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Supporting Reform in Science Education in Central and Eastern Europe - Reflections and Perspectives from the Project TEMPUS-SALiS

Marika Kapanadze
Ilia State University, GEORGIA

Ingo Eilks
University of Bremen, GERMANY

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After the collapse of the former Soviet Union, many Central and Eastern European countries underwent significant change in their political and educational systems, among them Georgia and Moldova. Reforms in education sought to overcome the highly centralized educational system of the former Soviet Union as well as to conquer the teacher-centred paradigm in schools that was both dominant in these countries during pre- and post-Soviet times. National reforms demanded more student-active and problem-based science education under the heading of hands-on and inquiry-based learning. Unfortunately, in many cases, the curricula, teaching materials, and teacher training facilities were inadequate in implementing these reforms successfully. In the case of science education, this paper reflects upon how European Union (EU) initiatives can help the countries in Central and Eastern Europe in their reform efforts. Reflection is performed in relation to the cross-regional TEMPUS IV project SALiS (Student Active Learning in Science). SALiS envisages countries strengthening their capacities to promote contemporary science education through investments in science teacher education curricula and infrastructure. The current paper discusses the potential of such EU projects for aiding reform in science education in EU-neighbouring countries.

Keywords: science education, educational reform, inquiry-based science education, student-active learning, science teacher education, low-cost-laboratories

INTRODUCTION

Diminishing motivation and decreasing levels of interest among young students in science classes are two often-reported problems in many Western countries (Osborne, 2003). The same seems to be true for several countries in Central and Eastern Europe (Holbrook, 2008; Janiuk & Mazur, 2010; Zhilin, 2010). Learner motivation for studying science and purposely choosing science classes during the course of their education is low. Practitioners, science educators, science education researchers, and educational policy makers all over the world plead for initiative to increase encouragement of students to opt for science courses and studies (European Commission, 2004; 2007). One potential reason for such poor attitudes and failing motivation with regard to science studies may be the prevailing orientation of science education seen in many countries (Hofstein et al., 2011). A reorientation of science

Correspondence to: Prof. Dr. Ingo Eilks,
Department of Biology and Chemistry,
Institute for the Didactics of the Sciences (IDN)
University of Bremen, GERMANY
E-mail: ingo.eilks@uni-bremen.de
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State of the literature

- With the political change in the former communist countries in Central and Eastern Europe starting from the 1980s, the educational systems in those countries became focus of many reforms.
- Nevertheless, teaching practices in the sciences in many of these countries are still dominated by a teacher-centred paradigm and a low orientation on general educational skills.
- The European Union tries to contribute reform and innovation in science education in the EU neighboring countries in Central and Eastern Europe, however, reflective reports as well as research about educational reform in the former communist countries in middle and eastern Europe are still rare.

Contribution of this paper to the literature

- This paper gives a review about the state of educational reform in former Soviet Union republics in the cases of Georgia and Moldova.
- A theoretical framework for reform of science education in former Soviet Union republics is outlined.
- The support of reform in science educationa and science teaher education by knowledge transfer from European Union member countries towards EU-neighboring countries is reflected along the case of the EU-funded project SALIS-Student Active Learning in Science.

education's goals and pedagogies in various dimensions for many European countries seems unavoidable (Holbrook, 2008; Janiuk & Mazur, 2010). One such dimension is the overall role which practical work should play in science education (Hofstein, 2004).

Independent of widespread criticism questioning the effectiveness of most prevalent approaches to practical work in science education (Hofstein, 2004; Hofstein and Lunetta, 2003), the science laboratory is still unanimously believed to be an essential part of science education (Abrahams, 2011). The objectives of learning science in the laboratory are to make science education more hands-on and motivating, while simultaneously promoting a deeper understanding of both scientific ideas and the nature of science itself (Blosser, 1983; Duschl, 1990; Nakleh, Polles & Malina, 2002). Unfortunately, conventional laboratory courses often do not fulfil these intentions (Tobin, 1990; Hofstein, 2004). Research indicates that a change away from conventionally employed, "cookbook recipe" experiments is necessary to shift practical work in the correct direction (Abrahams, 2011; Kipnis & Hofstein, 2007). Research suggests that more student-centred methods of laboratory instruction should be introduced into contemporary science education. This can be achieved by employing inquiry-based learning, encouraging open experimentation, contextually embedding laboratory work, and connecting practical work to forms of cooperative learning (Hofstein et al., 2013). Opposite to most traditional practices, such settings have the potential to promote a more in-depth understanding of science, raise learner capabilities in problem-solving, and create a more motivating atmosphere for the learning of science (Abrahams, 2011; Bybee, 2000; Kipnis & Hofstein, 2007; Witteck, Most, Kienast & Eilks, 2007; Hofstein & Mamlok-Naaman, 2008).

Reform to change the laboratory into a promising learning environment is needed (Hofstein, 2004). However, the key to any successful educational reform is involving the teachers, as has already been suggested by research (Anderson & Helms, 2001; Hattie, 2009) and also by educational policy (European Commission, 2007). But how can we expect teachers to apply inquiry-based science education or open experimentation in their own teaching when they themselves never experienced it during their own time as pupils in school or as students at university? This holds doubly true if such educational experiences were likewise unavailable to teacher trainees during their pre- and in-service teacher education programs. Both of these scenarios are generally the case for the vast majority of teachers in countries belonging to the former Soviet Union. Science teaching in post-Soviet Union countries was - and in many cases still is - dominated by the "structure of the discipline" approach and teacher-centred paradigms in the realm of pedagogy. The role of practical work was and is often reduced to pure teacher demonstrations (Kask, Rannikmae & Mamlok-Naaman, 2008). Even this has decreased in many former Soviet countries after the fall of the Soviet Union (Holbrook, 2008; Zhilin, 2010).

Based on this situation, the current paper discusses the need for reform in science education and science teacher training in the former communist and post-Soviet countries. This has already been suggested by Reiska, Holbrook and Rannikmae (2008). The discussion will be illustrated using Georgia and Moldova as examples. This paper discusses a project funded by the European Union (EU) which aims at innovations in higher education in the specific field of science teacher training while having Georgia and Moldova as partners: 'SALiS – Student Active Learning in Science'. The course of the project, its achievements to date, and a reflection on the potential role of such projects for the field of science education in general will also be given.

The need for reform in science education in post-Soviet societies

After gaining their independence, the countries of Georgia and Moldova inherited quite complex educational systems from the former Soviet Union. Despite certain achievements in science and science education in the former Soviet Union (McFadden, 1982), the overall Soviet educational model was also recognised having many negative aspects as well. The highly centralized nature of the system prevented educators in all the single republics within the former Soviet Union from working independently towards meaningful curriculum developments and innovations for the pedagogy of science teaching (Holbrook, 2008). The overriding function of the Ministry of Education and its subservient educational institutions in the various Soviet republics was previously the implementation of curriculum policies mandated by the Central Ministry of Education of the whole Soviet Union.

The Soviet Union possessed a unified system of public education, which covered pre-school care, general primary and secondary education, out of school pursuits, vocational training, specialized secondary education and higher education (universities and institutes). The aim of general education as stated in all official state documents was to develop all sides of learners' personalities and to strike a proper balance between the Humanities and the Natural Sciences (Bushkanets & Leukhin, 1976). However, education in the former Soviet Union was quite different from Western ideas of education. Compared to Western countries, the basic aim of education was not to promote critical thinking skills for responsible citizenship as outlined by the central European tradition of Allgemeinbildung (Elmose & Roth, 2005, Hofstein, Eilks & Bybee, 2011), or as obtained from the application of Activity Theory to science education (van Aalsvoort, 2004; Holbrook & Rannikmäe, 2007). The Soviet pedagogic literature outlines an explicit, underlying political focus: "the role of Soviet education is to assist in the building of a communist society shaping the materialist world outlook of the students, equipping them with a good grounding in the different fields of knowledge and preparing them for socially useful work." (Ushinsky, 1975)

The centrally-driven command economy within the Soviet system set the goals of science education and prescribed the pedagogy to be employed. The main objectives of science education were thus the recruitment and exacting preparation of a maximum number of future scientists and engineers. There was little focus on science education either for entrepreneurship or for critical reflection on the use of science in societal issues. Science education was sought to take place at a high academic level, but with little orientation towards general educational skills (Holbrook, 2008). The lessons in all science domains were strongly based on the rote learning of theoretical knowledge – as is still the case in many countries all over the world (Hofstein et al., 2011), among them many countries in Central and Eastern Europe (Janiuk & Mazur, 2010; Zhilin, 2010). The central focus of science lessons was the transfer of subject matter knowledge. This also can be seen by the suggestions for the pedagogy of science teaching. Concerning the pedagogy involved, there were five basic types of lessons suggested by the Soviet pedagogical literature (Kharlamov, 1990):

Lessons giving new knowledge from the teacher
Lessons strengthening knowledge
Lessons reviewing and systematizing knowledge
Lessons based around controlling and assessing knowledge
Mixed or combined lessons with different phases (a combination of the first three types listed above).

All these study processes overwhelmingly used a teacher-centred approach, were without exception teacher-controlled, and primarily assessed the rote learning of scientific theories and facts (Kharlamov, 1990; Holbrook, 2008). Only in very few cases did students have the opportunity to perform practical work. In most cases, laboratory work in science was restricted to lecture demonstrations of fundamental principles by the teacher.

After the collapse of the Soviet Union, many countries like Georgia and Moldova were faced with the double challenge of converting to democracy and a market economy. Science education also had to change in line with these developments; it had to move towards a more democratic emphasis as described by Fernandez, Holbrook, Coll and Mamlok-Naaman (2013). It was also necessary to move away from a command-based structure in educational policy towards more open, diverse approaches of curriculum development and implementation. This challenge was beyond the resources of the newly established countries in many cases (Holbrook, 2008). In Georgia and Moldova, as well as in most other former Soviet Union countries, the "structure of the discipline" approach has remained the basic curriculum principle in science teaching (Zhilin, 2010). Many of these countries are still struggling to overcome the purely academic, subject-matter structured, and teacher-centred paradigm in science education which survived from school science education of the Soviet times (Kapanadze, Janashia & Eilks, 2010; Reiska et al., 2008; Zhilin, 2010). Additionally, decreasing financial resources for education in many post-Soviet countries led to even more limitations in the application of laboratory work. Student-centred practical work diminished even more (Holbrook, 2008; Zhilin, 2010). Instead of focusing on process-oriented skills and capabilities promoting a successful, responsible life in society-at-large, the strong focus on rote learning of theory maintained its chokehold on most teachers, textbook authors, and educational assessment methods.

Since the independence of many of the former soviet republics, the local capacity to carry out educational change, to develop a national curriculum framework, to establish innovative systems for teacher education, or to monitor learning outcomes became challenged for the first time ever (Kapanadze et al., 2010). In the case of Georgia, reform initiatives started in 2004 with the preparation of new national curricula for all secondary school subjects. Within this reform package aiming at the creation of new school curricula, five areas of pedagogy innovations formed the core:

Student-oriented learning,
Orientation on students' age, interests, physical and psychological abilities,
Learning as a combination of development of knowledge, skills and attitudes,
Collaborative choice of teachers and students on the best suitable learning pathways rather than following pre-scribed ways, and
Orientation towards quality rather than quantity of knowledge.

The Georgian national reforms demand more student-active, problem-based science education, which included higher levels of hands-on, inquiry-based learning in the laboratory (Slovinsky, 2012). This development was paralleled in many other former Soviet republics (Reiska et al., 2008).

As one consequence of the reform, there was focus on the standards and syllabi pertaining to science teacher education. In Georgia, new standards for science teachers were developed and approved (Teacher's Professional Development Center, 2012). They specify the competencies required of the science teachers, which should allow them to effectively achieve the desired outcomes defined in the National Curriculum.

The process of implementation for the National Curriculum began in 2006, but the process faced many difficulties. A wide variety of factors hindered implementation: a lack of materials and equipment, varying school sizes and local environments, and shortcomings in science teacher education programs and in-service professional development. Therefore, the Georgian Ministry of Education and Science set priorities to guide the reform process (Slovinsky, 2012):

Developing and implementing guidelines for inquiry-based learning,
Establishing teachers' professional development programs, and
Investing in appropriate equipment and laboratories for inquiry-based science learning.

To help Georgia meet these priorities, Ilia State University in Tbilisi, Georgia and the University in Bremen, Germany cooperatively launched a new project called SALiS (Student Active Learning in Science) (Kapanadze et al., 2010). SALiS intended to aid countries like Georgia in meeting the multiple challenges inherent in science education reform by investing time and resources in the three priorities mentioned above.

Theoretical framework of the SALiS project

Science teaching in many classrooms all over the world is still widely criticized as being too strongly teacher-oriented in nature. If laboratory work takes place at all, it is often limited to teacher demonstrations or requiring students to blindly follow "cookbook recipe" experiments (Hofstein, 2004). Teacher interaction with and among the students is limited to short periods employing guided questions and short answers. This interpretation of learning does not correspond to that which educational theory suggests as proper. Instead, we know that knowledge cannot be directly transferred intact from the mind of one person into the mind of another (Bodner, 1986). Learning with meaning and understanding only takes place if the learning process becomes an activity within the mind of each individual learner (Wittrock, 1989). This means that educational quality cannot be largely enhanced in mere terms of teaching efforts. The quality – and quantity - of learning is much more dependent on the level of activity being exerted by and within the learner (Eilks & Byers, 2010).

Today, our understanding of effective science learning is generally related to the theory of constructivism (Bodner, 1986). Constructivism suggests applying teaching methods which force the learner to be an active player. Such methods should encourage the learner to become cognitively engaged in developing a personal understanding of the topic being taught. The more elaborated interpretations of constructivism not only seek to make students active thinkers, but also to promote interaction and collaboration between them and other learners. The socio-constructivist framework suggests learning through interpersonal communication and social interaction as being essential for effective learning (Hodson & Hodson, 1998; Eilks et al., 2013). Socio-constructivism explains that effective learning requires a process which mainly functions through cultural and social mediation about content (Driver & Oldham, 1989).

The theoretical perspective of the SALiS project was derived from these theories. SALiS is meant to support educational reform by encouraging more student-active science learning. Within the project, enhancing student activity was conceptualized using different dimensions

(Eilks, 2012). SALiS was implemented to cause innovation in science teacher training curricula and infrastructures and to allow prospective teachers to learning exactly how one can make the science classroom more student-active. The different foci of the SALiS teacher education modules focussed on:

1) *Activating students' foreknowledge*. Constructivist learning theory suggests that learning depends on the learner's foreknowledge and interests (Bodner, 1986). Neglecting students' *a priori* knowledge and interests will lead to diminishing learner motivation and limits learning to mere rote memorization. The result will be the learning of isolated facts, which are detached from their scientific origins and any possible contexts of practical application. This means that the knowledge acquired is basically inert, having no chance to be effectively applied in or to any type of real-world situation (Pilot & Bulte, 2006). Putting subject-matter content into a context connected to the learners' foreknowledge and interests is essential for effective learning (Greeno, 1998; Gilbert, 2006). A priori knowledge should therefore be activated and any associations that a student might have with a given topic should be made explicit. Making previously-learned concepts explicit and raising student awareness of the potential discrepancies between cherished foreknowledge and scientific explanations can also be used to motivate debate within science learning (De Jong, Blonder & Oversby, 2013).

2) *Activating students' minds.* Learning science, beyond the cold memorization of facts and theories, is never a passive diffusion of knowledge from one person to another (Byers & Eilks, 2009). Only actively-constructed knowledge has any chance of becoming practically-applicable knowledge, which is transferrable to new situations (Bodner, 1986). If new information is presented which directly challenges the prior understanding of the learner, then cognition will be accommodated, resulting in new knowledge. Therefore, science education should try to activate the students' minds by challenging them via "cognitive conflict" (Piaget, 1985). New information should contradict and challenge prior conceptions, which may be scientifically unreliable. Tasks should be chosen which challenge students' thinking and guide the learning process in an inquiry-based mode, especially in connection to learning in the laboratory (Hofstein, Kipnis & Abrahams, 2013).

3) *Activating students' hands.* Learning can make use of many more pathways than merely the audio or visual channels. The more senses activated, the better the chance is for learning to take place (Medina, 2008). Student-active learning should include hands-on student activity. Practical work is a unique chance to raise both levels of motivation and learning effectiveness (Hofstein et al., 2013). Micro-scale and low-cost-techniques can help open laboratory opportunities to pupils, even to schools with small budgets or insufficient laboratory equipment (Poppe, Markic & Eilks, 2011). However, also other physical and social activities should be embedded into the science classroom, e.g. working with physical models, using ICT, or carrying out drama and role-playing exercises in the classroom (Eilks, Prins & Lazarowitz, 2013).

4) *Activating student-student cooperation.* Cooperative learning provides a whole range of strategies for effective, motivating and student-active learning in science classrooms by promoting student-student cooperation (Johnson & Johnson, 1998). Student-active science learning demands that we apply cooperative learning methods with positive interdependence of the learners, instead of relying on teacher-centred approaches or traditional, unstructured group work. Promising examples of such methods are, e.g., the Jigsaw Classroom or the Learning Company Approach (Eilks et al., 2013).

5) *Activating student-student communication.* At the heart of social constructivism is the idea that learning is "meaning-making" in communication to others, preferably not just with the teacher as a partner (Hodson & Hodson, 1998). Communication and negotiation between learners provoke meaning-making and the shaping of new concepts in their minds. Student-active learning in science should also provoke various forms of communication. It demands that multi-directional forms of communication are present. Pedagogies such as the "1-2-4-All" method (Think-Pair-Share) can help students to organize meaning-making via negotiation and cumulative communication. Methods like the "Ball Bearing" (Inside-Outside-Circle) can help to train communication skills and use reciprocal teaching-learning-scenarios (Eilks et al., 2013).

The course of the project

In 2009, the SALiS project was launched through the joint cooperation of Ilia State University in Tbilisi, Georgia, and the University of Bremen in Germany (Kapanadze et al., 2010). Together with further partners in Ireland, Bulgaria, Germany, Georgia, Moldova, and Israel a reform network application was submitted to the TEMPUS program of the European Union.

Partners in SALiS:
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
University of Haifa – Oranim College, Israel

TEMPUS supports the modernization of higher education in the EU's neighbouring countries and creates an area of co-operation with and within countries surrounding the EU. Established in 1990, 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 Euros. Individual projects receive funding of between one-half and 1.5 million Euros. The SALiS project was successfully approved as a cross-regional TEMPUS project in the summer of 2010 with a total budget of roughly 800,000 Euros. It was conducted between the years 2010-2012.

SALiS aimed at promoting secondary school science teaching through promoting student-active experimental learning in science classes. The project intended to promote inquiry-based laboratory work as one of the foundations of modern pedagogy in science teaching (Kipnis & Hofstein, 2007). Recognizing that the teachers are the core for any innovation in educational settings (Anderson & Helms, 2001; Hattie, 2009), SALiS focused on achieving innovations in science teaching by improving science teacher education. In order to do this, all of the institutions involved jointly developed modules for teacher training (pre- and in-service) to prepare the groundwork for more thoroughly applying student-active pedagogies in school science classrooms (Kapanadze et al., 2010). These modules were designed to enable science teachers to strengthen both hands- and minds-on student learning through the use of innovative approaches to laboratory instruction. These included learning about guided and structured inquiry, open forms of practical work and the use of cooperative learning methods in the laboratory environment. SALiS also provided funds for investments in the respective infrastructures of the participating universities in Georgia, Moldova, and Israel.

From 2010 onward, the SALiS consortium jointly developed teacher training modules, school teaching materials, and an implementation concept for SALiS specifically promoting the use of micro-scale and low-cost laboratory experiments. The objectives of curriculum development for science teaching and science teacher training were as follows:

- *Collecting and disseminating good practices from all partner countries and making them available to the other partners by translation and adoption,*
- *Establishing structures and curriculum materials in the beneficiary countries where a lack of inquiry-based science education exists, and*
- *Building up a platform for exchange of inquiry-based and low-cost supported science laboratory activities for students in secondary schools and secondary science teacher education courses.*

Although suitable laboratory facilities equipped for and dedicated to science teacher education were available in all SALiS partner institutions in the EU, this was not the case in Georgia and Moldova. Therefore, the project also invested in strengthening the infrastructure in the institutions in these countries. For the first time ever in the partner institutions in Georgia and Moldova, specific science teacher education laboratories were established and equipped. A central focus of equipping these laboratories was to invest in a sustainable structure. With this in mind, the concept developed was based on the use of low-cost-science equipment in the teacher education laboratories from the very start. This included such cost-saving measures as: 1) the use of micro-scale experiments with lower levels of chemical consumption, 2) more cost-effective experiments which used modified Petri dishes instead of buying more expensive glassware, 3) practical experiments using inexpensive medical equipment instead of costly lab material, e.g. manufacturing a functioning Hoffmann apparatus out of two syringes), and 4) specifically targeting chemicals and materials readily and cheaply available in supermarkets or home improvement stores in order to create simple, cheap and safe student experiments on a minimal budget.

This approach was chosen so that the laboratories could remain in operation long after the financial support of the EU had disappeared. A detailed, well-illustrated guide on the use of the above-listed techniques was also written and translated into all of the SALiS languages, including Georgian and Romanian. This guide was used as a training manual for the teacher training staff in order to clarify our modified approach to science experiments. It was also made available to all the teachers participating in the SALiS courses via print media and the Internet in their native languages. Additionally a data base of low-cost experiments was created on the SALiS website showing experiments from different science domains. It was also available in all the SALiS national languages. Objectives concerning the development of infrastructure in the SALiS labs included:

- Developing a concept for science teacher training laboratories feasible to the curricular targets of SALiS within institutions in the EU-neighbouring countries Georgia and Moldova and being equipped in a way that sustainability can be achieved under the economic circumstances of the respective institutions beyond the project funding,
- Development of detailed guides that describe the usage of such laboratories in science teacher education including questions of safety, logistics and maintenance issues, and

- Structuring of curriculum materials describing laboratory activities for science teacher education within the SALiS laboratories in the respective languages.

Modules for pre- and in-service teacher education were developed with the full cooperation of all partner institutions. To achieve sustainability in operating the SALiS laboratories, the teacher education staff working at the various institutions was educated in applying the changed pedagogies in science teacher training. One week workshops were conducted in each of the EU-neighbouring SALiS partner countries. Central elements of the staff training modules included an introduction to the philosophy behind SALiS, workshops covering laboratory safety and waste handling issues, sessions on cooperative learning and inquiry-based science education in students' practical work, and workshops addressing issues such as raising levels of student motivation and interest, including questions about how to assess such issues. Additionally, staff placements at the EU-member universities were also offered. Objectives included:

- Qualification of staff for in- and pre-service teacher education courses concerning the SALiS objectives by conducting one week workshops for the teacher education staff on driving the SALiS laboratories within the partner institutions, and
- Learning about practical science teacher education by sharing teaching experiences during placements of staff from the beneficiary institutions in the EU partner institutions.

Although the essential SALiS components and facilities were already available in all the EU partner institutions, the whole process was also believed to lead to further improvements in the individual teacher education programs and available training modules (pre- and in-service) also in the EU partner institutions.

The impact of SALiS in Georgia and Moldova

In Georgia, both participating institutions piloted and implemented the SALiS courses formally into their regular science teacher education curricula. Five training modules were accredited and respective courses for in-service science teachers were implemented from October, 2012. These modules encompassed courses in Chemistry, Physics, Biology, integrated Science education, and elementary Science education. Table 1 gives an overview of the Chemistry education module.
Beside the two original partner institutions, a third regional university in Georgia, the University of Batumi, involved itself in the implementation of SALiS courses both by participating in the Georgian staff training workshop and the final SALiS conference in Tbilisi. The courses also included people from decision-making bodies such as the National Curriculum and Assessment Centre, which is responsible for development and the implementation of the curriculum on the national level. The final SALiS conference held in Tbilisi, Georgia, also allowed the ideas presented by SALiS to be promoted at the national level. Representatives from many Georgian universities, public schools, and educational authorities attended this conference. This was the first time that an international conference on science education had ever taken place in the country of Georgia.

Also Moldova saw both partners developing curricular frameworks and course syllabi for implementing SALiS in their teacher training programs (pre- and in-service). The University of the Academy of Sciences in Chisinau implemented SALiS modules in their pre-service science teacher education program. The Institute of Educational Sciences (IES), the national body for all in-service science teacher professional development in Moldova, undertook a review and revision of the National Curriculum for secondary schools in whole Moldova. The IES connected this revision with the innovations implemented by the SALiS project and changed the syllabi for continuing education courses for teachers accordingly in all the science teaching domains. The educational objectives and course structure of the implemented SALiS module for Chemistry education are documented in Table 2 and 3. Beside the new teacher education laboratories established by SAliS funding, a new center was also initiated at the IES and named The Center for Didactic Excellence. This center will contribute to developing educational software for teaching science. Each year, a total of 700 science teachers from Moldova participate in continuing education courses which were developed in accordance with SALiS' goals and based on teaching materials and curricula which were developed during the SALiS project.

An internal evaluation was also carried out, which was based on observations, discussions, self-reflection questionnaires, snapshot tables, and self-reporting during the project. Analysis of the data covered issues such as project management, reflection on international networking, development of SALiS curricula and teaching materials, establishing SALiS laboratories, the overall success of the training and dissemination of the resulting materials and data (Epitropova & Dimova, 2012).

In the self-evaluation phase, all of the partners stated that the project had been characterized by a positive atmosphere and high levels of cooperation. Although the language barrier with respect to normal school teachers was often quite a problem, specifically in the cases of Georgia and Moldova, intense discussions were nevertheless carried out during the SALiS workshops and staff placements with the help of translation and interpretation. These outcomes show that all of the

Table 1. Structure of the SALiS Chemistry course module operated by Ilia State University in Tbilisi (Georgia) – 30 hours contact time

Focus	Time	Objectives	Content
Student-active Learning in Science (SALiS) – Chemistry education	6 days ; 12 sessions (two sessions per day); each session 2,5 hours	Skills in: - raising levels of pupil motivation in Chemistry lessons - applying inquiry-based pedagogies in Chemistry education - implementing inquiry based science education at the lower and upper secondary school levels - conducting experiments in Chemistry lessons based on low-cost techniques - safe, risk-free operation of school laboratories	- laboratory safety - employing low-cost experimentation techniques in the laboratory - analysing chemical substances - inquiries into and Chemistry experiments on: chemical bonding, chemical reactions, solution chemistry, energy changes during chemical reactions, acid-base chemistry, chemical kinetics, metals and non-metals, Organic Chemistry

Table 2. Objectives of the SALiS course module developed by the Institute of Educational Sciences in Chisinau (Moldova)

1. **Knowledge level:**
   - Conceptualization of theoretical models of scientific knowledge and skills development during the teaching and learning of Chemistry
   - Knowledge development about pedagogies which apply theoretical models of scientific knowledge, stress skills development in practical work and are constructed around low-cost techniques in Chemistry education
2. **Practical level:**
   - Developing skills in applying pedagogies and technologies according to the SALiS philosophy of scientific knowledge and skills development in Chemistry education
   - Establishing connections between contemporary learning theories, theoretical models of Chemistry education, and one's own teaching experiences
   - Understanding students' knowledge and skills development through the application of inquiry-based science education according to the SALiS philosophy
   - Promoting students' skills in identifying, selecting, analyzing, and evaluating information in Chemistry education
3. **Integrational level:**
   - Strengthening learners' capacity to identify and solve chemistry-based problems, including those found in everyday life
   - Combining skills in carrying out low-cost experimentation techniques in the laboratory with inquiry-based science education techniques
   - Promoting creative skills in students by addressing tools which initiate student-active inquiry projects in Chemistry education

partners acted to create a common understanding of the SALiS theoretical framework, including how to implement SALiS in the different countries via teacher educational reforms. All the partners declared a willingness to continue the implementation of the SALiS ideas. Each partner also outlined a clear strategy for sustaining SALiS in their country.

Table 3. Structure of the SALiS Chemistry course module operated by the Institute of Educational Sciences in Chisinau (Moldova) – 20 hours contact time

Focus	Time	Objectives	Content
Strategies and technologies promoting competence development in Chemistry education	4 hours theory, 2 hours practice	Skills in interractive and constructivist methodologies of scientific knowledge development: - Applying educational strategies and technologies for Chemistry education based on the SALiS philosophy - Applying interractive and competence-based instruction in Chemistry teaching and learning	- *Typologies of student-active pedagogies in domain-specific teaching/ learning processes* - *Interractive methods of forming scientifc knowledge via contructivist approaches and the use of ICT* - *The constructivist character of Chemistry problem-solving tasks* - *Inquiry-based learning as a student-active approach* - *Promoting student's creativity via chemistry experiments*
The SALiS approach to chemical experiments	4 hours theory, 6 hours practice	Training practical skills in the Chemistry laboratory: - Experimental investigations of chemical substances and processes - Working safely in the laboratory and handling chemicals in a risk-free fashion - Carrying out cooperative work in the laboratory so that conflict situations are prevented or quickly taken care of	- *Laboratory experiments as a student-active way to acquire scientific knowledge in Chemistry education* - *Various types of laboratory experiments available for Chemistry education* - *Using low-cost techniques in practical work* - *Specific experiments focussing on target topics taken from Inorganic, Organic and Analytical Chemsitry*
Computer-based instruction and ducational software in Chemistry classes	2 hours theory, 2 hours practice	Skills employing ICT: - Using ICT and online tools in Chemistry education	- *Computer-based teaching/ learning in lessons* - *Implementing educational software in Chemistry classes with the help of interractive whiteboards* - *E-learning/ distance-learning*

The curricula and the teaching materials developed and implemented during SALiS were evaluated by the participants as being highly relevant for necessary educational reform in their countries. Feedback from participants from all the partner institutions revealed that the project had also contributed higher levels of both interest and motivation among the teachers and teacher educators in Georgia and Moldova in the area of innovative science teaching methods, including the growth in personal self-confidence when applying student-active pedagogies to science teaching and science teacher education.

Some example quotes from participants in the SALiS staff and teacher education workshop can illustrate the claims found in the internal evaluation:

- *For me this training was very motivating to teach my students better, as I did before. During the training I was a student again and I saw the process from the student's point of view again. I'd like to have this kind of training in the future.*
- *I have learned the simple experiments which I can use during my lessons. These experiments will enhance the motivation of my students.*
- *After this training I can plan my lessons at school better. I teach at the university, too, and these experiments are also very helpful for me when conducting practical work there.*
- *It was my first training on the topic active learning, with many interesting materials on inquiry-based learning. I can use them during my lessons……*

One year after the first SALiS course in Georgia, a random sample of participants was interviewed by telephone. The investigation attempted to follow-up on the impact of the SALiS program on teachers' personal practices. The questions in the interviews were asking to whether the teachers changed their practice both in operating now approaches of inquiry learning as well as whether they started using low-cost-techniques to promote student active learning. To reveal more concrete impressions the teachers were asked for their consideration of their most interesting teaching experience and experiment after having participated in the SALiS course. Finally, the teachers were asked to whether they consider that the changed teaching practice affects the students in terms of learning and motivation, and how.

All of the teachers interviewed reported that they had begun to employ a more student-active style of teaching:

"My lessons have become more interactive, students have more interest in the subject and I am also more satisfied with my lessons."

"Before the SALiS training I only used experimental demonstrations in my lessons. Students weren't active during the lessons. Now my kids are working in small groups with different experiments and sharing their knowledge with each other. They like the Chemistry classes and look forward to the next lesson with great anticipation. This motivates them to really learn the subject and ask lots of pointed questions about the phenomena they are observing."

The core of the project – the implementation of low-cost, micro-scale techniques to allow student experimentation - was viewed as an essential element for moving lessons toward more student-active learning:

"The most important thing learned during the training is how to use low-cost-materials during Chemistry and science lessons. We keep the book on low-cost techniques in our laboratory in the Georgian language. This is a very big help for me, as a teacher […] After the training I prepared some simple experiments with syringes and metal cans and conducted them during my lessons. I divided my class into small groups and each group had its own equipment. […] When my students saw that it is possible to prepare interesting experiments with simple, everyday materials, they even tried to develop some new equipment on their own. One of them got the idea to prepare a low-cost communicating system by two metal cans and a piece of string. He showed it to the Physics teacher. Another student prepared a simple model of a hydraulic machine and explained its principles. Thus, the use of low-cost-techniques during the lessons has become very important for me as a teacher. My students now are more creative. Every single thing they see is now considered to be potential scientific equipment. I see that my students are now more motivated to learn Chemistry. They like to prepare the simple equipment for experiments".

As stated in the last quote, many other teachers also referred to the issue of increasing pupils' intrinsic motivation and promoting their interest in science education. Both of these themes were referred to in the context of including higher numbers of experiments during lessons and increasing students' hands-on activity. Both were dependent upon the use of more open and cooperative pedagogies:

"During the SALiS course I saw that impressive and interesting experiments are very important for student motivation. […] Experimentation is very important. First I showed the new experiments to all of my students. Later they started demonstrating experiments to each other in small groups. After that they started discussing the experiments in small groups, which tried to explain what exactly was going on. After that we analysed the Chemistry content of these experiments as a group. The students started talking about these experiments to other students in school. Now boys and girls from other 10th and 11th grade classes are coming to me and asking if they can participate in my lessons. I think that this kind of lessons raises the level of interest my students have in Chemistry. This was not the case before. They have started asking numerous questions and also try to do some simple experiments at home, too!"

"*I now work hard to prepare my classes in a different way than I used to do, so that all my students are involved actively during the lessons. They prepare and conduct experiments on their own and with great interest. I am very happy that I could motivate my students to learn Chemistry. Now they know that it is a beautiful and 'magical' subject.*"

The issue of safety was also raised. Safety became a big issue in the SALiS course, especially for the chemistry-related modules. One teacher stated:

"After the SALiS course, safety in the Chemistry laboratory became very important to both me and my students. I explained safety to my students in the same way that I learned during the SALiS course. Now we all wear lab coats, safety glasses and gloves when we are doing experiments."

This interview study did not cover the full sample of participants. It is also limited by the fact that the information about changed practices was provided solely via self-reporting by the teachers. Nevertheless, these reports and the quotes listed above indicate that some encouraging changes in teachers' personal practices have already taken place. None of the interviewed teachers stated that they had not tried to implement any changes in their teaching practices. Instead the remarks reinforced the fact that the interviewees had moved towards more student-active involvement during lessons and the use of easy, cheap, hands-on experiments in laboratory exercises.

The potential of cross regional EU-projects for the innovation of science education

Over a period of two years, ten partners from Europe and Israel worked together to achieve innovations in science teacher education in the EU and EU-neighbouring countries. The SALiS project provided a valuable platform for exchange and innovation in science teacher education. Many new materials and modules were developed and subsequently implemented. Revisions of teacher education curricula and coursework were also implemented in the EU and its neighbours, e.g. modules on micro-scale and low-cost laboratory work and in-service science teacher professional development courses in different countries. Several hundred pre- and in-service science teachers attend the latter every year.

The feedback and evaluation data from the SALiS project was very promising and suggests that there may be hope for effective and sustainable implementation of innovative modules in science teacher pre-service education and continuous professional development.

Both the providers of teacher education and the candidates attending the training courses responded positively towards the innovations. This was especially true for the chance to attend hands-on courses for implementing practical work into their teaching. The micro-scale and low-cost techniques were especially appreciated in those countries where practical work has not been a reliable, affordable component of science teacher education so far. A great political echo in the countries of Georgia and Moldova of getting EU funds for promoting science teacher education, helped the project partners in the eastern European partner countries a lot in making the initiative broadly visible up to educational authorities and ministries, as well as in newspapers and national TV. The fact that SALiS was the first EU-funded project which had ever coordinated by a Georgian institution also helped to make the importance of science education research visible on a national level. A similar echo was heard in Moldova and in the community surrounding the partner from the Israeli Arab sector.

The investment not only in content but also in infrastructure in the beneficiary institutions made laboratory-based pedagogical instruction in science teacher education courses available for the first time ever in the partner institutions in Georgia and Moldova. The supporting cooperation in curriculum development with the EU partners, as well as the local training workshops for teacher trainers, supported the establishment of the SALiS laboratories and will assure their sustainable use in the future.

Although the project ended in October of 2012, the established cooperation still exists. Single courses are already being negotiated between the staffs of the various partners and institutions. This cooperation has also initiated bilateral research which increases cooperation among the individual SALiS partners. Such continued contact, exchange and cooperation may eventually result in promoting the overall quality and quantity of science education and science education research in countries like Georgia and Moldova when viewed in the long-term. We hope that the EU continues funding such initiatives which support and strengthen reform in science education and science teacher training in the countries neighbouring the EU. Based on our own experiences, this funding has proven itself to be a good investment in Europe's future and will help bringing the countries in all of Europe closer together.

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