of this is that students are taking part in activities similar to those in which scientists engage in developing understanding. By making these activities conscious, students develop their ideas about science*".

In our opinion in this definition has an important aspect missing and we should add: "*Inquiry requires identification of assumptions, use of*

critical and logical thinking, and consideration of alternative explanations"
(National Research Council 2004, p. 14).

The term inquiry-based learning sets a stronger focus on learning as an active process; the learning process is shifted to the student's side (National Research Council 2004, p 174). Inquiry-based learning (IBL) has its roots in constructivist theory[1]

In contrast 'inquiry-based teaching' (IBT) means the teaching process which is planned and initiated by the teacher, with the goal of bringing students in the process of inquiry-based learning. It is obvious that there is a great overlap between IBL and IBT.

In the following we do not differentiate between IBL and IBT but use mainly IBSE – Inquiry-Based Science Education – which may be understood as the sum of inquiry-based learning and teaching processes *and* the goal to be competent in inquiry-oriented thinking on the part of students. Five characteristics formulated by the National Research Council (2004 p. 24) show the essence of IBSE:

> "*Learners are engaged by scientifically oriented questions"*
> *"Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientificially oriented questions"*
> *"Learners formulate explanations from evidence to address scientificially oriented questions"*
> *"Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding"*
> *"Learners communicate and justify their proposed explanations*".

Transfer to the SALiS-Workshop conception

Based on the theoretical underpinnings we developed the SALiS-workshop 'Experiencing inquiry learning'. This workshop is addressed to staff members at universities, who are involved in pre-service and in-service teacher training, as well as to teachers in school. The aims are to inform the participants of the IBSE-approach and of possibilities to implement this approach in universities and schools.

Due to the different preconditions (cultural, social, religious, financial) in the countries taking part in the SALiS-project, a common approach had to be found which is productive for all participants. Starting points for inquiry-based learning can be phenomena and things from the environment and everyday life that can give rise to questions. These questions can be scientifically investigated in accordance to the IBSE approach. Such a real-life-oriented aapproach provides the involvement with products from food stores, drugstores or pharmacies. These shops are often well-stocked with 'interesting' products. Hence teachers and teacher trainers in each country can easily adapt our product-inquiry proposals to the local conditions. Another benefit is that using products from everyday life offers a low-cost way to start a inquiry process.

Figure 1: Copper cloth, which can be bought in German organic supermarkets

One of the selected products used in the workshop is the 'copper cloth', which is available in some organic supermarkets in Germany (Figure 1). The packaging of the copper cloth is labelled with 'eco' (in German öko), written in green.

If one starts to explore the product and reads intensively the product description on the packing many questions can be formulated, for example: Why is the copper cloth called 'eco'? Why is it made of copper? What does scratchproof mean?

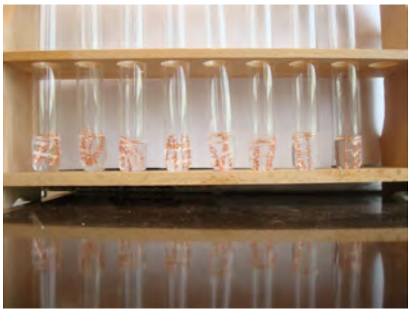
[1] Constructivism is a learning theory. This theory deals with the way people create meaning of the world through individual constructs. The learning process is social, emotional, self-regulated, and active. It is of particular importance for successful learning to have a context and authentic learning environments.

Which function does the copper have? Is the ecological copper cloth environmentally friendly?

With the formulation of a question the scientific inquiry process begins: formulating assumptions, planning and carrying out experiments to test the assumptions, analyzing the data and observations, testing the assumption and maybe formulating new ones… are steps that follow the initial question.

To show in our example if the ‘copper cloth‘ is environmentally friendly or not, small pieces of the copper cloth were put into test-tubes and mixed with household items such as vinegar, ethanol or water (Figure 2).

(a)



(b)

Figure 2: Top (a): pieces of copper cloth in: water, water and soap, water and ethanol, water and vinegar, vinegar essence, ethanol, descaler, hydrochloric acid.
Bottom b): after a few days soaking in the solutions.

After just a few days the blue coloration shows copper ions are present in the solution. The conclusion - that using the ‘eco copper cloth’ is not absolutely environmentally friendly - brings the participants/learners into a discussion about advertising and sales strategies and eventually into processes of critical thinking.

SALiS-Workshop: Experiencing Inquiry Learning

In the Workshop ‘Experiencing inquiry learning’ the participants are invited to explore everyday life products available in the world around them, to think critically, scientifically, and most importantly ask questions from which the inquiry process can begin. Of particular importance is that the participants have opportunities to develop their own questions and assumption, to plan and carry out experiments and that they can develop the inquiry process by themselves. Especially for teachers and for teacher trainers it is not easy to change the roles from being a teacher to being a learner. A fruitful method to accomplish this change of roles is to ‘teach’ the teachers with the same method which is being talked about. By making the change of roles conscious, the processes of reflection can be strengthened and this can contribute to the enhancement of teachers’ professionalisation.

In the following we illustrate the contents of the workshop we created for the SALiS-project and outline the phases involved:

Investigating a household product

Phase 1: welcome and introduction regarding the meaning of IBSE, goals of this workshop.

Phase 2: teachers (in small groups) get ‘interesting’ products from supermarkets (for example copper cloth, effervescent tablets, lactose free milk, bath essence which crackles in water – Figure 3) to stimulate questions and to start the inquiry process.
In this phase the teachers shall:

- talk about the product,
- formulate questions regarding the product,
- select one of the questions,
- formulate assumptions to the question,
- plan an experiment to test the assumption.

Figure 3: Products from supermarkets as a starting point for IBSE

Phase 3: Teachers investigate the questions about the chosen product in the laboratory. In the fortunate case that materials are available to test the teachers' own assumptions experimentally, they should do so. If this is not possible, we also have prepared possible questions, assumptions and experiments for each product. This can be necessary, because it is difficult to prepare a workshop in a way that everybody can investigate their own questions which arise. An example-instruction sheet, concerning the copper cloth is shown in Figure 5.

Phase 4: In small groups teachers are asked to find explanations for the experiments, to reflect on their assumptions, to find answers for the questions and to formulate additional questions. Teachers can use additional information about the product; the information may help to find more detailed explanations and answers.

Phase 5: In the workshop the teachers had their own experience about how inquiry-based learning could work, without the need for any advanced laboratory equipment but with simple everyday products and materials. The steps of inquiry-based learning are summarized and the participants get the opportunity to discuss possibilities of transfer the IBSE approach into their own universities and schools.

Figure 4: Impressions from the workshops conducted at Ilia State University (Georgia), University of Academy of Science (Moldova), Arab College of Education and Oranim College (Israel) – going clockwise

Ecological Copper Cloth

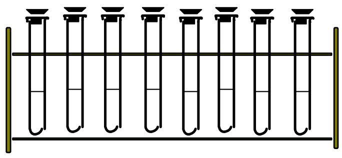
Question I: Is the ecological copper cloth environmentally friendly?

Assumption 1: The ecological copper cloth is not environmentally friendly because acids can attack it and lead to a release of copper ions. These are harmful for organisms.

Assumption 2: The cloth is environmentally friendly because copper is a noble metal, which cannot be attacked by any other substance in the household.

Instructions for testing the assumptions

Fill 8 test tubes with equal amounts of different liquids used as household cleaning products (e.g. water, water with washing-up liquid, table vinegar, vinegar essence, spirit, descaler, hydrochloric acid, bathroom cleaner). Now add same-size pieces of the copper cloth to each of the test tubes and seal them.



At regular intervals (hours and days) take a few drops of liquid from each test tube and add a few drops of concentrated ammonia. A blue colouration (tetramminecopper(II) complex) shows the presence of copper(II) ions.

Product sources: Food stores, organic food stores and pharmacies

Figure 5: Example of a worksheet

References

Harlen, W. (2010): *Principles and big ideas of science education*. The Association for Science Education. College Lane, Hatfield, Herts.

Kapanadze, M., Eilks, I., Janashia, S., Makashvili, M., Stuckey, M., & Markic, S.: Promoting student-active and inquiry-based science learning by the project SALiS. In: *Proceedings of the 9th ESERA* Conference, Lyon 2011 (2012)

National Research Council (2004): *Inquiry and the National Science Education Standards. A Guide for Teaching and Learning*. National Academy Press. Washington D.C. 8.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H.& Hemmo, V. *(2007):Science Education Now: A New Pedagogy for the Future of Europe*. European Commission. Available at: http://www.eesc.europa.eu/resources/docs/rapport rocardfinal.pdf

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Low-Cost Techniques in Science Classrooms

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Introduction

Experiments are a fundamental part of thinking and working in science (Fisher *et al*., 1998). This is true in equal parts for the field of science as well as for its later implementation in engineering and industry. Experiments help students to follow and to understand science. The students experience the unique side of science, that is to say, they ask questions and make hypotheses and let nature respond through experiments and observations (Lunetta et al., 2007; Beasley, 1991). However, experiments also help to develop manual skills, illustrate abstract theories and promote problem-solving thinking (Bradley et al., 1998). The inherent value in experiments in science is that they provide breaks in classroom activity and act as a motivation for students (Lunetta et al., 2007).

However, experiments in science are always associated with costs. Classes with over 30 students quickly create higher financial costs if students also conduct experiments. Thus, traditional experimentation is associated with numerous financial burdens. This is the case for all countries, no matter how developed they are. Also in developed countries, the budget for science education has decreased while, at the same time, the related burdens due to risks and hazardous substance regulations have increased. Also, one has to be aware of the fact that each experiment is associated to certain risks. As a consequence, science teaching is more often required to take place in a traditional classroom setting (Bradley et al., 1998). As a result the students' activities are reduced to its minimum.

In this regard, low-cost experimentation offers an alternative. In low-cost experimentation, cheaper and more easily accessible equipment replaces expensive equipment. Equipment and chemicals from everyday life reduce costs and are accessible everywhere. A key aspect of this principle is its simplicity and its good overview of the instruments used (Pike, 2006). The use of alternative experimental equipment, as well as the type and quality of the chemicals used, lead to a reduction of cost (Bradley et al., 1998). At the same time, hazardous equipment, as well as risky chemicals, are replaced with safer alternatives.

Furthermore, the low-cost approach follows quite different strategies. An important technique, in particular for chemistry, is the minimization of the amount of chemicals used (e.g. in microscale, see Hugerat, Schwarz & Livneh, 2006). This best way to conserve resources and avoid pollution, as well as avoiding disposal problems, is to use smaller amounts, of less hazardous and less toxic chemicals. Furthermore, they will also reduce the potential risks in handling substances because much smaller amounts of chemicals are used in these experiments (Wood, 1990; Singh et al., 1999). The equipment and the substances are reduced as much as possible without compromising accuracy (Pike, 2006). Thus, the multitude of chemicals in chemical experiments can be reduced from several milliliters used traditionally, to a few microliters of liquids or from several grams to a few milligrams in solids (Szafran et al., 1989). In this case, one speaks of the transition from the macro technique to the semi-micro, micro or ultra-micro technique. The micro or semi-micro technique is particularly well suited for science teaching in schools and in teacher training. Overall, the amount of chemicals used in the consistent execution of experiments is reduced by a factor of 10 following the microscale principle, while a reduction by a factor of up to 100 is possible (Szafran et al., 1989). The mentioned reduction applies to both the amount of the substances used and the amount of the substances which have to be disposed of. In line with societal, safety and economic demands, experiments in the laboratories of universities and industry become therefore less hazardous, more environmentally friendly and more cost-effective. Thus, the low-cost principle, according to Singh et al. (1999), ensures that experiments in science education are not omitted due to high cost.

Furthermore, in the low-cost experiment a replacement of the traditional experimental and laboratory use takes place, where materials from the household are used for scientific experiments in the school context. Examples include household containers, such as pots, jars, bowls or old plastic bottles. However, materials such as disposable articles used in medicine, or that come from a home improvement store, an aquarium store or an electronics specialists store are used. Following Obendrauf (2006), the minimization of the equipment in combination with the use of inexpensive resources has a double-saving potential. Thus, the possibilities of a more frequent and flexible use are increased. Wood (1990) describes the benefits of using alternative equipment as following:

- Lower costs through the use of resources taken from medical engineering, home improvement stores, electronics specialist stores or everyday use.
- Availability of the resources in large numbers due to the lower purchase price. Thus, it is possible for almost all experiments to be carried out in small groups of students.
- Reduced risks in comparison to traditional glassware due to the lower risk breakage.
- Less time required for the preparation and clearing up for the teachers.
- Increasing of mobility because the equipment can be transported and used without restrictions, so that specially equipped laboratories are not required.
- Experiments can also be carried out as homework.

Similar to the replacement of traditional laboratory equipment, the substances used can also be replaced. Experiments with food, detergents, household chemicals or solids taken from the kitchen and garage, complete the techniques mentioned above. These substances cannot only be purchased for a lower cost in supermarkets, home improvement stores or pharmacies, but also dealing with and transporting them is easier. In addition, the handling of these resources is more motivating, since the students are working with substances which already play a role in their lives. Overall, the presented principles are therefore ideal to promote student-based active experimentation and learning in science (Joling, 2006).

In following sections, different low-cost techniques will be presented.

Experiments with resources from medicine and aquarium engineering

A common problem with experimentation in chemistry classes is that the instruments are often made of glass. This glassware is expensive and can easily get broken. Therefore, it represents a potential source of risk to the students and must be replaced when damaged, which might be associated with extensive costs (Obendrauf, 2006; Bradley, 2006). However, a wide variety of medical equipment provides alternatives to traditional laboratory devices. Syringes, cannulas, cut-off stopcocks, infusion tubing and infusion bags are produced in large quantities for the medical sciences. Thus, they are priced accordingly.
(**Note:** it is not recommended to reuse hospital or medical waste but new items can be bought from hospital suppliers.)

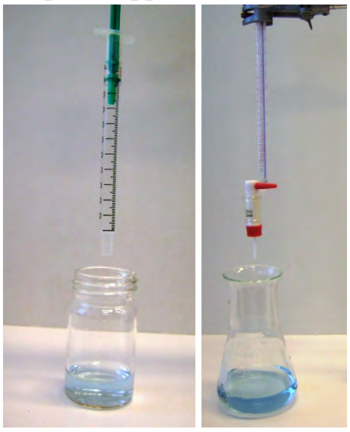

Figure 1: Syringes used as burettes

The possibilities of application of disposable syringes are widely diversified. For instance, Singh et al. (1998) propose medical disposable syringes as a replacement for pipettes and burettes in a microscale titration (Figure 1). When using disposable syringes as burette replacements, liquids must be filled in the syringe without any air bubbles. For this purpose, first some liquid is taken up with the syringe and then abruptly forced out again. If this process is repeated several times, the bubble-free filling of the syringe can be managed. The synthesis and the absorption of gases in syringes by Obendrauf (2006) has been well established as well (Figure 2). Therefore a soft rubber stopper, which is pierced with two cannulas, is set on a conventional test tube.

CAUTION: the cannulas are sharp, metal needles and great care must be exercised when using them.

A 2 mL disposable syringe is used to drip liquids into the tube, while the evaporating gas is collected in the 20 mL disposable syringe. In the low-cost gas generator, many gases can be synthesized.

Figure 2: Gas production

Experiments in petri dishes and spot plates

Many experiments in science can be easily conducted in petri dishes containing one, two or three compartments or on spot plates made of plastic. Here we will demonstrate, with the help of a Daniell cell, how an LED can be used as a current and voltage meter. This requires a two-chambered petri dish, a piece of zinc wire, a piece of copper wire, connecting wires, a LED, a zinc sulfate and a copper sulfate solution. The materials are put assembled as shown in Figure 3.

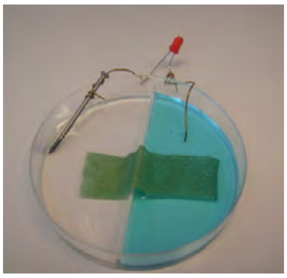

Figure 3: Daniell cell in a petri dish

However, petri dishes open up additional possibilities. For instance, the lid of the petri dish can create a closed space. In this case, a gas exchange between the chambers of the petri dish can take place. However, gas exchanges with the environment do not take place. Examples are the preparation and experimental analysis of chlorine gas from bleach solution (Choi, 2011) and the synthesis and the detection of carbon dioxide (Full, 1996). Here, one chamber of the petri dish is filled with limewater. The second chamber is filled with a piece of marble, which is in contact with hydrochloric acid (Figure 4).

Figure 4: Synthesis and detection of carbon dioxide

Experiments using waste household containers

What some people see as rubbish can be used for or chemical and physical experiments. For instance, the use of empty pill packages, glass, tin cans, plastic cups or containers of cosmetic products are very well suited.

Thus, a metal can is well suited for the construction of a battery, since the wall of the can may be used as an electrode. The upper part of the can should be removed and the cleaned container is filled with a sodium chloride solution. The body of the can serves as an electrode and is connected to a crocodile clip or a voltmeter by using a wire. In order to complete the circuit, a graphite electrode or a pencil lead is dipped into the solution by using a crocodile clip (Figure 5).

Figure 5: A simple battery

The design of pill packages is strikingly similar to spot plates made of plastic. These empty pill packages also have the same benefits as the multiwell plates. Once the aluminum foil is removed from the drug packages, all the experiments, which can be conducted in spot plates, can also be conducted in an empty pill package. The color scale of red cabbage indicator is shown in Figure 6.

Figure 6: Color scale of red cabbage indicator

Even models in biology can be created in such a way, like the model of the eye. Through this model, the students learn about the functioning of an eye. For this model, a cardboard box, duct tape, a magnifying glass, play clay (plasticine) , a paper tissue, a flashlight and a globe-shaped vase (or a glass teapot) are required (Ardley, 1997). The paper tissue is glued on the outside of the vase and a figure is cut in the cardboard box. Then the vase, the magnifying glass and cardboard box are built together and stabilized with the help of modeling clay as shown in Figure 7.

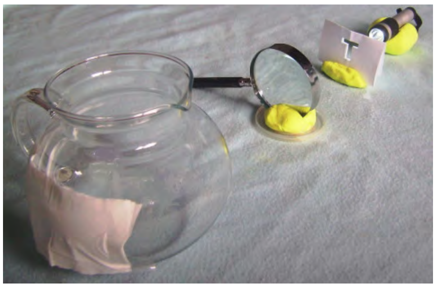

Figure 7: Model of an eye

Experiments with plastic bottles

This section discusses how plastic bottles are well suited for various experiments. According to Wilke (1998) an experiment for the demonstration of the third Newton's law can be conducted if a plastic bottle is suitably prepared. Some bendable straws, glue, a thin thread and a plastic bowl are required. For the experiment, the plastic bottle is placed closely above the ground with the help of three drill holes, which have a length of 4 mm each and which are set apart by 120°. A bendable straw is inserted in each of these holes. One of the side lengths of each straw has been shortened (see Figure 8). The straws have to be attached to the plastic bottle using the glue. Also, the straws have to be bent in an angle of 90°.

Figure 8: Straws in a plastic bottle

More information about the low-cost techniques and the list of different experiments can be found at the SALiS website: www.salislab.org

References

Ardley, N. (1997). *101 spannende Experimente aus Wissenschaft und Technik.* Bindlach: Loewe-Verlag.

Bradley, J. (2006). The Microscience Project and its Impact on Pre-service and In-service Teacher Education . In M. Hugerat, P. Schwarz, & P. Livneh, *Microscale Chemistry Experimentation for all Ages* (p. 26-39). Nazareth, Israel: Al-Nahda.

Bradley, J. D., Durbach, S., Bell, B., & Mungarulire, J. (1998). Hands-On Practical Chemistry for All - Why and How. *Journal of Chemical Education, 75* (11), 1406-1409.

Beasley, W. (1991). Matching Laboratory Learning Goals to Evaluation of student Performance: A Standards-Based Approach. *Journal of Chemical Education, 68 (7)*, 590-591.

Choi, M. M. (2011). Microscale Chemistry in a Plastic Petri Dish: Preparation and Chemical Properties of Chlorine Gas. *Journal of Chemical Education*, 79 (8), 992-993.

Fisher, D., Harrison, A., Henderson, D., & Hofstein, A. (1998). Laboratory Learning enviroments and practical tasks in senior secondary science classes. *Research in Science Education, 28*, 353 - 363.

Full, R. (1996). Lichtblicke - Petrischalenexperimente in der Overhead-Projektion. *Chemie in unserer Zeit,* 30 (6), 286-294.

Joling, E. (2006). Introduction of Microscale Chemistry in the Netherlands. In M. Hugerat, P. Schwarz, & M. Livneh, *Microscale Chemistry Experimentation for all Ages* (p. 183-197). Nazareth, Israel: Al-Nahda.

Hugerat, M., Schwarz, P., & Livneh, M. (2006). *Microscale Chemistry Experimentation for all Ages.* Nazareth, Israel: Al-Nahda.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Learning and Teaching in the School Science Laboratory: An Analysis of Research, Theory and Practice. In S. K. Abell, & N. G. Lerderman, *Handbook of Research on Science Education* (p. 393-442). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Obendrauf, V. (2006). Fundamental Microscale Experiments from Austria, Presented Worldwide. In M. Hugerat, P. Schwarz, & M. Livneh, *Microscale Chemistry Experimentation for all Ages* (p. 300-321). Nazareth, Israel: Al-Nahda.

Pike, R. M. (2006). Through the Years with Microscale Chemistry. In M. Hugerat, P. Schwarz, & M. Livneh, *Microscale Chemistry Experimentation for all Ages* (p. 13-25). Nazareth, Israel: Al-Nahda.

Singh, M., M., McGowan, C., Szafran, Z., & Pike, R. M. (1998). A Modified Microburet for Microscale Titration. *Journal of Chemical Education, 75 (3)*, 371.

Singh, M. M., Szafran, Z., & Pike, R. M. (1999). Microscale Chemistry and Green Chemistry: Complementary Pedagogies. *Journal of Chemical Education 76* (12), 1684 - 1686.

Szafran, Z., Singh, M. M., & Pike, R. M. (1989). The Microscale Inorganic Laboratory - Safety, Economy, and Versatility. *Journal of Chemical Education*, 66 (11), 263-267.

Wilke, H.-J. (1998). Überraschende Experimente mit Kunststoffflaschen: Eine Einführung in die Beitragsreihe. *Der Mathematische und Naturwissenschaftliche Unterricht, 51* (1), 20-25.

Wood, C. G. (1990). Microchemistry. *Journal of Chemical Education, 67* (7), 596-597.

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One of the workshops in the Arab College of Education, Haifa in Dec. 2011

Using Science Demonstrations to Develop Thinking and Inquiry Skills

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Introduction

Demonstrations are widely used in lectures and in lessons to capture student's interest or to illustrate something. They may be used in magic shows without explanation or in teaching with the explanation and connection to the topic being taught. Often the student is a passive recipient of impressions or ideas, rather than an active participant. As part of the TEMPUS SALiS project on 'Student Active Learning in Science' we have developed a lecture demonstration presentation to show how demonstrations can be used to encourage students to think and become more actively involved, thus promoting scientific inquiry and learning. This article describes the approach used in the lecture as a model for using the various examples in a teaching situation. (Additional examples will be found on the SALiS website.)

The format of the lecture was that a demonstration was introduced and performed and then the audiences were asked questions to help them think about what they had seen, to suggest explanations, propose hypotheses to explain what had happened and suggest further experiments to test their ideas. The science behind the demonstration was then explained after the audience had time to discuss and come up with their own ideas. In a teaching situation it is envisaged that each example would be developed and would lead to further discussion and experimentation, consolidating the material and developing a deeper understanding of a scientific approach to problems. This was not possible in a lecture setting and this article follows the format of the lecture: first the demonstration is described, with information on how to do it; sample questions are then given to stimulate thinking about the example; and finally an explanation is given for the teacher. However, it should be stressed that the teacher is not expected to jump straight to giving the answer but should lead the students through the process of questioning, hypothesising and testing ideas, only giving the explanation at the end.

The purpose of this inquiry-based teaching approach is to:

- stimulate thinking and to get your students involved – 'minds-on';
- use demonstrations and experiments to encourage thinking not just to provide answers;
- not use demonstrations just as science magic, because we want to end up with answers and develop scientific thinking not just arouse amazement.

The importance of questioning

"I keep six honest serving men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who."
Rudyard Kipling

This famous poem by Rudyard Kipling reminds us how important questions are in teaching. We want to get our students involved in thinking, discussing, proposing solutions and questions are the way we can start this process.

Some points to bear in mind when using demonstrations for inquiry-based learning:

- Make it interactive: the demonstrator should interact with the audience and get them involved;
- Ask questions throughout to raise the level of involvement;
- Get them to make observations as the demonstration proceeds;
- Stimulate thinking by showing unusual things, often known as discrepant events (Fensham and Kass 1988; Liem,

1990),which can be used to provoke discussion;

- Encourage discussion amongst students, so they argue with each other about what is going on and sharpen their ideas;
- Ask students to suggest why the demonstration works and what this means;
- Get them to suggest possible reasons and how they could test them experimentally;
- Ask 'what if?' to take the demonstration further by extending it and if possible do this and test out ideas.

We want to move beyond the belief that hypotheses are not speculations, but can in fact be tested by further experimentation, and that experimental evidence is used to test them.

In the following section some of the demonstrations covered in the lecture are described to illustrate the approach used.

Colour changes

Colour changes are one way of recognising a chemical change and when the changes are unexpected or are presented in a 'magic show' format they can be used to stimulate thinking. Some examples are given below.

a) **Magic writing:**

How to do it:
An invisible message is written using phenolphthalein solution on a sheet of paper or the back of a lab coat. This is then sprayed with a colourless solution (0.1M NaOH or dilute ammonia solution) and a pink message appears. When left for some time this message disappears.

What is happening?
Why can a colourless solution produce a pink colour?

The students might recognise the colour of phenolphthalein from titrations and guess that the solution sprayed might be a base.
How might you test the solution that was sprayed? Litmus or universal indicator would show that the solution was basic. Testing with phenolphthalein would produce the same colour as that observed.
Why does the colour slowly fade?
Is this due to light or something in the air?
This is more difficult to explain and there could be several explanations. If it was due to light then we could leave the message in the dark and see if it still disappeared.
However, knowing the colour is due to an acid-base indicator that goes from colourless to pink with base, might lead to the suggestion that if it changes back an acid must be involved to neutralise the base or that the base evaporates reversing the reaction. Where could the acid come from? From the cloth or paper or from the air? The same thing happens for cloth and paper so it is more likely to be the air. Is there anything acidic in the air? What about carbon dioxide? How could you test this hypothesis? We could put the coloured cloth in air with no carbon dioxide. We could test whether bubbling carbon dioxide through dilute sodium hydroxide plus phenolphthalein, changes the colour from pink to colourless. We could put the paper or cloth in a jar containing carbon dioxide.

The explanation:
The cloth or paper contained an invisible message written in phenolphthalein solution. When sprayed with dilute sodium hydroxide (or another base) the indicator changed from colourless to pink. However, air contains a small amount of carbon dioxide which slowly reacts with the alkali, neutralises it and thus removes the pink colour. This is a slow reaction due to the low concentration of carbon dioxide in air and the fact that it has to diffuse into the paper or cloth and react.
For more ideas for magic writing see:
http://www.nuffieldfoundation.org/practical-chemistry/magic-writing
http://www.rsc.org/Education/Teachers/Resources/Practical-Chemistry/Videos/magic-writing.asp

b) Anyone for wine? Water into wine

How to do it:
A cup of 'water' is poured into a glass and turns pink. Water into wine! This is then poured into a

series of glasses and turns first colourless, then it fizzes (lemonade), turns white and cloudy (milk), and finally the milk turns pink (indigestion mixture).

What is happening?

How can the various changes be explained? The demonstration presupposes some knowledge of acid-base chemistry and indicators, and tests for common ions. These are often done in introductory chemistry classes and thus this demonstration is an interesting way to revise this material.

What could change water into wine and then back again?

The characteristic colour of phenolphthalein should suggest that the initial 'water' is a dilute alkali and the first cup contains phenolphthalein. To remove the colour we need an acid, so the second glass contains a small amount of a more concentrated acid than the original alkali.

What causes the fizzing to produce 'lemonade'? What fizzes with an acid?

It could be a carbonate or hydrogencarbonate, as there is no smell.

What causes the colour change to 'milk' in the next glass? What could the white precipitate be? It must be something that reacts with the chemicals from the previous step. White precipitates commonly covered include barium sulphate (test for sulphate ion) or silver nitrate (test for chloride ion). This would mean that the acid used in step 2 was either sulphuric acid or hydrochloric acid. How could you check which it was?

In the final step the white precipitate turns pink. What could cause this? Since we know we have phenolphthalein present, the final glass must contain an alkali to neutralise any remaining acid, thus restoring the basic colour of phenolphthalein.

The explanation:

The original glass contains 0.1M NaOH(aq) and the second class a few drops of phenolphthalein, which turns pink in the alkali. The third glass contains a few drops of 1M sulphuric acid. This is concentrated enough to neutralise the acid and change the phenolphthalein back to colourless. The fourth glass contains a small amount of solid sodium hydrogencarbonate or a few drops of concentrated solution. It fizzes as the acid reacts and liberates carbon dioxide. The fifth glass contains a small amount of saturated barium nitrate solution or barium chloride solution. This forms a white precipitate of barium sulphate from the sulphuric acid. The sixth glass turns pink, colouring the white precipitate. It contains a few drops of 1M sodium hydroxide which neutralises any remaining acid and turns the solution alkaline.

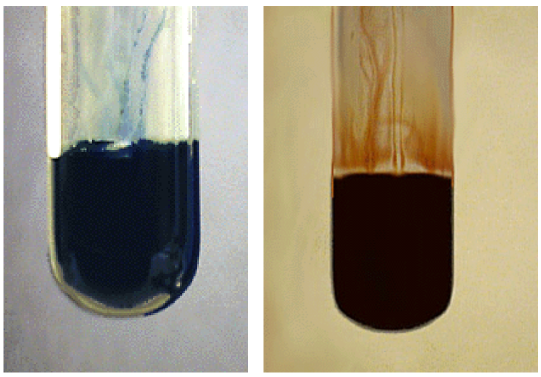
There are many variations on this demonstration and it provides a good way to revise acid-base reactions and tests for common ions. You could extend it by asking students to devise their own series of colour changes using the chemistry they have covered in class.

For a video see: http://www.rsc.org/Education/Teachers/Resources/Practical-Chemistry/Videos/turning-wine-int-water.asp

c) Red blood or blue?

How to do it:

A spray bottle or a jug contains a yellowish solution. When sprayed onto a piece of blank paper, writing in a mixture of red and blue letters appears. Alternatively when poured into two glasses, one turns blood red and the other dark blue.



What is happening?

How can one solution produce two totally different colours?

There must be something different on the paper or in the glasses to produce two different colours. What sort of reaction could it be? They could be acid-base reactions with two different indicators. The yellow colour of the initial solution is a clue – what could this be due to? What tests could you do on this solution? Acid or base? What happens if you add a base?

The explanation:
The solution is an iron(III) salt, which will be acidic. On adding a base a yellow/red precipitate of iron(III) hydroxide is formed. Iron is a transition metal and forms coloured complexes and compounds. The first glass contains a small amount of thiocyanate ions (from potassium, KCNS, or ammonium thiocyanate, NH_4CNS), which form a blood-red complex with iron(III) ions. The second glass contains a small amount of potassium ferrocyanide ($K_4[Fe(CN)_6]$), which forms a dark-blue precipitate (Prussian blue) with iron(III) ions. The invisible writing is made using thiocyanate ions (red letters) or ferrocyanide (blue letters).

Other colour changes are possible using iron(III) ions by forming different complexes or changing the pH, so that one solution can be changed into several different colours.
For more information:
http://www.flinnsci.com/media/514015/cf10371.pdf
http://www.thecatalyst.org/download/demos/2message.pdf
http://chemistry.about.com/od/chemistrydemonstrations/a/Olympic-Ring-Colors-Chemistry-Demonstration.htm

d) The blue bottle

How to do it:
A stoppered 500 cm^3 flask contains a solution. When shaken the solution turns blue and when left to stand the solution slowly goes colourless again. Further shaking restores the colour, whose intensity depends on how long the flask is shaken. The stronger the colour the longer it takes to discolour. After some time the contents of the flask may become yellowish but the blue colour will still appear on shaking. Eventually, however, after prolonged shaking no blue colour will be produced on shaking.

What is happening?
Why does the solution change colour when shaken? Why does the colour disappear slowly on standing? Why does the intensity of the colour and the time taken to discolour depend on how much it is shaken? Why does the process eventually stop after prolonged shaking? Clearly a chemical reaction is taking place and it is reversible. It is initiated by shaking. Some people will suggest it is due to the energy being put in by shaking. Others will suggest it is due to the mixing of the air and the solution. What is reactive in air? It could be an acid-base reaction due to CO2 but levels of this are very low and the reaction would soon stop. Oxygen is the most reactive gas. How could we show it was due to the reaction with oxygen? We could fill the flask with nitrogen or carbon dioxide and repeat the experiment. It is easier and more dramatic, to fill up the flask with water. After the initial blue colour fades, no more colour is produced on shaking. However, when some of the water is poured away the blue bottle starts working again.

The explanation:
The bottle is made up as follows: half-fill the 500 cm^3 flask with tap water. Add ~5 g glucose and shake to dissolve and then ~ 5g sodium hydroxide and shake to dissolve. Add ~1 cm^3 of 0.1% methylene blue solution. The concentrations are not critical although it is important not to add too much methylene blue or it takes too long to decolourise. Stopper and shake. The solution is an alkaline solution of glucose, which is a reducing agent. Methylene blue is a redox indicator which is blue in the presence of oxygen and colourless in its absence. Shaking dissolves air and hence oxygen in the solution. This turns the methylene blue to its blue form. The glucose then reacts with the oxygen and uses it up and the methylene blue turns colourless. This is a slow reaction and so the colour fades slowly. The stronger the initial colour (due to high oxygen concentrations), the

longer it takes to go clear. Eventually all the oxygen in the air in the flask will be used up and the reaction will stop. The solution runs yellowish due to the oxidation of the glucose. Other indicators e.g carmine red, can be used to make a red bottle.
For more information:
http://www.nuffieldfoundation.org/practical-chemistry/blue-bottle-experiment
http://www.youtube.com/watch?v=e6bHEIQPzo4

e) The iodine snake experiment

How to do it:

Two large measuring cylinders are set up, inside a large plastic bowl or tray. 25 cm^3 of 30% hydrogen peroxide solution is poured into one and 25 cm^3 of 6% hydrogen peroxide solution is poured into the other. Nothing appears to happen. A few squirts of washing up liquid (liquid detergent) are put in each cylinder. Nothing appears to happen. Simultaneously add ~10 cm^3 of 10% potassium iodide solution to each cylinder and observe what happens. The mixture starts to bubble and foam is produced which moves up the measuring cylinder until it overflows at the top and cascades down the side. The one with the 30% hydrogen peroxide solution reacts faster and produces more foam than that with the 6% solution. The foam is a yellow-brown colour.

The demonstration can be set up again and done by adding ~1 g manganese(IV) oxide solid (MnO_2,s) instead of potassioum iodide solution. The same reaction happens except now the foam is not coloured but may be dirty due to the trapped solid. It can also be done using 30% hydrogen peroxide solution plus washing-up liquid and then adding to one some pieces of raw liver and to the other cooked liver.

What is happening?

Why does nothing happen until the potassium iodide solution is added? What is the purpose of the washing up liquid? Why is in a foam produced and what is in the bubbles? Why does the 30% hydrogen peroxide solution react faster and produce more foam? Why is the foam coloured? How could you identify the gas in the bubbles? What would happen is you used 15% hydrogen peroxide solution? Why does nothing happen until potassium iodide solution, manganese(IV) oxide solid or fresh liver is added? What is the role of these substances? Why does nothing happen if cooked liver is used?

The explanation:

Hydrogen peroxide is a strong oxidising agent and is relatively unstable. In the presence of a catalyst it decomposes to give oxygen gas and heat. The gas given off produces a foam with the washing-up liquid so that the bubbles contain oxygen gas. The more concentrated the hydrogen peroxide solution the faster the reaction and the more oxygen is given off, thus the foam rises up faster in the cylinder and more foam is produced. The identity of the gas can be shown by the fact that glowing splint is rekindled if inserted into the foam and a lighted splint burns brighter. With potassium iodide solution there is a reaction and some iodide is oxidised to iodine, which colours the foam yellow-brown. Manganese(IV) oxide solid is only a catalyst but tends to get carried up in the foam making the foam look dirty. Fresh liver contains the enzyme catalase, which catalyses the decomposition of hydrogen peroxide. Cooking the liver destroys the enzyme so that there is no reaction when added to hydrogen peroxide solution. 30% hydrogen peroxide solution can be diluted by a factor of 5 to prodce 6% solution and by a factor of 2 to produce 15% solution. As this is ~ half-way between the other two concentrations we would predict it to react faster and produce more foam than 6% but slower with less foam than 30%.
For more information:
http://www.youtube.com/watch?v=2qlb8X_ffO8&feature=related
http://cldfacility.rutgers.edu/content/catalytic-decomposition-hydrogen-peroxide-potassium-iodide

Conclusion:

In this article we have just given a few examples of the demonstrations done in the lectures during the SALiS workshops, in order to give you a flavour of the approach. The use of questioning to develop thinking skills through demonstrations can be applied to many other demonstrations and gives added value to traditional demonstrations, often just used as science magic to arouse interest. We want to go beyond this to developing both scientific method and scientific understanding. The more chemistry or science the students have done, the more they can use their previous understanding and knowledge to explain new phenomena. They should also be encouraged to try out the demonstrations themselves, as they use readily-available chemicals and are low-cost, particularly if they test their out own hypotheses or investigate variations of the standard demonstrations.

References

Fensham, P. J. and Kass, H. (1988) 'Inconsistent or Discrepant Events in Science Instruction', *Studies in Science Education,* 15(1), 1-16.

Liem, T, (1990), *Invitations to Science Inquiry*, 2nd edition, Science Inquiry Enterprise

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SALiS on the Web

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This paper describes the SALiS-website (www.salislab.org) as the major instrument of dissemination of SALiS materials beyond the project partner institutions. Exemplary resources from the website will be presented. The materials are available in many different languages. The website is designed to be a valuable resource for science teachers and science teacher educators in various countries.

Introduction:

The project "Student Active Learning in Science" (SALiS) was funded by the TEMPUS IV program of the European Union. TEMPUS IV is focusing on "Modernizing higher education in EU neighbours". SALiS focuses on modernizing science teacher education as part of higher education in the EU neighbouring countries: Georgia, Moldova and Israel. The central objective of SALiS was to develop, implement and disseminate modernized curricula and materials for science teacher training within the participating countries, but also to collect and develop materials which would support science teachers and science teacher educators in various countries beyond the SALiS project. The central instrument for dissemination, both within the participating countries and beyond, is the SALiS website at *www.salislab.org*.

The SALiS website was developed and designed at the University of Bremen (Germany) and represents all the content developed by the different SALiS partners. The webpage describes the activities of the partners and the project as a whole. The website contains a description of the project and its objectives and presents the materials which have been produced within the SALiS project.

The central access to the website is in English. Nevertheless, jointly used materials were also translated into the other SALiS language (German, Bulgarian, Georgian, Romanian, Arabic and Hebrew). Additional materials developed in the different SALiS partner institutions are also available in their local languages. Specific materials from the partners referring to the national curricula and circumstances in the respective local languages are important to influence reform in science education within the participating countries beyond the partner institutions.

Content of the website

The SALiS website includes information about the project, the SALiS-philosophy, objectives, and the administrative framework of this TEMPUS IV project. Information about all the partners and access to the local SALiS labs within the partner information is available too. A calendar shows important meetings and conferences of the

SALiS-project. The front page has a navigation menu to access the different features (Figure 1).

For non-SALiS members the outcomes from SALiS might be of most interest. For universities in the EU-neighbouring countries, the newly developed science teacher training materials might be used as examples of good practice within the ongoing reform in science teacher education.

Of even broader potential use might be the materials that have been developed for the SALiS teacher training workshops. The SALiS project developed a Teacher Guide on techniques for Low-Cost- and Microscale-Experimentation in the science classroom (Poppe, Markic & Eilks, 2011). This guide (originally in German) is available in all the SALiS languages, including English (Figure 2). The website also includes descriptions of more than 200 low-cost experiments for science teaching in all science domains and all school levels. Also these descriptions are available in the different languages, including English. These experiments can be used for school science teaching, as well as in teacher training programs.

Presentations for staff and teacher training, which have been prepared for SALiS-meeting are available, and can be used for local trainings too. Powerpoint presentations are available about theoretical justifications for student-active learning in science, motivation in science education, experiencing inquiry learning, low-cost-techniques in science, or safety in the laboratory. Links on the webpage refer to content in related projects, e.g. with low-cost-techniques or experiments on video.

A list of publications from SALiS will provide an overview about the dissemination of the project and will provide further information. All of these materials will help to promote pre-service science teacher education and the continuous professional development of teachers.

Figure 1: Screenshot from the SALiS frontpage on the website

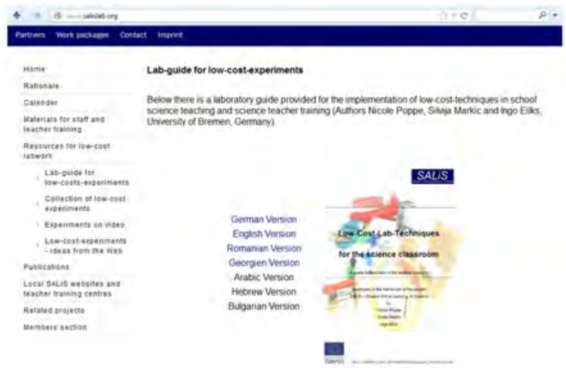

Figure 2: Access page to the Low-cost lab guides

All the content of the website was developed and collected through the course of the SALiS project. Single elements will be updated during the final phase of the project. Additional materials will be added even beyond the end of the project.

References

Poppe, N., Markic, S. & Eilks, I (2011): *Low-cost-lab-techniques for the science classroom.* Bremen: SALiS Project (published in English, Arabic, Bulgarian, German, Georgian, Hebrew and Romanian).

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The Impact of the TEMPUS-project SALiS from the Perspective of Georgia

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After the end of the Soviet Union time the intended change in education still seeks to overcome a centralized and teacher-centered paradigm in science education in Georgia. National reforms ask for more student-active and problem-based science education under inclusion of students' hands-on and inquiry-based learning in the laboratory. Unfortunately, teaching materials and teacher training facilities are not well enough developed to support sufficiently the intentions of the reform.[1]

As a response to this situation, the TEMPUS-project SALiS (Student Active Learning in Science) was established. The project is led jointly by the Ilia State University in Tbilisi, Georgia, and the University of Bremen, Germany. SALiS aims at promoting science teaching through a better inclusion of student-active experimental learning in science classes. SALiS promotes inquiry-type lab-work as one of the foundations of modern curricular and methodological approaches in science teaching to reach higher order cognitive skills, a better learning of science concepts, and to enhance the understanding of the nature of science.[2]

With the help of the TEMPUS-program of the EU, an innovation of infrastructure and teacher training was implemented in Georgia. New laboratories for science teacher training were founded and equipped at Ilia State University and Kutaisi State University. Curricula were changed and the staff members were trained to train teachers more thoroughly in inquiry-based science education involving more student activity, especially based on low-cost and microscale laboratory techniques.[3]

Staff from Ilia State University and Kutaisi State University visited two European Universities – the Free University of Berlin, Germany and University of Limerick, Ireland. During the visit in Berlin SALiS partners had the opportunity to attend experimental out-of-school courses with children (age 9 to 10) KiWi, seminars with practical exercises with pre-service teacher students and in-service-teacher training courses. During the visit in Limerick SALiS partners took part in a Workshop on Chemical Demonstrations and Chemical Magic Shows with Irish teachers.

Workshop at the University of Limerick, June 2011

Two workshops were organized at Ilia State University. The first workshop was done by all European Partners in September, 2011. The materials for this workshop have been developed by the EU universities, in collaboration with other partners. These materials were translated in Georgian language and published.

Another three-day workshop on simple low-cost science demonstrations and experiments, was conducted by Peter Childs and Sarah Hayes from Limerick University, for the science teachers of the secondary schools in Georgia and for the academic staff of SALiS partner universities - Ilia State University and Kutaisi State University, but also for the academic staff for other Georgian Universities – Batumi State University and Telavi State University.

Workshop at Ilia State University, Tbilisi

Participants at the workshop in September 2011

SALiS courses were piloted at Ilia State University during the spring semester 2012 and afterwards they were evaluated. This information will be used for the development of the final version of the curriculum and of the teaching & learning materials.

Teaching and learning materials, labguides were developed, translated into the Georgian language and published.
The results of the project are disseminated by the SAliS website (www.salislab.org), on international conferences in Dortmund, Istanbul, Rome.

Five training modules will be accredited for September, 2012 and trainings for in-service Science teachers will be done at Ilia state University in SALiS Laboratory. These modules are:

1. Student Active Learning in Physics for basic and high school
2. Student Active Learning in Chemistry for basic and high school
3. Student Active Learning in Biology for basic and high school
4. Student Active Learning in Science for elementary school
5. Student Active Learning in Science for the 7th grade (integrated course)

Through the SALiS training modules, the dissemination of project activities will become more widespread and sustainable.

In August, 2012 the SALiS final conference was held in Tbilisi, Georgia, promoting the ideas of SAliS both on international and local levels.

References

1. M. Kapanadze, S. Janashia I. Eilks (2010) in I. Eilks & B. Ralle (eds.) *Contemporary science education*, 237-242.
2. M. Kapanadze, S. Janashia, I. Eilks, S. Markic, M. Stuckey (2011). Paper presented at the 9th ESERA conference, Lyon, France.
3. M. Kapanadze, S. Janashia, I. Eilks (2012) in I. Eilks & B. Ralle (eds.) *Contemporary science education*, (in print)

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Implementation of SALiS Project in Moldova: a) in the Institute of Educational Sciences

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The participation of the Republic of Moldova in the Tempus project SALiS is led by the Institute of Educational Sciences (IES) and the University of the Academy of Science of Moldova.

The Institute of Educational Sciences (IES), as a research institution of national importance in education and postgraduate education under the Ministry of Education, and as a plenipotentiary coordinator of scientific and innovative activity in subordination of the Academy of Science, is directed towards the capitalization of natural human and information resources for sustainable development.

Being one of the partners in the SALiS consortium, IES argues for teacher training curriculum partnership development, the elaboration of teaching modules, and SALiS concept implementation through lab-work. This way, the main goal of the IES within the SALiS project is to promote and support contemporary scientific education by developing the scientific knowledge competence of Science teachers from Moldova through continuing education courses, thus contributing to the effective implementation of science in schools.

For successful implementation of the above goal, the IES team intended to:
(1) develop conceptual framework in accordance to SAliS philosophy;
(2) develop teacher training theory and methodology through SALiS (curricula, guides, etc.);
(3) provide conditions for scientific knowledge competence development within teacher training course (equipping labs, staff training, etc.); and
(4) ensure effective SALiS project implementation and continuity.

To start with, the IES scholars developed the conceptual framework for scientific knowledge competence, analyzed from the perspective of the SALiS philosophy. This way, the scientific knowledge competence, seen as a general competence, has been defined as an integral unit of student's internal resources, common for Physics, Bilogy, Chemistry subjects, and focused on an interaction of: dialectical reasoning, epistemological thinking, scientific language use, and an adequate behaviour to solve significant pedagogically modulated situations.

To be specific, the dialectical reasoning emphasizes the dialectical categories such as: unity and struggle of opposites, quantitative vs. qualitative, the negation of the negation. The epistemological thinking means the epistemological regulations such as: from general to particular, from simple to complex, from phenomenon to essence, from cause to effect. The compliance of these philosophic categories eases the scientific knowledge process realization within Physics, Chemistry and Biology classes. Consequently, the scientific knowledge appears to have a rationalistic and pragmatic configuration specific to the above areas of knowledge.

Therefore, the students'/teachers' scientific education developed through the competence of scientific knowledge should be based on a methodological support and reasoning through observation, experiment and deduction.

The competence of scientific knowledge consists of the following specific skills which directly relate to a specific scientific content: (1) intellectual acquisition; (2) scientific investigation; (3) communication in scientific language; (4) pragmatic acquisition; and (5) environmental protection and personal health culture.

It is important to mention that the formation of the scientific knowledge competence has four stages: starting from fundamental knowledge to functional knowledge, then to internal knowledge, and finally to external knowledge. Thus, the didactic planning of a certain teaching unit, taken from the perspective of this competence formation, should reflect the above stages. Meanwhile, the didactic activities for each stage are centered on the students' active involvement in the educational process.

When a student possesses the scientific knowledge competence as a final acquisition. it means he or she should: master a set of fundamental knowledge depending on the problem to be solved; develop skills of applying this knowledge in concrete situations for a better scientific understanding; this way achieving their functionality; resolve different problem-solving situations; thus constructing their own functional image of the knowledge; and solve the significant daily problems in different contexts, by applying their final acquisition of behaviour/attitudes; meaning competences.

Further based on these concepts, it was developed the theory and methodology of teachers' scientific knowledge competence formation through the perspective of students' active learning. This way, three SALiS Curricula for the Continuing Education of Chemistry, Biology and Physics Teachers were modernized and translated into English (see Figure 1) . The content of each curriculum covers issues related to: (1) conceptual references regarding epistemological, managerial, communicative, investigative, meta-cognitive competences of Science teachers; (2) management of training the Curriculum content within 3 modules (*Psycho-pedagogy of Interactive Education; Axiology and Praxeology of Specialty Subject through SALiS; and IT Use and Implementation of Educational Software);* ideas about the process, contents and acquisitions of training activities; and a useful set of methodological and assessment suggestions.

Figure 1: Modernized and translated Curricula for Continuous Education of Science Teachers

Also, we translated and published a Romanian version of *"Low-Cost Techniques in Science Classroom"* guide, developed by Nicole Poppe, Silvija Markic, and Ingo Eilks; and also laborated two guides entitled *"Methodological Guide of the Implementation of Curriculum for Continuous Education of Teachers of Biology, Chemistry and Physics through the Perspective of SALiS Philosophy"* and *"Evaluation of the Scientific Knowledge Competences of Teachers of Biology, Physics and Chemistry based on SALiS conception"* (see Figure 2).

Figure 2: From left to right: Romanian version of "Low-Cost Techniques in Science Classroom"; "Methodological Guide of the Implementation of Curriculum for Continuous Education of Teachers of Biology, Chemistry and Physics through the Perspective of SALiS Philosophy";and "Evaluation of the Scientific Knowledge Competences of Teachers of Biology, Physics and Chemistry based on SALiS conception".

These documents will serve as a methodological support in teaching the SALiS philosophy during Science teachers' trainings as *it argues for the conceptual dimensions* of continuing development of the didactic staff from the perspective of the SALiS concept and the methodology of scientific knowledge competence development. They reflect: (a) the notion of teachers' scientific knowledge competence; (b) the specific character of a teachers' training curriculum; (c) the process of school curricula modernization ; (d) the methodology of forming scientific knowledge competence; (e) active didactic strategies and technologies based on constructivist teaching-instruction process; (f) low-cost equipment in experimental research; (h) procedure of evaluating students' scientific knowledge; (i) unit/lesson planning; and (j) the interdisciplinary aspect in Science teaching.

Additionally to developing methodology, the SALiS team from IES contributed to the equipment of the three modern training labs of

Chemistry (Figure 3.1*)*, Biology (Figure 3.2) and Physics (Figure 3.3), where participants may develop their scientific knowledge competence through innovative approaches to lab-work instruction, such as: inquiry-type strategies, open laboratory tasks or cooperative learning in the laboratory environment.

Figure 3.1 Chemistry Laboratory

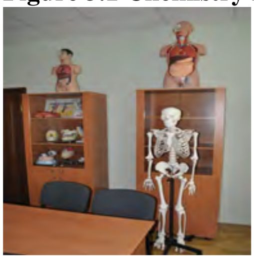


Figure 3.2 Biology Laboratory (left) and 3.3 Physics Laboratory (right)

These areas served as a space to provide effective Science teacher trainings. Thus, from January-June 2012, 323 Science Teachers were trained from Moldova. (Figure 4.1, 4.2)

Figure 4.1 Chemistry teacher trainings

Figure 4.2 Physics teacher trainings

The thematic content of the courses presented an instructive and applied character, which was delivered in form of seminars, workshops, case studies, and lab-experiments; thus contributing to developing professional competence of science specialists from the country.

Besides this, on the basis of SAliS, a new laboratory was opened - The Center of the Didactic Excellence, which will contribute to developing educational software for teaching Science.

In order to disseminate the information about SALiS project, the IES team:

- organized presentations on SALiS issues at the Specialized Scientific Council, international conferences, local seminars and trainings;
- managed to publish a SALiS Newsletter for a large audience of didactic staff from the country;
- published 4 scientific articles in "*Univers Pedagogic Pro*" newspaper and "*Univers Pedagogic*" scientific journal;
- and designed a www.proiecte-ise.md web site with continuously updated information about SALiS activity.

By accumulating a rich experience in developing teachers' scientific knowledge competence through SALiS idea, the Institute will keep promoting the scientific education throughout the country. This way, IES intends to disseminate widely the SALiS philosophy through continuing education courses for Science teachers (over 700 teachers per year) and to provide all Science teachers from the country with the set of methodological guides developed within the SALiS project.

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b) at the University of the Academy of Sciences of Moldova

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Founded in 2007, the University of the Academy of Sciences of Moldova (UnASM) is a state institution of university education, a centre of excellence in education, which combines and develops harmoniously educational and cultural activities, scientific research and innovation. It was created on the base of the Academy of Sciences of Moldova which is the highest scientific forum of the country and represents the only public institution of national interest in the sphere of science and innovation.

The interconnection with the Academy of Sciences provided for development of a scientific Cluster UnivERSCIENCE (University of Education and Research in Science), which is a combination of specialized structures including the Lyceum of the Academy of Sciences, the University of ASM, eighteen research institutes as well as four Technological Parks and Incubators of the Academy of Sciences, in order to concentrate material and intellectual resources available for the pursuit of scientific education and teacher training. Establishing the educational and scientific cluster contributed to strengthening the bridge between the process of training, academia and business in order to develop the research, development and innovation activities. The cluster serves as a foundation for a dialogue between research and innovative entrepreneurship representatives, within an educational environment in professional training of future researchers.

In 2010 UnASM became a partner in the consortium of countries involved in the development of the TEMPUS project Student Active Learning in Science (#TEMPUS-1-2010-1-GE-TEMPUS-JCPR). The SALiS project envisaged achievement of certain goals through realization of work packages related to development of SALiS curricula, equipping of laboratories, staff training, implementation of SALiS principles in school teaching, dissemination of SALiS principles and assurance of sustainability. The project objectives were harmoniously combined with our inherent mission and, as a result, the contribution of the project to the development towards fulfilment of our mission is invaluable.

At the initial stage of the SALiS project implementation the leading specialists of UnASM visited the universities of Berlin, Germany and Limerick, Ireland. During those visits they had the opportunity to get informed about the SAliS strategy and the experience of our colleagues from those universities. Later, basing on the experience and knowledge obtained the development of a draft SALiS curriculum commenced. While working on the draft curriculum, the project team took into consideration all the relevant recommendations, made by the teachers, consultants and partners of the project.

In order to pilot the developed SALiS curricula, we launched a training on SALiS methods for a large group of students as well as for the teachers from UnASM. The overall duration of the courses was 60 contact hours with the trainer in the class. During the piloting period, all the participants had the opportunity to express their opinion about the quality of the curriculum and its training materials. All the suggestions and recommendations have been collected and taken in account when developing the final version of the curriculum.

In order to insure a better implementation of the SALiS curriculum, we needed to modernize the labs involved in the project and supply them with high performance equipment. Also, we developed all the necessary procedures in order to provide a safe operation of the equipment. All the necessary operating instructions have been printed and exhibited in specially designed places.

In order to inform the teacher in Moldova about the methods of SALiS teaching, we organized a number of additional trainings during which we disseminated the teaching materials developed within the project (laboratory works, strategic principles, methodology guides etc.). We provided training courses and demonstrations for teacher from more than 30 schools throughout the country.

Every year, the University of the Academy of Sciences of Moldova, in accordance with the legal framework regarding the school teacher's training, holds two methodological sessions for the didactic cadres. Usually the courses are attended by teachers from 20-30 schools from the whole country. Starting with the current year, the teachers will get free of charge and in electronic format all the text books developed within the project, will study the SALiS methodology, will carry out experimental demonstrations and will participate in elaboration of the individual plans for the school classes in accordance with the SALiS principles. Additionally, the participants to these sessions will get acquainted with the Moodle educational platform, which will allow them to benefit, in the future, from the access to the SALiS new outcomes.

In conclusion I would like to mention that the SALiS project in Moldova addressed a big part of the problems in the educational system of the country. The developed SALiS methodology represents a strong support for successful implementation of the curriculum and will serve as a supplement for the school teachers. Through a vast number of SALiS exercises, through methodological development, through international consultancy etc., the SALiS project brought a new understanding of the role of the student in the process of education and to the development of the principle of Student Centred Learning. The website, the educational platforms, the on-line resources and the process of networking between school teachers will provide for the sustainability of the outcomes of the SALiS project.

The Impact of the TEMPUS-Project SALiS on Science Teacher Training in Israel

a) The Academic College for Education, Haifa

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Introduction

For many years science education in Israel and abroad, including the teaching of biology, is not only about teaching and learning of scientific facts and theories. In science, an attempt was made to provide students with the concept of science as the study with an emphasis on teaching and learning through research and the teaching of science research.

Children learn best through direct experiences. They are very curious, and once they realize they can find out things for themselves, their first encounter with science takes place. Science experiences enable young children to develop an appreciation and awareness of the world around them and to develop abilities of scientific inquiry methods - to wonder, question, explore, discuss, generate ideas, understand theories and more.

Teaching students to think and to help them develop a sense of curiosity are tasks that are facing educators, in general, and science teachers, in particular. The field of science that deals with the wonders of life has ample natural phenomena, which are fascinating and interesting and provoke thought and curiosity. Students begin to understand the natural world when they look at the phenomenon, using their senses for observation, and using measuring instruments to enhance the capacity of diagnosis by the senses (National Science Board, 1991, p. 27). Already in 1964, Novak suggested that research involves human effort to find reasonable explanations for a phenomenon that intrigues him. To satisfy curiosity, the research process should include activities and skills that focus on an active search for knowledge and understanding (Haury, 1993). Although scientific research is founded on a sense of curiosity, it relies on systematic processes such as observations, demonstrations and experiments, which present empirical evidence on the nature around.

Teachers differ in how they guide students in learning research. In recent years, evidence began to accumulate that structured inquiry learning, leading the student to systematically solve one prescribed question, is insufficient to develop critical and scientific thinking (Yen & Huang, 2001). In contrast, teachers of science search for ways to encourage students to understand the changing dynamic nature of the process of scientific inquiry (Khishfe and Abd-El-Khalick, 2002; Zion *et al.,* 2004) and so here we assume demonstration is one of the most effective ways to encourage students to understand scientific phenomena.

The Academic Arab College of Education (AACE) is one of the partners in the TEMPUS-project SALiS (Student Active Learning in Science) funded by the EU. The idea is to develop and promote innovative teaching strategies and develop the cognitive functions of teachers for the purpose of professional development. Since the goal of learning research is to lead students to construct their own knowledge, and since asking questions is an important skill, then developing educational programs that emphasize open inquiry learning and the way of asking questions during the inquiry process is an important challenge. The foundation of the program, developed as part of SALiS project in the college activities, is the assumption that dealing with student research questions, related to a particular phenomenon, and strung together logically, has a potential for developing scientific thinking.

The research method

To ensure the suitability of the developed materials to the learner, and prior to the use of this material in school, training sessions for school science teachers were held in the laboratories of the College in order to expose them to the idea, purpose and spirit of SALiS, so that they can go through these experiments and give their immediate feedback on the program to make the necessary changes and improvements. In this project, we followed the inquiry learning process by the use of demonstrations, with the participation of science teachers. The participating group of teachers took a two-year course in biology, led by instructors with doctorate degrees in biology and science education. The course was based on the SALiS rationale and purpose. They had no prior knowledge of the project context. To obtain information about the curious nature of teachers, they were interviewed at the end of the activity.

Reflection on the project

Raising questions is an act of scientific thinking indicating the interest and curiosity in things that that are taking place around the learner. In science, in general, and life sciences, in particular, experiments and demonstrations are at the centre of learning and research. They are considered as important means to encourage thinking and to involve students in learning and thinking. In research-based learning, using demonstrations encourages thinking and curiosity rather than only providing answers to questions or phenomena.
The main aspect of the project was:

- To train science teachers to develop teaching materials for school,
- The concept of implementing the SALiS project through the use of low cost laboratory equipment,
- To promote the scientific literacy of students by direct meeting with various natural phenomena with biology experiments and activities,
- To develop observation skills and analysis of these phenomena.

Talking with teachers and students during and after implementation of the project, we received these impressions:

Attitudes of teachers

The importance and contribution to the students:

The teachers stated that, prior to this "training" in the college (Figure 1), the role of the teacher and the student was not internalized inside them; in addition, the importance of activities and experiments and their contribution to students from several sides was not realised, such as increasing their motivation and involvement, cooperation and development of cognitive ability (Higher Order Cognitive Skills).

Figure 1: SALiS activities at the biological laboratory, the Academic Arab College – Haifa, May 2012

According to one teachers: "*experiments have contributed a lot to students; they are more relevant to the subject, give students a comprehensive and broad perspective that is interesting and challenging, relevant to daily life, improve the level of their investigation; the students were more active, challenged, involved, and they ask more questions ...* ".

The importance and contribution to the teacher:

All teachers emphasized that the training workshop and the continuing follow-up gave them self-confidence and, most importantly, it gave them pedagogical tools to incorporate additional teaching and learning strategies in the educational process. They noted that, following the training workshop, they would worry less about content and principles and feeding knowledge to students and more about devising challenging situations to develop cognitive abilities of the students: "*The process has changed the perception of my learning and made me, to some extent, prepare lesson plans that are different from the past, combining teaching through research and guiding students in a more active way. The most important thing is that we can prepare and plan a simple challenging experiment in order to convey scientific content*"; and "*the contribution of the training was great; it helped me organize the teaching material in a different perspective*". "*The main change for me is the awareness of the importance of the subject and its contribution*". "*The issue is very important. The emphasis is on student learning and activation, rather than the teacher's lecture and passing of knowledge. This creates a challenge in learning*".

Some teachers expressed difficulty in teaching and organizing the implementation of the teaching/learning practices: "*These things and procedures require a lot from both, teacher and student, but the end product is significant, useful and profound learning*". One teacher commented: "*We need more depth and expansion to better control this method. Perhaps, this can be done by organize training courses for teachers, these ideas should be passed to other teachers*".

It is possible to point out that the training brought about a change in teachers' perceptions. Especially significant is that, following the training and follow-up, the teachers treat the students more as partners in the teaching-learning process. This contrasts with the previous reference to students as passive partners, whose role is to comment on the content the teacher presents to them and abide by its provisions. Another expression of a change in perception is the statement of a teacher: "*I feel less responsible for the transfer of knowledge*".

Reference to teachers after training using miniaturized tools:

This workshop presents simple and feasible ideas to introduce the implementation of science experiments using accessible materials in the classroom (Figure 2) (Hugerat et al. 2010). One of the main objectives when implementing pre-service and in-service professional development for teachers is to facilitate the introduction of different ways to teach and learn the subject content. Bringing new materials and effective and creative ideas are an essential component of the professional development.

Figure 2: SALiS activites using microscale experiments at SALiS Center at The AACE.

Some of the conclusions from the comments of the teachers who passed the workshop are:

1. When asked about if they taught this topic in their classes, they said that they teach science in a conventional way to their students.
2. When the teachers were asked to describe briefly in which way the experiment presented in the workshop using low cost materials are helping them to better understanding of the science process; most of the teachers answered that after the activity, the concept of science was clearer for them and that they can explain it to others, and using micro-scale experiment enlightened her about the subject and how to present the subjects to her pupils. Most of the participants concluded also that using the micro-scale experiments allows the students to visualize what happens during different science concepts. In the same trend, teachers expressed that the experiments were presented in a doable way, easy to implement also without a science laboratory. Some of them also expressed a clearly gain on content knowledge using specific language to explain what occur in the activities.
3. When asked about the accessibility to disposable materials to implement the activity, the teachers believe that using disposable materials and natural materials made the experiment simpler, so they can think about other materials that they can use; and if they don't have it, they will find a way to obtain it or substitute it with other materials that are easier for them to obtain.
4. When asked about the possibility to implement this activity in the next academic year, the teachers expressed their intentions to implement some of these activities in their classroom.
5. When asked to express what are the main reasons that motivate them to implement these activities in their classroom, the participants stated in general that:
   These activities are very simple,

   The experiments can be carried out quickly;

   The students will be engaged and will feel part of the discovery process

   Their creativity will definitively be stimulated.

Attitudes of students:

a) Attitudes on the cognitive level

The implementation of teaching - learning strategies that promote inquiry and advances cognitive development also contributed to students. They were able to express this ability on different complexity levels: "*I began to think more in depth and comprehensively; my analytic and research ability has improved a lot*". Another student stated: "*learning is more interesting when it deals with more relevant subjects and more interesting phenomena in the laboratory ...* ".

b) Attitudes on the emotional level:

- *I related better to the study material; before, it was less.*
- *Raises the curiosity and involvement.*
- *I feel more connected, involved and partner to the subject.*
- *I enjoy the classes under the new method.*

Summary

Promotion of science teaching in schools around the world is a central, essential and fundamental issue, especially in the Arab community in Israel where lots of promotion and development are needed. If these projects, such as *SALiS* project, continue, they would lead to good results in the right direction.

References

Haury, D.L. (1993). Teaching science through inquiry. In L.E. Gronlund (Ed.), *Striving for excellence: The national education goals* (Vol. 2, pp. 71-77).

Hugerat, M., Basheer, A., Abu-Much, R., & Basheer, S. Using inexpensive to free materials to do chemistry experiments with all school ages. *Chemical Education Journal (CEJ), 13(2), 2010.*

Hugerat, M. Electrolysis of water using accessible materials: a case study of its implementation with middle and high school teachers. *Journal of Science Education, 2(10), 115-118, 2010.*

Khishfe, R. & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders views of nature of science. *Journal of Research in Science Teaching, **39***, 551-578.

Kapanadze, M., Janashia, S., Eilks, I., Markic, S., Stuckey, M. (2011). Paper presented at the 9th ESERA conference, Lyon, France.

National Science Board (1991). *Science and engineering indicators-1991*. Washington, DC: U.S. Government printing Office.

Novak, A. (1964). Scientific inquiry. *Bioscience*, **14**, 25-28.

Yen, C.F. and Hunang, S.C. (2001). Authentic learning about Tree Frogs by preservice biology teachers in open-inquiry research settings. *Proc. Natl. Sci. Counc. ROC(D),* ***11,*** 1-10.

Zion, M., Shapira, D., Slezak, M., Link, E., Bashan, N., Brumer, M., Orian, T., Nussinowitz, R., Agrest, B., & Mendelovici, R. (2004a). Biomind - A new biology curriculum that enables authentic inquiry learning. *Journal of Biological Education,* ***38***, 59-67.

Zion, M., Slezak, M., Shapira, D., Link, E., Bashan, N., Brumer, M., Orian, T., Nussinowitz, R., Court, D., Agrest, B., & Mendelovici, R. (2004b). Dynamic, open inquiry in biology learning. *Science Education,* ***88***, 728-753.

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b) Oranim Academic College of Education

Amos Cohn and Ricardo Trumper

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Oranim Academic College of Education is the leading Teacher Education College in northern Israel, granting Bachelor's and Master's degrees as well as Teaching Certificates. Together with the Haifa University, Oranim promotes active learning in science, and is part of the SALiS project funded by TEMPUS.

Thanks to the training received through the SALiS project, and the equipment acquired with its funds, the training provided by Oranim to students and prospective teachers emphasizes active learning methods providing skills and competencies such as critical thinking, asking questions and leading discussions, reading and writing, as well as specific skills and competencies related to scientific activity, such as using laboratory tools and materials and conducting scientific experiments (development of hypothesis, predicting, inferring, observation of the actual experimental procedure, data registration and analysis).

Active Learning in Science activities, although designed for high school pupils, are also used held with the secondary in-service science teachers in our M.Ed. Program, in the compulsory course **Project-Based Learning in Science,** in which students choose their own project, constructing a model illustrating scientific phenomena or principles. The students form their own investigation of a guiding question, allowing them to develop valuable research skills as they engage in design, problem solving, decision making and research.

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Photos from the lesson on Stationary Vibrations in a String at Oranim

Spring with a free end

Spring with a fixed end

SALiS Project - Summary of the Internal Evaluation

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Introduction

The evaluation strategy of the project is based on the concept of self-evaluation and an external evaluation. The process of evaluation is equitable, transparent and open, i.e. all the strategies, methods, evidence and materials concerning evaluation are accessible free for all the partners of the project and are published on the website of the project. The internal evaluation and quality assurance is part of the project work packages and was carried out by the Bulgarian partner in collaboration with all other partners.

The evaluation of SALiS project was carried out by the following methods: observation, discussion, questionnaires including self-reflection cards, snapshot table, reports. According to the TEMPUS projects requirements, and in order to make the evaluation process more objective, an external evaluator has been appointed. After collecting and analyzing data and evidence, the evaluation team is in a position to make suggestions to the leading and other partners to implement possible changes in the areas of concern.

Different aspects of the project have been studied:

1. Leadership and management.
2. Transnational partnership and meetings.
3. Development of the SALiS-curriculum and training modules for all SALiS Universities.
4. Equipping the SALiS laboratories in the SALiS beneficiary countries.
5. Trainings in the SALiS beneficiary countries including students and staff-training.
6. Dissemination of the information about the outcomes of the project and setting up the arrangements for the sustainability of the project.

The entire project documentation, the official web site and developed curriculum and teaching materials, self-reflection cards and questioners have been analyzed as primary sources of information.

1. Leadership and management.

The lead partner, Ilia State University Tbilisi, Georgia, through its coordinator Marika Kapanadze, has established good communication and information dissemination with all partners. The exchange of information was at regular intervals and at a high professional level, to include all the latest curriculum developments and training actions from partner countries. The team leader has managed to develop a positive atmosphere and trusting working environment between partners, meeting all the deadlines put forward. All partners have been informed on time about the project budget. Financial procedures between the leading partner and all other partners are adequate and correct. Every partner received necessary individually tailored support in preparing their quarterly financial and narrative reports.

2. Transnational partnership and meetings.

Each partner has a particular role in the project and is actively working to complete specific tasks. The schedule and the work packages at different stages of the project have been appropriately discussed during the plenary meetings. All meetings have been carefully planned, the programs have been distributed before the meetings and the partners' opinions have been considered before finalizing the program. The project leader showed the experience and ability to motivate partners to work together and create an efficient working environment during the meetings. The evaluation team has assessed the work done at the meetings and by analyzing the evidence and obtained information from reports, snap-shot tool, questionnaires and observation. Evidently the partners showed willingness to go ahead with the project and every partner has clear understanding of his work and the terms of completing it. The outcomes showed that the project management has been successful in enabling all the partners to create a common understanding and philosophy towards development of the main task of the project –

curriculum, courses development and trainings implementation.

3. Trainings, equipment and courses

The main results during the observed period before the final conference are:

- Development of a SALiS Curriculum specific for each partner's needs.
- Development of specific training courses for the trainings in the beneficiary countries and in Bulgaria.
- Course implementation during the trainings in the six institutions in Georgia, Moldova and Israel. An additional two trainings have been implemented in Bulgaria.
- Collecting and analyzing the data and evidences from the trainings.
- Developing and implementing a variety of evaluation strategies and tools.
- Dissemination of project outcomes and results.

Positive characteristics

The curriculum and the teaching materials developed, implemented and evaluated during the three trainings in the SALiS beneficiary countries, and additionally in Bulgaria, have been evaluated as successful and relevant to the project plan and its objectives. The evaluation team received positive feedback from all participants through discussions and written materials such as questionnaires, self-reflection cards and snap-shot questionnaire. According to the participants of all institutions involved, their activity and interest was rated as very significant. The increased motivation and self-confidence of participants has been reported through the evaluation tool self-reflection card. Aspects such as curriculum, experiments and methods have been reflected on and assessed by the participants.

The time management of the training sessions has been positively evaluated.

All partnering institutions have translated in their respective languages the teaching materials and evaluation tools used for the trainings. This enabled the trainees to understand and attend with their maximum potential in the training process.
All educational materials for the experiments and for the laboratory work have been distributed to the participants for future reference and implementation in their teaching practice.

According to the data collected from the participants in all the trainings, the SALiS tutors have excellent competences in all the areas of teaching. A significant rate of implementation quality has been reported for each session. All parties reported satisfaction with degree of cooperation and team work with the tutors. Safety requirements in the lab have been particularly emphasized.

4. Dissemination

As an outcome from the project, an official web site has been developed. It includes teaching materials in all the partners' languages and ongoing information. Each partner published information and training materials on their home institution's website. The results have been well presented at conferences and publications.

Teaching guides for SALiS specific trainings have been published in a variety of languages.

Point of concern

Some of the participants reported difficulties in using English as the instructional and reporting language.

Recommendations

The following two recommendations were shared:
1. It is necessary to inform science teacher associations in all participating countries about the outcomes of the projects.
2. It is necessary to elaborate and develop networking between different parties within each country.

Conclusion

The process of equipping laboratories and the conduct of the training workshops in each beneficiary country has been implemented according to plan and all the partners reported it as a successful and very useful experience. Based on the collected evidence and its analysis, the internal evaluation indicates that the work of the SALiS project is effective and accomplished the desired results. The partners are convinced that the project outcomes are beneficial for both the beneficiary and EU countries participating in SALiS project.

NOTE: This evaluation is supported by the reports from the various countries involved, which are included in this issue.

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The final conference in Georgia, August 28-29, 2012

The final event of the SALiS project was a conference held in Ilia State University, Tbilisi, Georgia. This involved all the partners, plus invited guests, and teachers and teacher trainers from Georgia. The programme of the conference, which consisted of lectures, reports and workshops, is given below. The Proceedings are being published as part of the project.

Presentation of the SALiS Project

SALiS - Overview and objectives I. Eilks/DE

The impact of SALiS in Georgia M. Kapanadze/GE

The implementation of SALiS in Israel M Hugerat/IL

Learning from SALiS also in the Western countries P. E. Childs/IE

Guest speakers perspectives on SALiS

Teachers professional development for inquiry-learning A. Hofstein/IL

Implementing low-cost- and microscale laboratory work in schools P. Schwarz/DE

E-learning for promoting inquiry learning G. Jonas-Ahrendt/DE

Student Active Learning in Science - Podium discussion
Marika Kapanadze/GE, Ingo Eilks/DE, Claus Bolte/DE, Peter Childs/IE, Avi Hofstein/IL and Peter Schwarz/DE

Perspectives for SALiS in Eastern Europe

Perspectives for SALiS in Georgia M. Kapanadze/GE and N. Kakhidze/GE

Stakeholder views on science in Georgia- Delphi Study C. Bolte/DE and M. Kapanadze/GE

SALiS – Experiences and implementation in Moldova M. Barbulat/MD and M. Duca/MD

SALiS and educational policy in Georgia E. Slovinsky/GE

Workshops - Round 1

WS 1.1 Ampoules, syringes and pipettes for low-cost student experiments
P. Schwarz/DE, N. Poppe/DE, M. Hugerat/IL

WS 1.2 Inquiry learning - Experiences from SALiS courses in Berlin and Aachen
S. Streller/DE, V. Schneider/DE, A. Schuermann/DE

WS 1.3 Student active learning in physics and astronomy A. Cohn/IL, R. Trumper/IL

WS 1.4 Electrical chemistry- experiments
A. Epitropova/BG, Y. Dimova/BG and N. Belova/DE

Workshops - Round 2

WS 2.1 Low-cost science demonstrations
P. E. Childs/IE, S. Hayes/IE and N. Belova/DE

WS 2.2 How to analyze student motivation to learn science
C. Bolte/DE, M. Albertus/DE, T. Mühlenberg/DE

WS 2.3 The laboratory between guided inquiry and open experimentation A. Hofstein/IL, M. Stuckey/DE, I. Eilks/DE and K. Kupatadze/GE

WS 2.4 An investigation of students´ science fair projects and lab reports
G. Jonas-Ahrendt/DE

Final reflections and closing

M. Kapandze/GE, I. Eilks/DE and P.E. Childs/ IE

Please contact Marika Kapanadze (marika_kapanadze@iliauni.edu.ge) for details of the Proceedings and their availability.

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Diary

2012

31st ChemEd-Ireland
Sat. 20 October
Dublin City University, Dublin
Odilla.finlayson@dcu.ie

ISTA Senior Science Quiz (Leaving Certificate Science Students ~850 participants last year!)
Thursday 15th November: Regional Finals of ISTA Senior Science Quiz - 11 venues nationwide during science week - details will be on www.ista.ie
Saturday 24th November: National Final of Senior Science Quiz - Trinity College (generously sponsored by PharmaChemical Ireland)

Science Week
11 – 18 November
http://www.scienceweek.ie/index.asp

2013

ASE meeting
2-5 January
University of Reading, Reading, UK
http://www.ase.org.uk/conferences/annual-conference/

New Perspective in Science Education Conference
14 – 15 March
Florence, Italy
http://www.pixel-online.net/npse2013/
Deadline for submission: 14th Nov. 2012

2013 NARST Annual International Conference
6-9 April
Rio Grande, Puerto Rico
http://www.narst.org/annualconference/2013conference.cfm

NSTA Annual Conference
11- 14 April
San Antonio, Texas, USA
http://www.nsta.org/conferences/2013san/

51st ISTA Meeting
12-13 April
Gorey, Co. Wexford
www.ista.ie

Eurovariety 2013
'Smarter teaching – better learning'
3-5 July
University of Limerick
www.eurovariety2013.ul.ie
peter.childs@ul.ie
Submissions: 1 November – 28 February

ChemEd,
28 July – 1 August
University of Waterloo, Canada
http://uwaterloo.ca/chemed2013/
jhein@uwaterloo.ca

IUPAC 44th World Chemistry Congress
11 – 16 August
Istanbul, Turkey
http://iupac2013istanbul.org/

10th ESERA,
2-7 September
Nicosia, Cyprus
http://www.esera2013.org.cy/nqcontent.cfm?a_id=1
info@esera2013.org.cy
Submissions: **5 September 2012 - 31 January 2013**

ICASE 4th World Conference on Science and Technology Education
29 September – 3 October
Borneo, Malaysia
http://worldste2013.org/

32nd ChemEd-Ireland
Sat. October 19
Limerick Institute of Technology, Limerick
Marie.walsh@lit.ie

Putting the WOW back into chemistry

Peter E. Childs and Marie C. Ryan
Dept. of Chemical and Environmental Sciences, University of Limerick, Limerick

Report on the 6th. Chemistry Demonstration Workshop at the University of Limerick, 18-22 June 2012.

Light my fire! Dana Kilroy, Dr Rita Godoroja, Moldova, and Orla Bergin. Photograph Liam Burke/Press 22

Smoke and steam, fire and flashes, colours and crackles – must the Chemistry Demonstration Workshop again! June 18-22 saw the 6th Chemistry Demonstration Workshop convene in the Department of Chemical and Environmental Sciences (CES), University of Limerick. This workshop is run in conjunction with the National Centre for Excellence in Mathematics and Science Teaching and Learning (www.nce-mstl.ie), and is sponsored by the PDST, Pharmachemical Ireland and the RDS Science Live for Teachers programme.

Aileen McWalter in action with the cannon fire demonstration Photograph: P.E. Childs

The student teachers sponsored by Pharmachemical Ireland. Front: Moira Elmore, UCC, Niamh Burke, NUIG, Elaine Keane, UL and Claire Beegan, UL. Back row: Alan O'Donoghue, UCC, Sean O'Brien, UL and Stephen Comiskey, DCU. Photograph Liam Burke/Press 22

This year we had 15 participants, including one from Moldova – a mix of experienced teachers and trainee science teachers who had just finished their courses. Brigid Corrigan came back for a second dose as she enjoyed and profited so much from the 2011 course. The workshop involved a series of talks on Why do demonstrations?; Safety in demonstrating; Using the OHP in Demonstrations and Using Demonstrations to Stimulate Inquiry. The participants had the chance to try a series of standard demonstrations, including the methane mamba, methanol cannon, whoosh bottle, the screaming jelly baby and to use liquid nitrogen. They were encouraged to share their own favourite demonstrations and to research others they would like to do, from published sources or from the internet, and then try them out themselves. There was also a session by Brendan Duane on using ICT in teaching chemistry. At the end of the course the participants, working in pairs, had to devise and put on a 20 minute science magic show. This year there was a special bonus as Paul Nugent and David Keenahan, on behalf of the Institute of Physics, put on a series of simple physics demonstrations.

Paul Nugent explains some simple physics demonstrations. Photograph: P.E. Childs

The four days were full and we ran out of time at the end and people had to be chased to lunch. There was a social evening on Wednesday night on campus and participants stayed in university accommodation and ate in the Paddocks. There was plenty of time to socialise over food and to share ideas.

A novel way to do the flame tests. Roisin Ni Bhriain, & Aileen McWalter. Photograph Liam Burke/Press 22

The main aims of these Workshops are to increase the chemistry teacher's confidence and skill in doing chemistry demonstrations; to give them chance to practise and perfect a wide range of new demonstrations; and to give them the experience of designing and presenting a science magic show – that can be used for open days, science promotion etc. This short experience of hands-on science is able change the way chemistry is taught and Brigid's own experience last year is an indication of the effect that bringing in these ideas into teaching can have to motivate and enthuse your students, as well as helping them to master the chemistry better. We suspect it may be more effective for weaker students who need more motivation to help them study.

An even more spectacular way to do flame tests. Brigid Corrigan, Helen Horan and Michelle Breathnach. Photograph Liam Burke/Press 22

The student teachers were sponsored by Pharmachemical Ireland and thanks to Tamara Lyons for organising this. The other teachers were subsidised by grants from PDST (thanks to Brendan Duane and Tony O'Shea) and the RDS (thanks to Karen Sheeran), which made it possible to run the course with 4 nights B&B and all meals for a fee of just €100. We would also like to thank Sinead Walsh, Brian O'Shaughnessy and Maria Munroe of the CES Department for providing the technical support needed to run the workshop.

A great craic was had by all – but all good things must come to an end. Photograph: P.E. Childs

We will probably run another workshop next year at a similar time and if you are interested in attending, email marie.c.ryan@ul.ie to be put on the list for further information. Marie Ryan also does Science magic Shows in schools in the area within ~70 miles of Limerick during the school year, aimed at classes up to Transition Year. If you would like more information on these shows please contact Marie at the email address above.

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Report on the 8th Irish Variety in Chemistry Teaching Meeting, Dublin Institute of Technology, May 10th 2012

Michael Seery and Claire McDonnell
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Michael.seery@dit.ie **and** Claire.mcdonnell@dit.ie

Dublin Institute of Technology (DIT) hosted the 8th Irish Variety in Chemistry Teaching meeting, modelled on the very successful UK Variety in Chemistry Education (ViCE) meeting, on Thursday May 10th. Sponsorship was provided by the Royal Society of Chemistry (RSC) Education Division (Ireland region) and there were 32 participants representing higher education institutions from across Ireland and some in the UK. The meeting opened that morning with an optional workshop dealing with two aspects of technology in chemistry teaching; podcasting using Audacity software, led by Michael Seery (and outlined in a recent article in Education in Chemistry) and using wikis, demonstrated by Claire McDonnell, who showed how to set up, edit and modify a wiki and highlighted the advantages of a wiki for monitoring group work – the ability to be able to track who did what and when. Claire identified this as the most useful aspect of wikis in teaching from her perspective.
The remainder of the day was divided into two themes, Supporting Student Learning, and Broadening the Curriculum; followed by the keynote talk from David McGarvey of Keele University. The presentations given are available on the conference website at http://www.dit.ie/chemistry/research/cert/cert-resources/#d.en.53384.

Supporting Student Learning

There's no doubt that technology is becoming more and more common-place as a means to support student learning in chemistry education. **Christine O'Connor (DIT)** opened this session by describing her implementation of the use of podcasts to support lecture material and annotate worked examples. Her ongoing work involves investigating how students use these resources; some key points were that students liked the audio files with their lecturer's voice, but they liked having print outs too as they could quickly scan through that material to the part they wanted to focus on, which they can't do with audio files.

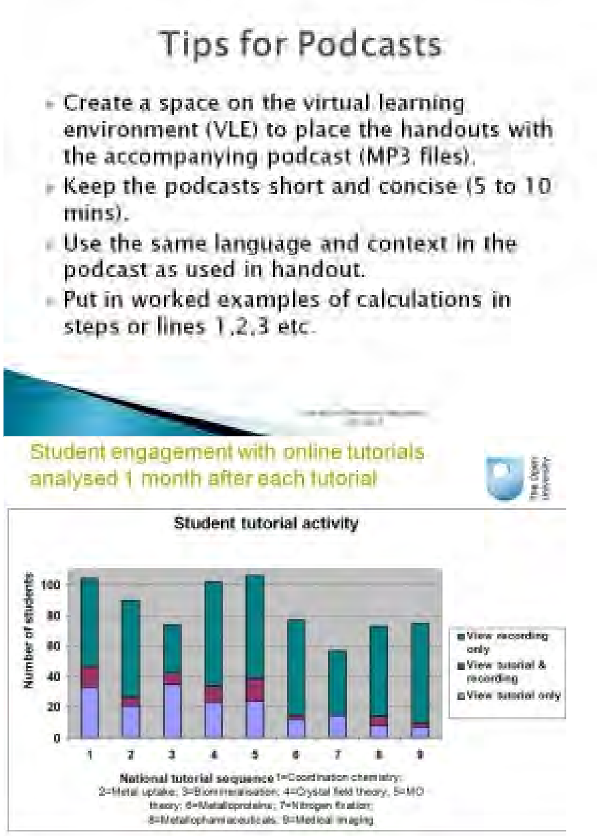

Figure 1: Screenshots from the first two presentations by Christine O'Connor and Simon Collinson.

Simon Collinson (Open University) then described his work with Eleanor Crabb on the use of online chat-rooms to run tutorials (using Elluminate software). The system allowed for voice, video, drawing and text input from both instructors and students. Simon reported that while students liked the chat function, he was worried that, with a large group, the text box may get distracting. He found that students liked the idea of a microphone but they were reluctant to use it "on the spot". Simon is interested in looking at how providing students with some advance material ahead of the chat-room sessions might help reduce the cognitive burden involved in both being online and thinking about chemistry.

Pat O'Malley (Dublin City University) used Articulate software to prepare some pre-lab activities for students. Some clever ideas here included providing a virtual map of the lab. Articulate Engage was used to annotate the image so that students could virtually navigate the lab and familiarise themselves with where things were kept. As well as videos on various techniques, he had a very useful resource on how not to use a pipette, along with the a demonstration of what can go wrong in those circumstances (Pat assured us that no students were harmed in the filming!). In terms of getting students to use the activities, Pat described how he made some questions very specific to them, for example; what label (a) referred to in a particular slide.

The final speaker in this session was **Mike Casey (University College Dublin)**. Mike described the implementation of a student presentation assignment, whereby groups of 4 to 5 first year undergraduates were given the name of a medicinally relevant molecule and required to prepare a presentation on it, to include the chemical structure, 3D structure, functional groups, uses and biological mechanism of action (if known) and a prediction of some chemical reactions it could undergo. The students had to independently use resources to work out how to draw the structure and prepare the PowerPoint slide so that it had a professional feel. What was most impressive was that this assignment was administered to class sizes of up to 450 students, and achieved a 96% participation rate. This was facilitated by using a lab session to introduce the assignment, and assign lab tutors to help students with queries. Each student team gave a 5 minute presentation where the core organic chemistry of the slide could be discussed. Student feedback was very positive and staff felt that although this activity was time-consuming, it was well worth the effort required.

Mike also described methods he had applied to make lectures more interactive and to engage students which included highlighting Ireland's role in the development of pharmaceuticals, in-class learning activities and the development of an open access eLearning resource called molevision which deals with structures, bonding and functional groups of many organic molecules (see http://www.ucd.ie/chem/molvis/index.html).

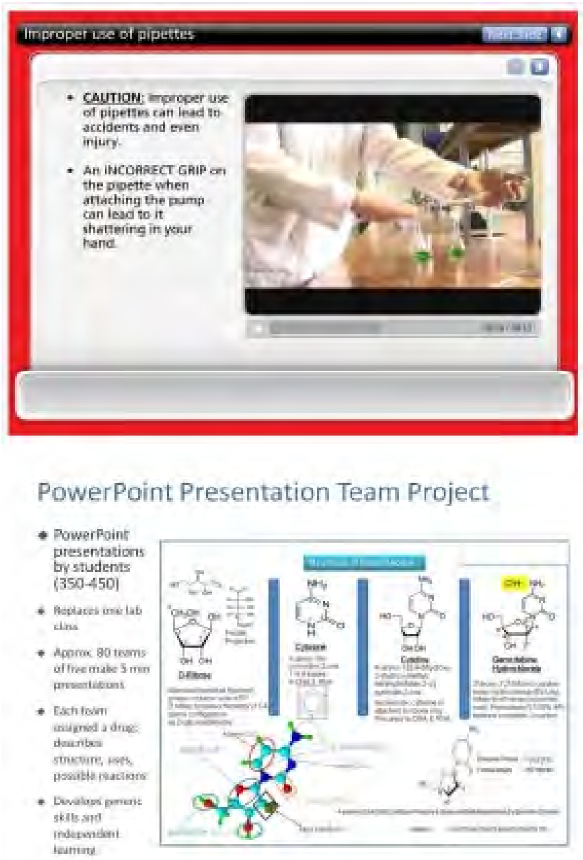

Figure 2: Screenshots from the presentations by Pat O'Connor and Mike Casey.

Broadening the Curriculum

The second session of the afternoon was on the theme of broadening the curriculum. The first speaker was **Tina Overton (University of Hull)** who described some of her work on dynamic problem-based learning (PBL). The idea is that, having presented students with their problem and context as in a normal PBL scenario (for example, designing a green-campus or costing the implementation of bio-diesel for a bus company), students are informed of a condition that has changed mid-way through the project - for example; changing costs of materials, changing legislation, a natural event (e.g. earthquake), etc. Students then have to re-assess the initial information they gathered and decide how to adjust their plans given the new conditions. The activity was carefully implemented through a well-organised card system. Feedback from students was positive and Tina is making several of these resources available on the RSC's website later in the year.

Marie Walsh (Limerick Institute of Technology) then spoke about her involvement in the "Chemistry is all around us" project - an evolving network of chemists from around Europe who are collating resources for chemistry education. This initiative follows on from a previous one which developed a website and pilot teaching materials (see http://www.chemistry-is.eu/). The new project is focussed on three themes: (1) Students' motivation; (2) Teacher Training; (3) Successful experiences. The associated network portal has been designed to facilitate the sharing of learning resources across the participating countries and allow related discussion to review and evaluate them (see http://www.chemistryisnetwork.eu/).

Figure 3: Screenshots from the presentations by Tina Overton and Marie Walsh.

Odilla Finlayson (DCU) described integrating research awareness into the curriculum, by getting first year undergraduates to talk to research staff and postgraduate students. The process was organised through a lab-session where students would meet researchers in their teams and find out about their research/process of research, and then report their findings in a group presentation. Student feedback showed that they liked this activity, and were much more aware of the research activities within the School.

Figure 4: Screenshots from the presentations by Odilla Finlayson and David McGarvey (keynote speaker)

Keynote Speaker

David McGarvey (Keele University) was the keynote speaker at the meeting, having received the 2011 RSC Higher Education Teaching Award. David gave a broad ranging talk that dealt with various innovations he has initiated over the last number of years. The first that he discussed was the development of context-based spectroscopy laboratory sessions using sunscreens as a basis. As well as experimentation, these laboratory practicals involved preparing a poster and completing a simulation on sunscreens depending on location in the world. One of the other novel features of this project was that students were required to complete a mock assessment exercise using criteria provided, so that learners could gain a real understanding of this aspect. David's work on sunscreens is available in full in an Education in Chemistry article that is accessible online

(Investigating Commercial Sunscreens, Education in Chemistry, July 2007, Vol 44 (4)).

Another project that David described was some impressive work with audio feedback. In the example shown, students had to prepare and deliver a PowerPoint presentation on a laboratory experiment. Rather than just providing feedback after submission, students were offered interim feedback on their PowerPoint slideshow. This was done using audio feedback, recorded with annotations on the student's work using a tablet PC. David shared a few of the sequences; the student's interim submission, his feedback, and the student's final submission incorporating the feedback points. It was a nice antidote to the notion that students don't take feedback on board and provided strong evidence for the value of providing feedback on an interim basis rather than at the end of an assignment. David's work on audio feedback is available on pages 5-9 in the July 2011 issue of New Directions which can be accessed online.

David also spoke about his screencasting work, whereby he uses Camtasia to record screencasts to deal with material that is causing difficulty to students, worked examples, *etc*. He recommended the use of a table of contents feature to allow easy navigation for students so they could move to the section they were interested in. David has also used screencasts as a means for feedback, in a collaborative project with Katherine Haxton, also at Keele University (see *New Directions*, July 2011, p 18-21).

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Elementary Chemistry

Element 114 is Named Flerovium and Element 116 is Named Livermorium

IUPAC has officially approved the name **flerovium**, with symbol Fl, for the element of atomic number 114 and the name **livermorium**, with symbol Lv, for the element of atomic number 116. Priority for the discovery of these elements was assigned, in accordance with the agreed criteria, to the collaboration between the Joint Institute for Nuclear Research (Dubna, Russia) and the Lawrence Livermore National Laboratory (Livermore, California, USA). The collaborating team has proposed the names flerovium and livermorium which have now been formally approved by IUPAC.

For the element with atomic number 114 the discoverers proposed the name flerovium and the symbol Fl. This proposal lies within tradition and will honor the Flerov Laboratory of Nuclear Reactions where superheavy elements are synthesised. Georgiy N. Flerov (1913 - 1990) was a renowned physicist, author of the discovery of the spontaneous fission of uranium (1940, with Konstantin A. Petrzhak), pioneer in heavy-ion physics, and founder in the Joint Institute for Nuclear Research the Laboratory of Nuclear Reactions (1957). It is an especially appropriate choice because, since 1991 this laboratory in which the element was synthesized, has borne his name. Professor G.N. Flerov is known also for his fundamental work in various fields of physics that resulted in the discovery of new phenomena in properties and interactions of the atomic nuclei; these have played a key role in the establishment and development of many areas of further research.

For the element with atomic number 116 the name proposed is livermorium with the symbol Lv. This is again in line with tradition and honors the Lawrence Livermore National Laboratory (1952). A group of researchers of this Laboratory with the heavy element research group of the Flerov Laboratory of Nuclear Reactions took part in the work carried out in Dubna on the synthesis of superheavy elements including element 116. Over the years scientists at Livermore have been involved in many areas of nuclear science: the investigation of fission properties of the heaviest elements, including the discovery of bimodal fission, and the study of prompt gamma-rays emitted from fission fragments following fission, the investigation of isomers and isomeric levels in many nuclei and the investigation of the chemical properties of the heaviest elements.

A new Joint Working Party, appointed by the Presidents of IUPAC and IUPAP has begun work to assign priority for the discovery of elements 113, 115, 117, 118 and heavier elements, for which claims may be submitted.

http://www.iupac.org/news/news-detail/article/element-114-is-named-flerovium-and-element-116-is-named-livermorium.html

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