STUDENT ACTIVE LEARNING IN SCIENCE

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Preface

SALiS (Student Active Learning in Science) was a cross-regional project funded within the TEMPUS IV program of the EU from 2010-2012. SALiS involved partners from Georgia, Germany, Bulgaria, Ireland, Moldova, and Israel. The purpose of the project was innovating science teaching by implementing modern and effective strategies in science teacher education. The focus of innovation was to strengthen inquiry-based science education with a high degree of student activity, hands-on and minds-on.

On the base of the theoretical framework of SALiS, science teacher training modules and materials were developed and applied in the SALiS-trainings in all the beneficiary institutions. Teacher training modules were implemented into the teacher training curricula in the beneficiary countries. The curricula introduce prospective and in-service teachers to well established practices of inquiry-experiments, open lab work, problem-solving activities, and forms of collaborative and cooperative learning. Innovations in the beneficiary countries were also touching reform by implementing infrastructure for more hands-on and laboratory activities in pedagogical courses in teacher training, and implementing the culture of low-cost- and microscale-experimentation in science teacher training by equipping respective labs accordingly.

As a final point of exchange and dissemination a conference of SALiS was held with support from the European Union at the end of the project. The conference took place at Ilia State University in Tbilisi, Georgia, on 28-31 August, 2012. This book of proceedings mirrors the presentations, workshops and discussions of the conference.

We thank all the SALiS-partners, the guest speakers, and participants of the conference for their contributions.

Marika Kapanadze & Ingo Eilks

Student Active Learning in Science (SALiS) – The theoretical and organisational framework of a TEMPUS IV project

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Educational theory suggests that learning science follows the theory of social constructivism. This theory asks for organizing the teaching-learning-process in a student-active mode to be characterized by high 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 different dimensions of making the student more active in the science classroom as a theoretical underpinning of the EU-project TEMPUS-SALiS. The framework of the project will be presented.[1]

Justifying more Student Active Learning in Science

Science teaching in many classrooms all over the world can still be characterized as being a teacher-centred approach. The teacher is presenting the content while the students are passive and thought to absorb the information showered on them by the teacher. If laboratory work is embedded at all, it is very much often limited to the teacher demonstrating experiments. Interaction with and among the students is limited to short periods of guided questions and short answers. As a result, we all too often find outthat what we had taught and what our students had actually learned are very different. The most often reaction by the teacher is to try to explain better. The teachers hope that the better they will present the content the better their students will learn(Byers & Eilks, 2009).This interpretation of learning is not in line with what educational theory suggests, e.g. Bodner (1986). Educational theory suggests that, knowledge cannot be transferred intact from the mind of one person into the mind of another. Learning with meaning and understanding only takes place if the learning becomes an activity within 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 education should not be assessed in terms of the effort being put in by the teacher. The quality – and quantity - of learning is much more dependent on the effort being put in by the learner.

Today, our understanding of effective science learning is generally referred to the theory of constructivism (Bodner, 1986). Constructivism suggests applying teaching methods making the learner the active player and 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 and collaboration between them. The socio-constructivist framework suggests learning in interpersonal communication and social interaction as being essential for any effective learning(Hodson&Hodson, 1998).Socio-constructivism explains that effective learning requires a process that mainly functions through cultural and social mediation about content (Driver & Oldham, 1989).

From these theories, we know that science education should apply methods fostering activity in the students' contemplation with the content and also make science education a collaborative and cooperative practice. 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 or learning via practical work. If all the different dimensions of making the student active – hands-on and minds-

[1] This paper is a draft version of a manuscript to be published in the special issue of *Chimicanella Scuola* on the ICCE/ECRICE conference in Rome 2012.

on – are used in science education, the classroom environment has high potential for effective learning, student motivation, and the development of skills beyond the rote learning of subject matter knowledge. More general educational skills will be promoted includinginquiry skills, organising and structuring of projects, or team working abilities. In the result higher cognitive achievement, better development of higher-level thinking skills, increased student self-confidence and satisfaction and better attitudes towards subject matter will be the result (Lazarowitz& Hertz-Lazarowitz, 1998).

2. Dimensions of Making the ScienceClassroom Student-active

Considering the theoretical framework briefly discussed above (see also Eilks, in press), we can allocate different domains where more student activity in the classroom will lead to more effective science learning.

*Activating students' prior knowledge.*One of the first assumptions of constructivist learning theory was that learning depends on the learner's prior knowledge and interest. Neglecting students' prior knowledge and interests will lead to diminishing motivation and will limit learning to rote memorization. The result will be memorization of isolated facts detached from their scientific origin and potential contexts of application leading to 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 effective learning. The prior-knowledge should be activated and associations a student might have with the topic should be made explicit. Making prior-concepts explicit and making students aware about the potential discrepancy between their prior-conceptions and scientific explanations can be used to motivate contention with science learning (De Jong, Blinder & Oversby, in press).

*Activating students' minds.*Learning science, beyond cold memorization of facts and theories, is never a passive diffusion of knowledge.Only actively constructed knowledge has chance to become applicable knowledge, transferrable to new situations. If new information is presented challenging the prior understanding of the learner cognition will be accommodated, resulting to new knowledge.Therefore, science education should try to activate the students' minds by challenging them in a cognitive conflict in the learner. New information should contradict and challenge prior conceptions that might be not scientifically reliable.Tasks shall be used to challenge students' thinking and guide the learning in an inquiry-based mode, especially in connection to the learning in the laboratory (Hofstein, Kipnis& Abrahams, in press).

Activating hands. Learning can make use of more channels than only the acoustic and visual channel. The more senses are activated the better is the chance for learning. Student-active learning 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, 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 operating dramaand role play(Eilks, Prins&Lazarowitz, in print).

*Activating cooperation.*Cooperative learning proofed to offer a whole range of strategies for effective and motivating learning in science by promoting student-student-cooperation. Student-active science learning asks for applying cooperative learning with positive interdependence of the learners instead of the teacher-centered approach or traditional, unstructured group work(Eilks et al., in press). Promising examples are e.g. the Jigsaw Classroom Eilks (2005)or the Learning Company Approach (Witteck & Eilks, 2006) .

*Activating communication.*In the heart of social constructivism is also the idea that learning is meaning making in communication to others, preferably not only the teacher. Communication and negotiation between the learners provoke meaning making and shaping of concepts in their minds. Student-active learning in science should provoke various forms of communication. It asks for multi-directional forms of communication.Pedagogies like the 1-2-4-All method can help students to organize meaning making by negotiation and cumulative communication(Eilks & Witteck, 2005); methods like the ball bearing can help to train communication and operate reciprocal teaching(Witteck, Most, Leerhoff & Eilks, 2004).

3. TEMPUS-SALiS – The Organisational Framework

All the above discussed theories promise to 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. Unfortunately, classroom practice in many countries of the world still seems to be dominated by a teacher-centered teaching paradigm with low student-activity in minds and hands. That is why within the cooperation of the Ilia State University in Tbilisi, Georgia, and the University of Bremen, Germany, the project initiative 'SALiS - Student Active Learning in Science' was launched in 2009. Together with further 10 partners from Bulgaria, Germany, Georgia, Ireland, Israel, and Moldova, an application for a reform network was submitted to the TEMPUS program of the European Union. The project was successfully approved in summer 2010 and was conducted from 2010 to 2012. The budget was approx. 800.000 €.

SALiS aimed at promoting science teaching through a better inclusion of student-active and inquiry-based experimental learning in science classes. The project intended to promote i.e. inquiry-type lab-work as one of the foundations of modern science curricula and pedagogies to raise motivation, support development of higher order cognitive skills, a better learning of science concepts, and to promote a broad range of general educational skills.

Recognizing that the teachers are the core for any innovation in educational settings, the project aimed at innovating science teaching in the above mentioned sense by improving teacher training. For the purpose described, all participating institutions jointly developed curricula and materials for science teacher training. These curricula and materials enabled 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 strategies, open lab tasks, or cooperative learning in the lab environment. Additionally, respective infrastructure was installed in the participating universities from Georgia, Moldova and Israel. In the two years of SALiS several outcomes were reached:

— The SALiS consortium jointly developed teacher training modules, school teaching materials, and a concept of implementation of SALiS via the use of low-cost lab equipment.

— We collected and disseminated good practices from all partner countries and made them available to the other partners by translation and adoption.

— A lab guide for low-cost- and microscale-experimentation in science education was developed and translated in seven languages. A database of more than 150 experiments in different languages for low-cost- and microscale-experimentation was made available via the SALiS website (www.salislab.org).

— SALiS strengthened the science education infrastructure in the six beneficiary institutions through equipping science teacher training laboratories including guides that describe the usage of such laboratories in teacher training including questions of safety, logistics and maintenance issues.

— 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.

— Although the essential components and facilities of SALiS are available in all the EU partner institutions, the whole process also led to an improvement in the teaching skills and available training modules in the EU partner institutions.

Further information can be obtained via the SALiS website: www.salislab.org.

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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 intended change 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 lab. Unfortunately, teaching materials and teacher training facilities are not well enough developed to support sufficiently the intentions of the reform (Kapanadze et al., 2010).

As a response 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 (Kapanadze et al., 2011).

With the help of the TEMPUS-program of the EU, innovation of infrastructure and teacher training were 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 was trained to train teachers more thoroughly towards inquiry-based science education with more student activity, especially based on low-cost- and microscale-laboratory techniques(Kapanadze et al., 2012).

Staff from Ilia State University and Kutaisi State University visited two European Universities – 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.

Fig. 1. *At the University of Limerick, Ireland*

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 languaged published.

Another workshop was conducted by the colleagues from Limerick University for the science teachers of the secondary schools in Georgia, also 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.

Fig. 2. *Trainings at Ilia State University, Tbilisi*

SALiS courses were piloted at Ilia State University during the spring semester 2012. After they were evaluated. The evidence has to be used for the development of the final version of the curriculum and teaching & learning materials.

Teaching and learning materials, labguides were developed, translated in 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 are accredited and trainings for in-service Science teachers will be done at Ilia state University from October, 2012 in SALiS Laboratory. These modules are:
1. Student Active Learning in Physics for basic and high school (2 ECTS)
2. Student Active Learning in Chemistry for basic and high school (2 ECTS)
3. Student Active Learning in Biology for basic and high school (2 ECTS)
4. Student Active Learning in Science for elementary school (2 ECTS)
5. Student Active Learning in Science for the 7th grade (integrated course) (2 ECTS)

Through SALiS training modules the dissemination of project activities becomes broad and sustainable.

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SALiS in Kutaisi State University, Georgia

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This paper describes how the innovations were brought in Kutaisi Akaki Tsereteli State University in aspects of learning natural sciences with the project: „Student Active Learning in Science" (SALiS).

As you know, our country is in the basic educational reform era. National Curriculum and Assessment Center has completed its work in the years 2011-2016 on the national curriculum. The experts of the center have drawn out the plan together with the invited experts - the members of the academic circles and the acting teachers. By the decision of Ministry of Education and Science, learning - teaching sustainability training plan will not change for at least 5 years. The main purpose of New National Curriculum Center is to give knowledge to the students, help them to support the skills, values and attitudes output for their individual formation, with analysis and logical reasoning skills.

In order to meet the criteria of science teaching, a student must:

- have an interest in the surrounding world, news of the discovery and knowledge;
- develop Natural Science for basic research - seizure skills and be able to use them in different situations;
- be aware of current developments in the world of unity;
- to equip the surrounding universe-care skills;
- change of critical thinking and communication skills;
- develop self-esteem and self-control, listen different opinions, and evaluate skills to be able to define their place in society;
- be given the opportunity to possess a healthy and safe lifestyle;
- be aware of the role of science in human progress;
- have an understanding of the need for human cooperation for human development.

The New National Curriculum Center pays a great attention to the emphasis on the organization of a new way of teaching of Natural Science. To strengthen the teaching of Exact and Natural Sciences stand as a top priority for Ministry of Education and Science.

The teaching of Natural Science focuses on the attitude of mood and dependence, on the development of research - searching skills and the use of knowledge required by a modern pedagogy, as well as Georgian classic didactic. According to the great Georgian teacher and didactic figure I. Gogebashvili, the principal aim for learning of nature is „to pave the sympathy of nature to young learners and make them to find out its investigation and its review".

For improvement and perfection of teaching Natural Sciences a joint initiative of the project"Student Active Learning in Science"(SALiS) was launched by Ilia State University and the University of Bremen in 2010 which was implemented in Georgia and in other partnership countries. As we know, a teacher is a leading force for implementing all the positive innovations in educational field. The project aims to implement the innovations in teaching Natural Sciences through the teachers trainings. Therefore a training module is created for each participant institution.The training will be conducted, based on research. This module will enable students and teachers to strengthen a teaching laboratory for conducting innovative approaches.

As I mentioned, this project involved academician personnel of Kutaisi Akaki Tsereteli State University: Gogi Berdzulishvili - training processes and monitoring senior management, Full Professor; N. Kakhidze - Department of Chemistry, Coordinator, Associate Professor; Sh. Jinjolia-Coordinator, Department of Biology, Associate Professor; D.Tedoradze - Associate Professor of the Department of Physics; I. Gogiberidze - an associate professor at the Department of Methodology. T. Dograshvili Associate

Professor, Department of Methodology. Within this project we have gone through two trainings.

We listened to the lectures on the following topics:

- Active teaching of Natural Science with modern trends. (Presented by I. Eilks)
- The ways to increase a motivation for teaching Natural Sciences. (Presented by S. Bolte)
- Natural Science research-based training (Speakers P. Childs, S. Hayes)

Workshops on the following topics:

- Motivation, cooperative teaching and the modern curriculum of Natural Science. (Speakers S. Bolte, I. Eilks, A.Epitropova)
- Research-based teaching experience. (Speakers S.Streller,, S. Hayes)
- Planning and implementation of research-based teaching. (Speakers S.Streller, S. Markic)

Laboratory Course:

- Low-cost technologies for lessons (Speakers S. Markic, P. Childs, M. Stuckey)
- Experiment in Chemistry (Speakers P. Childs, S. Hayes)
- Experiment in Biology (Speakers P. Childs, S. Hayes)
- Experiment in Physics (Speakers P. Childs, S. Hayes)

This training has achieved its mission - to us, it became clear that the old methods are not suitable and it is necessary to innovative approaches and interactive teaching methods. Interactive method involves many forms, all of them are common for those that are actually provided by the teachers and pupils to participate actively and reciprocally. Teachers' professional knowledge and experience is aimed not for only transferring their knowledge and its utilization control, but also to students of internal forces and the maximum expressions of their personal growth. Thus, during traditional teaching methods at the lesson, the central figure was a teacher, the students were readily transmitted knowledge by asking the tasks, solving problems. But with interactive methods students who are attending schools they tend to be in the center of attention together with their classmates. They analyze, evaluate, make conclusions and form their own opinions.

The trainings helped us to use low-cost technologies to conduct experiments. Inexpensive reagents and materials used in the experiments are based on everyday life. They can be found in the supermarket, farm shop, drug store, etc. Thus, these materials will be available at lower prices. In addition, the experiment provides factors such as safety and the pollution of the minor. Class of low-cost technologies for experimentation helps us to reduce costs, but also reduces the risk of contamination and danger. As a result, it is often possible to conduct experiments in class. Trials, experiments and other practical works are of great importance for studying Natural Sciences. Experiments and trials allow us to provide some of the natural phenomenon in classroom conditions artificially, check the assumption expressed by the students. Prerequisite for experiments conducted by students in order to apply their knowledge in practice successfully. The method is used to develop the students' communication skills, such as: the nature of the concepts of objects and events, information collection, generalization, comparison, analysis, and conclusions capacity - development of the concentration of attention, interest and responsibility.

Tempus - The Project „Student Active Learning in Science" (SALiS) of Kutaisi Akaki Tsereteli State University established a new laboratory. The Deputy Minister of Education and Science Irine Kurdadze, opened the laboratory (Figure 1). Teaching Exact and Natural Sciences is one of the priorities of the strategic plan for the Ministry of Education and Science of Georgia .The laboratory is equipped with modern conveniences (Figure2).

Fig. 1. *Presentation of the laboratory*

Fig.2. *The new laboratory of Kutaisi University*

Laboratory experiments will be conducted using the new technologies of modern Physics, Chemistry and Biology. It is important that the laboratory work will be possible not only for the students of the universities but also, for schools. It will contribute the learning of Natural Sciences.

Laboratory SALiS - schools and institutions of higher education that aim to promote the study of Natural Sciences and the development and introduction of modern methods of experimental teaching methods hence the learning process. The laboratory experiments with the traditional experiments focus on low-cost technologies in the learning process. Coping current innovations in education and teaching Natural Sciences provide the implementation of trainings for teachers as well.

Scientific research will be conducted in the laboratory - SPARK Science Learning System. The lab aims to help students to cope the learning of science before they join into the scientific research. The students will learn how to:

- involve in the process of scientific research, the results of prediction, data collection and analysis and interpretation of observations.
- the use of Pasco as the most popular and effective equipment.

The student gains an experience in the following methods:

- to use SPARK Science Learning System using various types of experimental data collection;

- SPARK-periodic samples of data and usage of its methods;
- to use a temperature measuring sensor for collecting datum of temperature of the various subjects with the SPARK data collecting system;
- the use of temperature measuring sensor and a periodic schedule measurements.

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Student Active Learning in Science at the University of the Academy of Sciences of Moldova

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The University of the Academy of Sciences was built with the mission to sustain the excellence in science through education of a new generation of dedicated researchers. Education based on research generates new dimensions for conceptual understanding, skills training, intensification of analysis and systematization abilities which encourage students to integrate and apply their knowledge for generation of new hypotheses and their elaboration into projects. Students of our university are equipped with curricular opportunities that capture science and technology within the learning activities especially in the modern laboratories.

Our efforts are continuously directed towards adjusting of educational plans and curricula to the needs of the science and innovation community, effective collaboration with institutes of ASM, best use of human potential, application of state of the art education technologies including the development of e-learning capacity, rational and effective use of academic facilities. Obviously, such elaborated ambitions required modernization of the university curricula according to the student-centred learning, competences and needs of the education labour market, modernization of the quality assurance system in the higher education, continuous instruction of teaching professionals and staff members. This determined us to search for effective partnerships that will contribute to successful accomplishment of prospected goals.

In 2010 UnASM became a partner in the consortium of countries involved in the realization of 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 elaboration 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 of UnASM and fulfilment of our mission became invaluable.

Republic of Moldova was represented in the SALis project by two teams that assumed one goal in spite of the work with different target groups. The consortium was joined also by the Institute of Education Sciences, which is an institution of national importance in pedagogy and post graduate teaching providing in-service training for active teachers along with the University of the Academy of Sciences of Moldova which is an education and research cluster providing programs for all the levels of education from license to PhD level which joined the project not accidentally but premeditatedly.

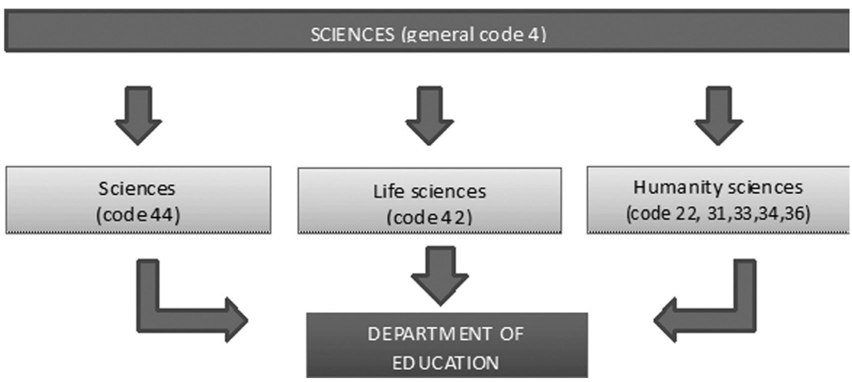

***Fig. 1**.Student active learning in science (SALiS) in UnASM*

The determination of UnASM to enrol the project was based on several reasons:

1) UnASM has an elaborated training program in various fields including general sciences, life sciences and humanities;

2) In accordance with regulations related to education, the University has developed a consistent education module of pedagogy and psychology administered by the department of education. The program is available for enrolment for students from any faculty. The department works hard on developing programs for students that provide for developing their capacities and learning skills;

3) the university has negotiated and adopted a developed strategy of joint development in collaboration with the majority research institutes of Moldova in the frames of the cluster entitled "UnivER Science". We have assumed the mission to promote the development through research-education and innovation;

4) before the commencement of the project works we already started development of publications related to education through research – that later on become our motto. Again, as one may already observed, SALiS project harmoniously complements each of our aspirations.

Joining the project determined the need for a new vision of education at UnASM. It was formed as a result of the thorough investigation of SALiS principles, consideration of consultations obtained during meetings with foreign experts both during site visits to partner countries and during the workshops carried out in Moldova and finally from literatures investigation related to active learning.

Fulfilment of the first work package and accumulation of experience and knowledge allowed us to upgrade the curricula for our individual "Module on psychology and pedagogy".

The project contributed with implementation of new components inspired from the experience of foreign project partners for the module related to pedagogy practice and didactics of experiment and a new course entitled SALiS.

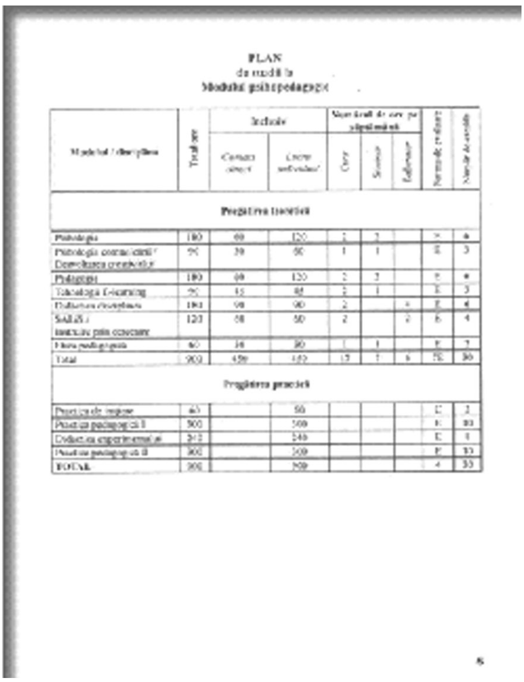

Fig. 2. Integration of the SALiS course into the curriculum of the psychological and pedagogical module

The syllabi for each discipline included in MPP and the syllabi for the SALiS course were elaborated and published

The SALiS course was developed by Mr. Iurie Cristea, the director of the Lyceum of the Academy of Sciences of Moldova under the supervision of cor mem of ASM Maria Duca, head of the SALiS implementation team at UnSAM.

The draft of the SALiS curriculum was discussed by the working group members, and the recommendations made by teachers, consultants and project partners were considered before the approval for implementation.

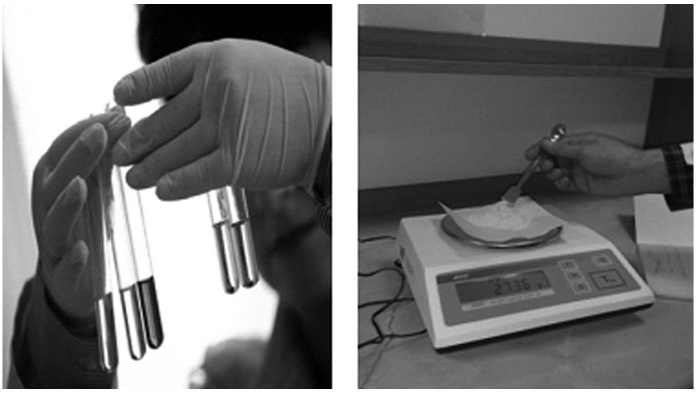

Fig. 3. *Development of curriculum and training modules*

The final structure of the course was accepted and enforced by the senate of UnASM. In its current state the course accounts for 120 hours, out of which 60 hours goes for direct contact hours with the trainer and the rest for individual work. Each student obtains 4 EST credits upon graduation from the course. Topics covered in the SALiS course reflect the aims of SALiS activities, principles, methodology and mode of evaluation.

The development and piloting of the course between January–May 2012 emerged into the development and publication of a guide for professors that comprises our findings and provisions for teaching of SALiS course and application of its components while teaching science related disciplines in schools and lyceums.

Fig. 4. *Elaboration of the "Guide for implementation of SALiS strategy"*

Simultaneously, local members of the project have developed didactic materials that contain practical works for biology and chemistry classes that are meant to be applied for classes taught in schools and universities during in-service and pre-service phases.

While developing the training materials, along with international experience, there was considered contribution of local emeritus teachers to inquiry based learning.

For example the SALiS guide for teaching of physics was based on 65 practical works for schools and 36 articles in the national didactic newspaper "Făclia" elaborated by prof. Mircea Colpajiu. All the works were preliminary tested in lyceum classes, while the electronic version of the guide will be made available in electronic format freely to all the schools of the country.

Fig. 5. *Elaboration of "the Guide for teaching of SALiS practical works on physics" and "Active learning during chemical experiments"*

Three laboratory spaces were provided by the university for the realization of SALiS activities and appropriate devices were selected, acquired and installed in the laboratories of physics, biology and chemistry. The functionality and mode of operation were tested;

At the initial stage of the SALiS project implementation, prof. Maria DUCA, rector of the University of the Academy of Sciences of Moldova, the head of the SALiS-team in the University along with Mr. Iurie Cristea, director of the Lyceum of the Academy of Sciences of Moldova visited the universities of Berlin, Germany and Limerick, Ireland. During those visits they had the opportunity obtain knowledge about the SAliS strategy and the experience of our colleagues from those universities. These meetings provided the most important accomplishment of the project – which is accumulation of knowledge about the subject, experience in realization of SALiS trainings and improvement of professional abilities.

Table 1. *SALiS mobility, 2011*

Dr. Coropceanu. Prof. M. Duca	***Bremen, Germany February***
Dr. Cristea	***Limerick, Ireland***
Prof. M. Duca	***Berlin, Germany, June***
Dr. A.Glijin	***Limeric, Ireland, October***

Equally valuable for us was the training hosted by UnASM in Moldova were the expertise of experts from partner countries was shared with invited teachers, master and PhD students. The trainings and workshops were dedicated to realization of SALiS chemical experiments, demonstration of inquiry based learning tasks, realization of instruction with application of cheep materials and devices, improvement of student centred learning and others.

Fig. 6. *Staff instruction at the University of the Academy of Sciences of Moldova*

Upon the fulfilment of the WP1 – WP2 tasks (elaboration of curricula, development of SALiS laboratories) the process of de facto application of SALiS principles was initiated that was oriented to three target groups:

- UnASM students
- Laboratory technicians and young teachers
- School pupils (through delegation of UnASM trainers in various regions of Moldova)
- Teachers from various regions of the country

In order to pilot the developed SALiS curricula, we launched a training of the SALiS methods for a large group of students as well as for the teachers of the UnASM. In order to inform the teachers in Moldova about the methods of SALiS teaching, we have organized a number of trainings during which teaching materials developed within the project (laboratory works, strategic principles, methodology guides etc.) were disseminated. We provided training courses and demonstrations for Teachers from lyceums and gymnasium from more than 30 schools throughout the country (two workshops were attended by teachers from Moldova, Ukraine, Romania in January 2011), teachers from LASM (M.Duca delivered a report to the council of professors in September 2011).

It has to be acknowledged separately the contribution of our member of SALiS team to the process of dissemination of SALiS principles.

The first pilot course on SALiS methodology was elaborated and realized by Iurie Cristea. His fist course graduates consisted of 73 students who applied for this course. The profile of the groups consisted of

- 36% of students from natural sciences department
- 26% of students from life sciences and
- 36% of students from natural sciences

Additionally, there are must be mentioned active implication of technical staff members of UnASM. Following the SALiS trainings, they have contributed to the development and application of new practical

SALiS works, redesigned the operation procedures with regards to safe management procedures.

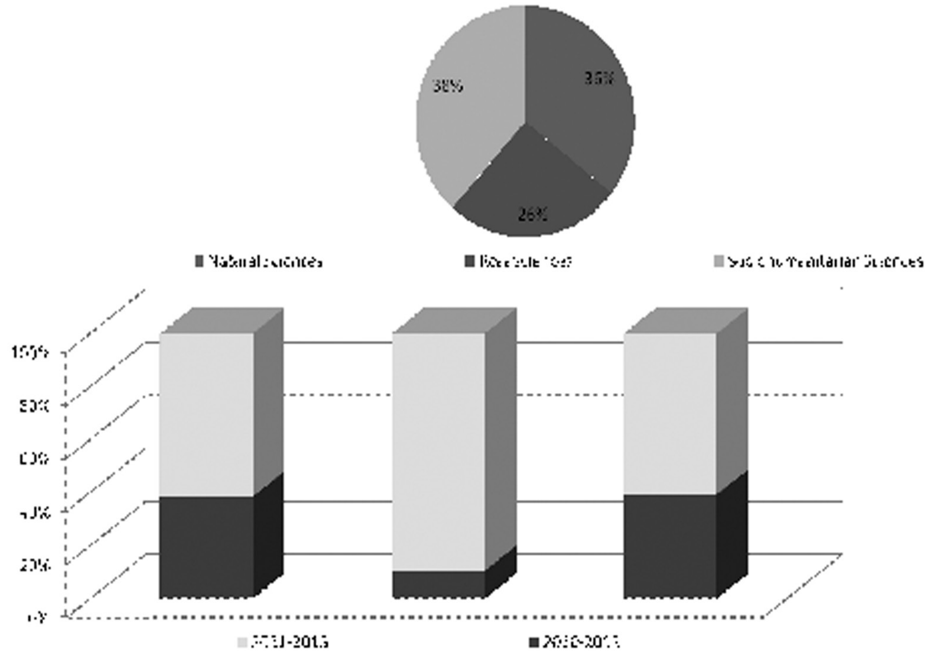

__Fig. 7.__ Distribution of attendance of SALiS course between departments

Here is a representation of the locations of meetings carried out by UnASM representatives. During these visits discussions with pupils took place and the dissemination of SALiS promotional materials was performed.

__Fig. 8.__ Dissemination of SALiS information in schools of the Republic of Moldova

In all, we managed to contact 44 lyceums, 5 colleges and 4 educational administrative units in 20 districts of our country.

The last year, as you see, was abundant in various forms of SALiS trainings. UnASM has hosted various meetings with school and lyceum teachers located throughout the country. In all the UnASM was visited by 280 pupils and 57 teachers that had and exposure SALiS laboratory works demonstrations.

Here is a list of SALiS relevant publications that were published in national academic journals throughout the duration of the project. Our team is determined to continue the development of SALiS relevant methods of training. Current realizations were included in 8 printed materials and also talks were delivered in the frames of the international forum entitled "Nano -2011 cooperation and networking of universities and research institutes "study by doing" (6-9 October, 2011, Chisinau, Moldova)

In order to assure the sustainability of our efforts, the UnASM continuously work on the development of e-learning capacity. All the materials developed will be disseminated through our e-learning platform that will be made available to all the attendees of our future SALiS related trainings.

Also for the purpose improving the capacity of storage for information UnASM purchased and installed a new server and the SALiS web page was created. Later, we placed on the web page all the relevant materials and today they are at disposal of the teachers, students and all those others who are interested in the SALiS project.

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 biggest contribution comes from the task of creating the educational curriculum for the psycho-pedagogical module. The developed curriculum has already been implemented within the University of the Academy of Sciences and certainly can serve as a model for other universities in Moldova that teach natural sciences and do not have pedagogical profiles, for example: Technical University, Academy of Economic Studies, Medical University, Agricultural University and others.

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 sites, 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.

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The Implementation of SALiS Project within the Institute of Educational Sciences from Moldova

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The participation of the Republic of Moldova in Tempus 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 scientific knowledge competence of Science teachers from Moldova through continuous education courses ; thus contributing to effective implementation of science in schools.*

For successful implementation of the above mentioned 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, within the course of the project SALiS team from IES **participated in 4 trainings** on: active learning methods providing overall and specific competences related to scientific activity in Chemistry, Physics and Biology; and issues on the integrated science education. So, the coordinators and scholars attended the following trainings:

a) February, 19-22, 2011- SALiS Kick-off meeting, Bremen, Germany ;
b) October, 16- 20, 2011- SALiS mid-term meeting in Limerick, Ireland ;
c) October, 22-28, 2011- SALiS training in Chisinau, Moldova;
d) October, 16- 20, 2011- SALiS mid-term meeting in Limerick, Ireland.
*e)*June, 16-24, 2012- „Chemical Demonstrations and Chemical Magic Shows“ workshop, Limerick, Ireland.

This experience contributed to **the development of the conceptual framework of the scientific knowledge competence**, analyzed through the perspective of 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, focused on an interaction of: dialectical reasoning, epistemological thinking,scientific language use, and an adequate behaviour to solve significant pedagogically modelated situations.

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 Continuous Education of Chemistry, Biology and Physics Teachers** were modernized and translated into English . 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.

Also, it **was translated and published a Romanian version of *„Low-Cost Techniques in Science***

***Classroom*"** **guide** developed by Nicole Poppe, Silvija Markic, Ingo Eilks; and **elaborated 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".

These documents will serve as a methodological support in teaching SALiS philosophy during Science teachers' trainings as it *argues conceptual dimensions* of continuous development of the didactic staff from the perspective of SALiS concept and 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 the developed methodology, the SALiS team from IES contributed to the equipment of the three **modern training labs of Chemistry, Biology and Physics**, where participants may develop their scientific knowledge competence due to innovative approaches to lab-work instruction, such as: inquiry-type strategies, open lab tasks or cooperative learning in the lab environment. These areas served as a space to provide effectively Science teacher trainings.

During the implementation of the project, **IES organized 2 trainings for the personnel** on: (a) Methodology of Teaching SALiS Concept; and (b) Lab-Work Management. There were discussed the topics such as: techniques and methods in teaching SALiS concept; constructivism as a modern approach in science teaching; the impact of scientific experiment in increasing student's motivation; the principles and methods of scientific experiment implementation; security techniques in organizing science lab- experiments; specific aspects in implementing low-cost equipment experiments; methodology of implementing lab-experiments within Physics, Chemistry and Biology Classes, etc.

It is important to mention that from January-June, 2012 there were **trained 323 Science Teachers from Moldova.** The thematic content of the courses presented an instructive and applying 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, on bases of SAliS labs 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 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 *(picture 8)*, and designed a ***www.proiecte-ise.md*** web site with continuously updated information about SALiS activity.

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 in mass SALiS philosophy through continuous 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 SALiS project.

Taking everything into account, there comes the idea that each of us is determined by what is known, and knowledge is a feature of society in which we live. Currently, the depth of scientific knowledge is immense, and technological development occurs rapidly. Thus, nowadays the power of scientific knowledge is undeniable value in the formation of student personality and an obvious necessity in an era of a permanent change.

The Implementation of SALiS Project on Innovations in Science Teacher Training in Israel

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Naji Kortam, Riam Abu-Much and Saleem Zidani
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Since 2010, 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. SALiS aims at the expansion and enhancement of science education in formal education by innovating teacher training. The purpose of the project is to develop new teacher training materials and incorporate them into pre- and in-service training of chemistry and science teachers. The idea is to develop and promote innovative teaching strategies and cognitive functions of teachers for the purpose of professional development.[1]

According to the rationale of SALiS and the ultimate goal of the project, science experiments and activities were developed and processed at the College. They were written in Arabic to suit the target population. Afterwards, they were translated into Hebrew and English. The processed / developed experiments were selected from a variety of topics in science such as biochemistry, enzymes, genetics and molecular biology, botany, microbiology, environment (sustainability) microscale chemistry, nano-chemistry, physical chemistry, and more. In most of these experiments, science teachers participated. According to testimony from participating teachers, the use of demonstrations allows the transfer of knowledge in a very experiential and relatively simple means, particularly, the use of microscale chemistry. The experiments were performed in the biology / chemistry lab in the college. During the process, we used the equipment that was purchased by SALiS budget. All the carried out experiments of the SALiS project were bound in three brochures that can be distributed to teachers and their students.

Introduction

For many years science education in Israel and abroad, including the teaching of biology, is not only 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 experience enables 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 make 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 is ample natural phenomena fascinating and interesting, which provoke thought and curiosity. Students begin to understand the natural world when they look at the phenomenon, using the senses for observation, and use measuring instruments to enhance the capacity of diagnosis of the senses (National Science Board, 1991, p. 27). Already in 1964, Novak suggested that research involves human effort to find reasonable explanation for a phenomenon that intrigues him. To satisfy curiosity, the research process should include activities and skills that focus on 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 demos 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 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. On 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, is a potential for developing scientific thinking.

The research method

To ensure 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 change 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 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 signs that that are taking place around the learner. In science, in general, and life sciences, in particular, experiments and demonstrations are at the center of learning and research. They are considered as an 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 (Fig. 1), the role of the teacher and the student was not internalized inside them; in addition, the importance of activities and experiments and its contribution to students from several sides 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 to 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 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 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 (Fig. 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.

Fig. 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:

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 ... „.*

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.

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The impact of the TEMPUS-Project SALiS on Teacher Training within the EU-Partners

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The Tempus project SALiS, Student Active Learning in Science, involves four EU partners:

- University of Bremen, Bremen, Germany
- Free University of Berlin, Berlin, Germany
- University of Limerick, Limerick, Ireland
- University of Plovdiv, Bulgaria

In this article I will describe briefly how the EU partners have utilised the ideas and materials developed as part of the SALiS project.The main role of the German and Irish EU partners was to devise and present the lectures and workshops at the teacher training workshops held in Georgia, Moldova and Israel. The Bulgarian EU partner was responsible for the evaluation of the project.

a) **University of Bremen:** the group under Ingo Eilks, Silvija Markic and Marc Stucky at the University of Bremen were involved in SALiS in the following ways:

- In-service training sessions for the Bremen-Oldenburg Centre for Chemistry Teacher CPD.
- Two half-day sessions on SALiS experiments for student teachers in Bremen.
- Developed and maintained the SALiS website.

b) **Free University of Berlin**: the group under Claus Bolte and Sabine Streller were involved in SALiS in several ways:

- **Visit of SALiS Partners in Berlin – June 2011**

  The FUB SALiS-group organised visits for the colleagues of the partner countries to Berlin in June 2011. Staff members from the Academic Arab College of Education (Israel), the Ilia State University and Kutaisi State University (Georgia), and from the University of Academy of Sciences of Moldova visited the Department of Chemistry Education at the FUB. All guests attended lectures and seminars for students (Figure 1), out-of-school science courses (KieWi) for primary school children (Figure 2) and in-service teacher training courses (Figure 3)

  Beside the talks during and after the different sessions there were intensive discussions about science education and lab equipment for inquiry-based learning.

- **SALiS-Courses for Teachers – June 2011 to April 2012**

  During the project the FUB SALiS-group developed two teacher training courses for primary and secondary school teachers and conducted the courses several times. The foci were on Inquiry learning with everyday life products and on laboratory techniques (especially for science teachers in primary schools).

  Each course started with a short introduction followed by a lab session where the participants had the opportunity to try out prepared examples of learning materials and experiments. Subsequently the teachers had time to discuss their experiences and ideas and time to give feedback was also offered.

- **SALiS Pre-Service Teacher Seminar – January to July 2012**

  In special courses for pre-service chemistry teacher students the students planned and carried out a project week to the topic **„Air pollution and climate change“** for pupils of grade 7 of a cooperating school. The aim of this cooperation between school and university is, firstly, to give the pupils an educational opportunity that enables them to intensively deal with the topic in an **inquiry-based** and **active learning** way.

Secondly, the pre-service teacher students were provided with the opportunity to gather their first practical teaching experiences within their Bachelor degrees, because the planned science lessons were carried out by themselves in authentic teaching situations. In consultation with the teachers of the school, a central task for the pre-service teacher students was to put greater emphasis on integrating **socio-scientific contexts** and an **hands-on focus** into the planning and realization of the project week.

- **SALiS in Aachen: Pre-Service Teacher Training – November 2011 to July 2012**

  A hands-on seminar with the focus on school-relevant SALiS-oriented experiments at RWTH Aachen University were conducted in winter term 2011/12 and summer term 2012. In these seminars, the contents of the **SALiS curriculum** (inquiry learning, active learning, low-cost-techniques, motivation) were integrated. The students had the task to develop a sequence of SALiS-lessons in small groups: Starting point was an **everyday life product** which the students had to explore. Then they **formulated questions and assumptions** and **planned and carried out experiments** to test their assumptions. These sequences for inquiry learning and the experiments were presented and discussed in plenary sessions.

c) **University of Plovdiv:** the group under Ani Epitrovova and Jordanka Dimova developed the following aspects of SALiS in Bulgaria:

- We created our SAliS curriculum specific for Bulgarian active science education needs.
- This curriculum has been implemented in two SALiS training session (each one full day) with in-service teachers and pre-service chemistry students.
- SALiS was included as a selective subject in Master degree education course for pre-service chemistry teachers.
- A textbook with SALiS program and experiments is in the process of publication.
- We designed, implemented and reported internal project evaluation.
- We presented one training workshop at each of SALiS trainings in Georgia and Moldova about ‘Water properties – experiments’.
- For the final conference in Tbilisi we will conduct a session named ‘Electrochemistry experiments’.
- Teaching materials were published in the project official web-site. Presentation about SALiS trainings in Bulgaria was published in the web site of Chemistry Faculty of Plovdiv University. The low-cost lab guide was translated in Bulgarian language.

c) **University of Limerick:** Peter Childs and Sarah Hayes used the SALiS approach and developed materials in the following ways:

- Developed a lecture presentation on ‘Using inquiry in chemical demonstrations’ – used in SALiS workshops in Georgia, Moldova and Israel, which involved a series of interactive science demonstrations involving the audience.
- Brought in ideas from SALiS into the annual Chemistry Demonstration Workshops in Limerick for chemistry teachers.
- SALiS members from Georgia and Moldova took part in the Chemistry demonstration Workshops in Limerick in June 2011 and June 2012 (Figure 1)

Fig. 1. *Participants from Georgia and Moldova at the June 2011 Chemistry demonstration Workshop*

- Developed a three day workshop specifically for training teachers and teacher trainers in low-cost demonstrations in Science, which took place in Tbilisi in May 2012 (Figure 2)

Fig. 2. *Georgian teachers and teacher trainers at the workshop in May 2012*

- Developed a series of low-cost, inquiry-based Science demonstrations (biology, chemistry and physics), which are being packaged in a suitable format for teachers for the SALiS website.
- A set of 20 low-cost science demonstrations, using the SALiS ideas of inquiry-based science demonstrations, is being produced and will be distributed to Irish schools, with support from Discover Science and Engineering.
- As neither of the SALiS partners (PEC and SH) are involved in the chemistry teacher training programme at the University of Limerick, due to a change in personnel, we have not been able to include the SALiS ideas directly in these courses.

Conclusion

This article has given a brief survey of how the EU partners have used ideas and materials from SALiS in their own countries. In addition, the project has built a network of people involved in science education research and science teacher training from all the countries and we have learnt much from each other as we have worked and talked together over the course of the project. We think that the involvement in the SALiS project has been a very profitable and worthwhile experience for all involved, not least the EU partners, and we have all appreciated the opportunity to meet, travel to and work with our colleagues from the beneficiary countries.

Acknowledgements: I would like to thank Sabine Streller, Ingo Eilks and Ani Epitropova for sending on information about how their groups have utilised SALiS. This talk was also given at the SALiS symposium at the 22 ICCE/11 ECRICE in Rome, July 2012.

The SALiS Project in Berlin

Claus Bolte &Sabine Streller
Free University of Berlin, Germany

The SALiS group of Freie Universitaet Berlin has realized different activities for pre- and in-service teachers and for staff members of the partner institutions as well during the last two years. Our poster contribution informs about this activities.

1. Visit of SALiS Partners in Berlin – June 2011

The FUB SALiS-group organised visits for the colleagues of the partner countries to Berlin in June 2011. Staff members from the Academic Arab College of Education (Israel), the Ilia State University and Kutaisi State University (Georgia), and from the University of Academy of Sciences of Moldova visited the Department of Chemistry Education at the FUB. All guests attended

- lectures and seminars for students (picture 1),
- out-of-school science courses (KieWi) for primary school children and
- in-service teacher training courses.

Beside the talks during and after the different sessions there were intensive discussions about science education and lab equipment for inquiry-based learning.

Fig. 1. *Guests from SALiS partner countries together with pre-service teacher students in a hands-on seminar*

2. SALiS-Courses for Teachers – June 2011 to April 2012

During the project the FUB SALiS-group developed two teacher training courses for primary and secondary school teachers and conducted the courses several times. The focuses were on

- **Inquiry learning** with every day life products and on
- **Lab techniques** (esp. for science teachers in primary schools).

Each course started with a short introduction followed by a lab session where the participants had the opportunity to try out prepared examples of learning materials and experiments. Subsequently the teachers had time to discuss their experiences and ideas; time to give feedback also was offered.

Fig. 2*. Science teachers in aSALiS teacher training course in Berlin*

3. SALiS Pre-Service Teacher Seminar – January to July 2012

In special courses for pre-service chemistry teacher students the students planned and carried out a project week to the topic **„Air pollution and climate change“** for pupils of grade 7 of a cooperating school. The aim of this cooperation between school and university is, on the one hand, to give the pupils an educational opportunity that enables them to intensively deal with the topic in an **inquiry-based** and **active learning** way.

On the other hand, the pre-service teacher students were provided with the opportunity to gather first practical teaching experiences within their Bachelor degrees because the planned science lessons were carried out by themselves in authentic teaching situations. In consultation with the teachers of the school a central task for the pre-service teacher students was to put greater emphasis on integrating **socio-scientific contexts** and an **hands-on focus** into the planning and realization of the project week.

4. SALiS in Aachen: Pre-Service Teacher Training – November 2011 to July 2012

A hands-on seminar with the focus on school-relevant SALiS-oriented experiments at RWTH Aachen University were conducted in winter term 2011/12 and summer term 2012. In these seminars contents of the **SALiS curriculum** (inquiry learning, active learning, low-cost-techniques, motivation) were integrated. The students had the task to develop a sequence of SALiS-lessons in small groups: Starting point was an e**very day life product** which the students had to explore. Then they **formulated questions and assumptions** and **planned and carried out experiments** to test their assumptions. These sequences for inquiry learning and the experiments were presented and discussed in plenary sessions.

Fig. 3.*Pre-service teacher student presenting a inquiry learning sequence with cleaning products*

Members of the SALiS Berlin group: Sabine Streller, Vincent Schneider, Mario Hoffmann, Manja Erb, Claudia Benedict, Michael Albertus, Prof. Claus Bolte.

SALiS on the Web

Marc Stuckey, Moritz Krause and Ingo Eilks
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This paper describes the SALiS-website 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 thought as a valuable resource for science teachers and science teacher educators in various countries.[1]

Introduction:

The project „Student Active Learning in Science" (SALiS) was funded by the TEMPUS IV program of the European Union. TEMPUS IV is focusing „Modernizing higher education in EU neighbors". SALiS focuses on modernizing science teacher education as part of higher education in the EU neighboring 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 being of potential to support science teachers and science teacher educators in various countriesalso beyond the SALiS project. The central instrument for dissemination 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, 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-neighboring countries the newly developed science teacher training materials might be used as examples of good practice within the ongoing reform in science teacher education.

Even of 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 is available in all the SALiS language, among them in 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, among them in English.

[1] This paper is a draft version of a manuscript to be published in the special issue of *Chemistry in Action on* the SALiS project .

These experiments can be used for school science teaching and 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 allow for further information. All of these materials shell help to promote pre-service science teacher education and teachers' continuous professional development.

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 implemented continuously even beyond the end of the project.

Fig. 1. *Screenshot from the SALiS front page on the website*

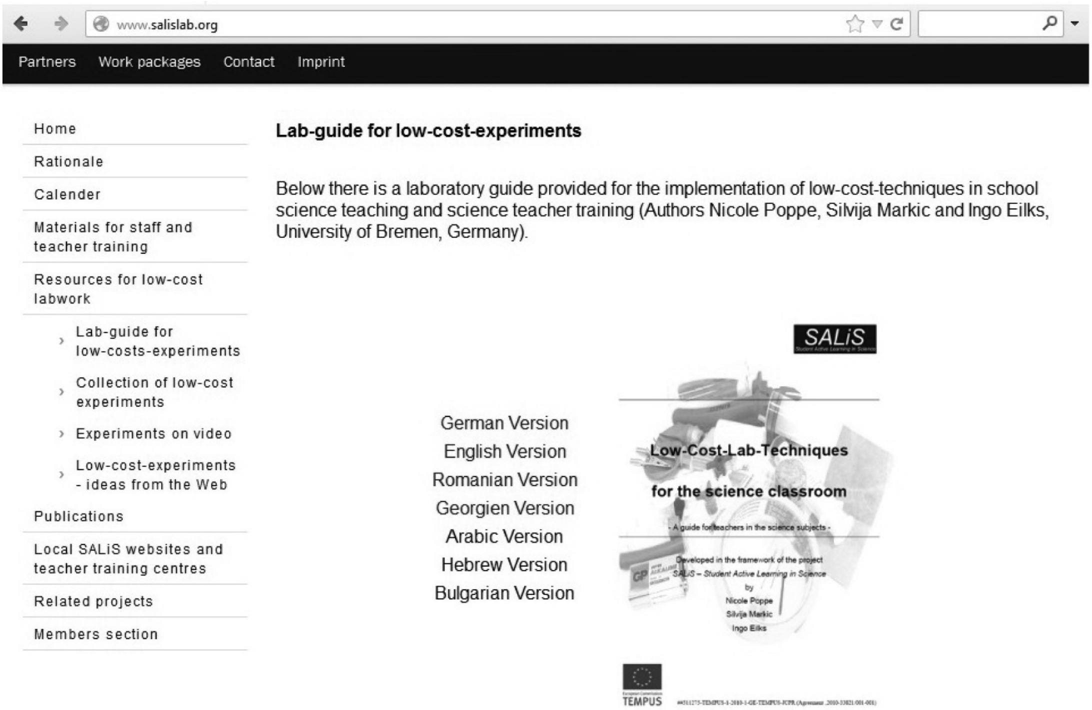


Fig. 2. Access to the Low-cost lab guides

Reference

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, Hebrewand Romanian).

SALiS Project - Summary of Internal Evaluation

Ani Epitropova & Yordanka Dimova
University of Plovdiv 'Paisii Hilendarski', Bulgaria

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 web site of the project. The internal evaluation and quality assurance is part of the project work packages and is carried out by the Bulgarian partner in collaboration with all other partners.

The evaluation of SALiS project is carried out by the following methods: observation, discussion, questionnairesincluding self-reflective 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 entireproject 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 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 trustable working environment between partners, meeting all deadlines put forward. All partners have been informed on time about project budget. Financial procedures between the leading partner and all other partners are adequate and correct. Every partner received necessary individually tailored support preparing his 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 meetings. All meetings have been carefully planned, the programs have beendistributed before the meetings and the partners' opinions have been considered before finalizingthe program. The project leader showed experience and ability to motivatepartners to work together and create an efficient working environment during the meetings. The evaluation team has assessedthe 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 aheadwith the project and every partner has clear understanding of his work and the terms of completing it. The outcomes showed that project management have 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:

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

The evaluation of the training aims to collect information and evidences for the realization of the project goals. Itregister the effects of the planned activities and generate data which are needed for the evaluation of the project.

Table 1.*Model for a monitoring and a formative evaluation*

Wider Objective of the project: ↓↑		To enhance the capacity of internationally relevant inquiry bases science teaching in SA-LiS countries
Specific Project Objective ↓↑	←	**Sustainably of the project's results** ↑
Goals of the training ↓	←	**Results** → **Stability of the results** ↑
Resources for the training	→	**Activities**

The model emphasizes the connections between the tangible project outputs of the training with the goals of the project, which are fixing in the SALiS' logical framework matrix.

The quality of the activities has been measured through specially created reflectivecardsforfastreflection. The reflection emphasizes the connections between feeling, thinking and doing.

Positive characteristics

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

The participants rated the main characteristics of experiments used during the trainings as follow: availability of materials, enquiry based - 91%, attractive and safe - 91%, process skills oriented - 82%. That is an evidence of efficiency of the experiments selected for the training process.

In their reflective card the participants reflect about the curriculum rated it characteristics as follow:science concepts are related to real life situations 92%, they enables students to experience success 71%. After the training teachers report that gain confidence in teaching by using those experiments – 63 %.

Table 2. Criteria and indicators for evaluating the training

Criteria	Indicators	Sources of information
Specific Project Objective • Development of the curriculum of SALiS Universities for training the science teachers into inquiry based science teaching methods	*Expected results* SALiS curriculum is operational (piloted and adopted) and teachers are being trained	Training reports
Goals of the training •To check in practice the effectiveness of the curriculumfortrainingscienceteachers •To check in practice the efficacy of the equipment of the SALiS laboratory	*Expected results* Thecurriculum fortrainingis effective The equipmentis efficient	All sources mentioned in the text official documents – report
Activities • Evaluationofthedevelopedcontent • Evaluation of the experiment as a basic method used in the training	*Quality* positive features	Reflective cards forfastreflection (reflection-on-events)
Resources • Evaluation of the educational environment (presentations, didactic materials,) • Evaluation of the work time management	Quality positive features areas of concern	Inquiry sheet (a questionnaire with positive strength-based questions)
Results • Trained people – self-evaluation of the participation in the activities	Quality positive features areas of concern	Reflective cards forfastreflection (self-reflection)
Sustainability of the results • Self-evaluation of the readiness of each participant in the project to use didactic materials in their pedagogic practice • Self-evaluation of the influence of the training on the motivation for further participation in the project	Quality positive features areas of concern	Reflective sheet

Fig.1

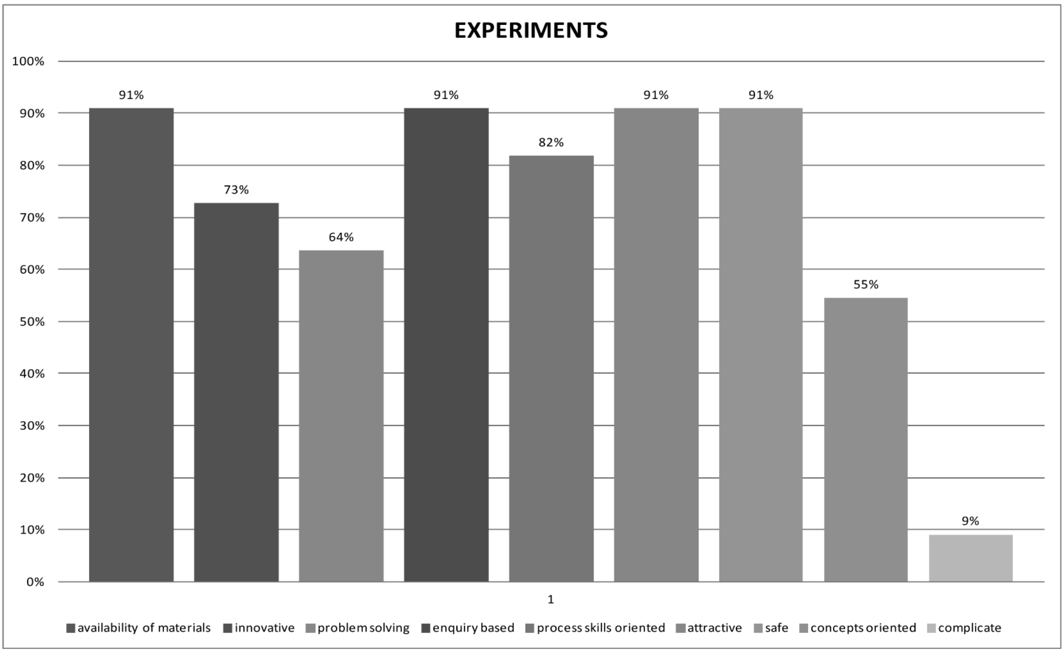
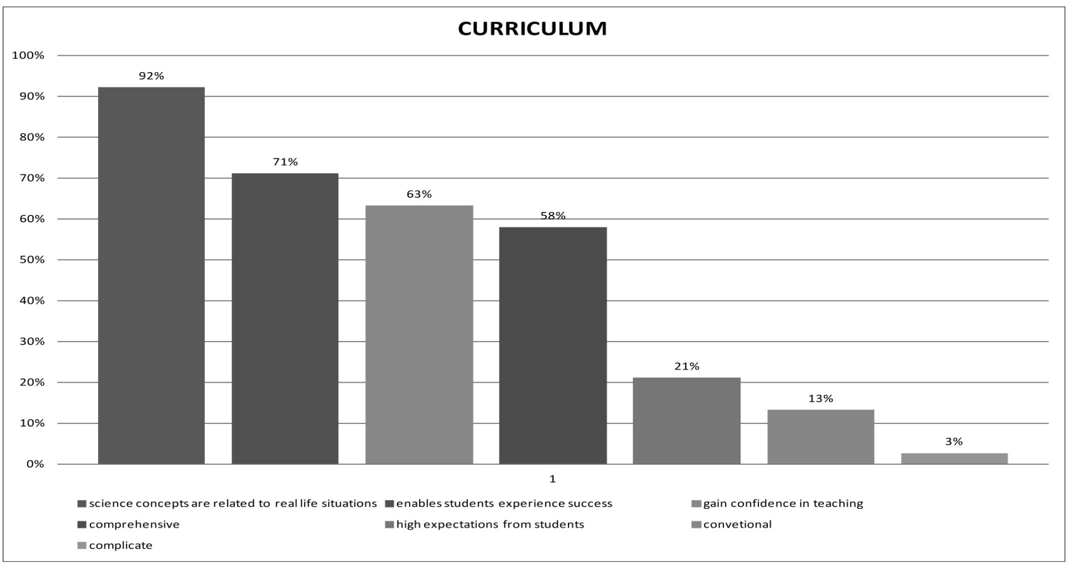


Fig. 2



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 lab 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 'SALiS tutors have excellent competences in all the areas of teaching. " A significant rate of implementation quality has been reportedfor each session. All parties reported satisfaction withdegree of cooperation and team work with the tutors.Safety requirements in the labhave been particularly emphasized.

4. Dissemination

As 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 the home institution web site. The results are 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 instructional and reporting language.

Recommendations

The following two recommendations were shared:

It is necessary to inform science teacher associations in all participating countries about theoutcomes of the projects.

It is necessary to elaborate networking between different parties within each country.

Conclusion

The process of lab equipment and trainings has been implemented according to plan and all the partners reported it as successful and very useful experience. Based on the collected evidence and analysis, the internal evaluation ascertains team that the project work is effective and accomplished the desired results. The partners are convinced that the project outcomes are beneficial for booth beneficiary and EU countries participating in SALiS project.

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Low-Cost Techniques in Science Classrooms

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This paper describes the role of alternative techniques to allow for experimentation as essential part for inquiry-based science education also in less equipped school environments. A theoretical justification and different techniques taken from a lab guide produced by the SALiS pro ect will be presented[1].

Introduction

Experiments are a fundamental part of thinking and working in science (Fisher et al., 1998). This istrue in equal parts for the field of science as well as for its later implementation in engineering and industry. Experiments help 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 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 ifstudents also conduct experiments.Thus, traditional experimentationis associated with numerous burdens. This is the case forall countries, no matter how developed they are. Also in developed countries, the budget for science education has decreasedwhile 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 classroomsetting (Bradley et al., 1998). The students' activities are reduced to its minimum.

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

Furthermore, the low cost follows quite different strategies. An important technique, in particular for the chemical aspect, is the minimization of used chemicals (microscale) (see Hugerat, Schwarz & Livneh, 2006). This is the best way to conserve resources and avoid pollution as well as avoiding disposal problems is to use smaller amounts, less hazardous and less toxic chemicals. Furthermore, they are also supposed to 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 traditionally several milliliters toa few microliters in 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, microor ultra-micro technique.The microor semi-micro technique is in particular well suitedfor science teaching in schools and teachers'training. Overall, the amount of chemicals used in a consistent execution of experiments is reduced by a multiple of 10 following the microscale fast principle,where 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 expended substances and the amount of the substances, of which have to be disposed. As originally

[1] This paper is a draft version of a manuscript to be published in the special issue of Chemistry in Actionon the SALiSproject .

requested, experiments in the laboratories of universities and industry becometherefore less hazardous, more environmentally friendly and more cost-effective.Thus, the low-cost principleaccording toSingh et al. (1999)ensures that experiments in science education are not failing due to high cost.

Furthermore, in the low-cost experiment a replacement of the traditional experimental and laboratory use takes place. Here, materials from the household are used for scientific experiments in the school context. Examples include containers from the household, such as pots, jars, bowls or old plastic bottles. However, materials such as disposable articles of medical engineering, 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 possibilitiesof 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 fracture risk.
- Less time required for the preparation and post-processing for the teachers.
- Increasing of mobility because the equipment can be transported and used without restrictions; specially equipped laboratories are not required.
- Experiments can also be carried out as homework.

Similar to the replacement of traditional laboratory equipment, the used substancescan 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 in supermarkets, home improvement stores or pharmacies for a lower cost, but also dealing with and transporting them is less regimented. In addition, the handling of these resourcesis 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 inscience (Joling, 2006).

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

Experiments with resources in medicine and aquarium engineering

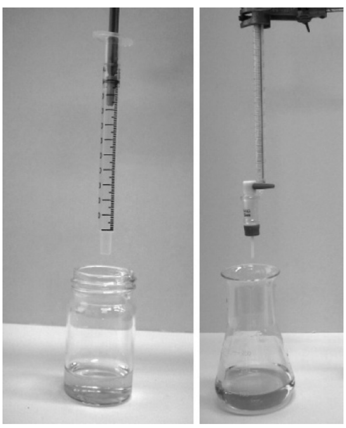

Fig. 1. Syringes as burette

A common problem with experimentation in chemistry classes is that the instruments are often made of glass. This glasswareis expensive and can easily get broken. Therefore, it represents a potential source of riskto the students and must be replaced when damaged, which might be associated withextensive costs (Obendrauf, 2006; Bradley, 2006). However, a wide variety of medical equipment represents alternatives to traditional laboratory devices. Syringes, cannulas, cut-off cocks, infusion tubing and infusion bags are produced in large quantities for the medical sciences. Thus, they are priced accordingly.

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 microscaletitration (Figure1).

When using disposable syringes asburette 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 repeatedseveral times, the bubble-free filling of the syringe can be managed. The synthesis and the absorption of gases by Obendrauf (2006) have 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. 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 developer, many gases can be synthesized.

Fig. 2. *Gas development*

Experiments in petri dishes and spot plates

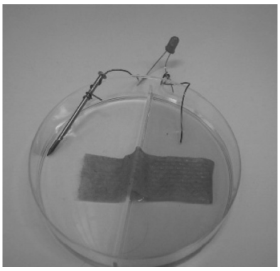

Fig. 3. *Daniell element*

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, it will be demonstrated with the help of a Daniell element 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, cable material, a LED, a zinc sulfate and a copper sulfate solution. The materials are put in order as shown in Figure 3.

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)andthe 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).

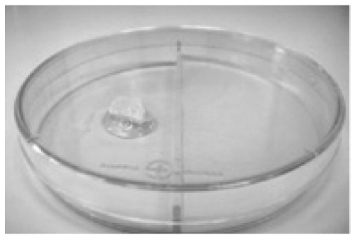

Fig. 4. *Synthesis and detection of carbon dioxide*

Experiments in household packages

Fig. 5. *Battery*

What some people see as garbage can beused 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 cup of the can serves as an electrode and is connected to a consumer or a voltmeter by using cable material. In order to complete the circuit, a graphite electrode or a pencil lead is dipped into the solution by using a consumer or a voltmeter (Figure 5).

The design of pill packages is strikingly similar to the spot plates made of plastic. These empty pill packages also have the same benefits as the multiwellplates. 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 presented in Figure 6.

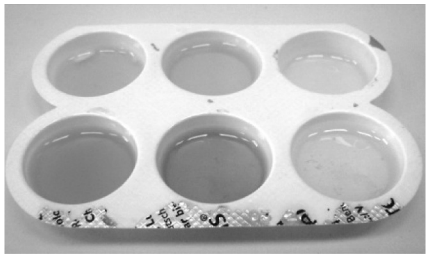

Fig. 6. *Color scale*

Fig. 7. *Model of an eye*

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, a paper tissue, a flashlight and a globe 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.

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 °.

Fig. 8. *Straws in a plastic bottle*

More information about the low-cost techniques and the list of different experiments can be found on theSALiS-webpage:www.salislab.org.

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Management of Science Teachers' Continuous Education Curriculum Implementation based on Scientific Knowledge Competence Development

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The continuous education of teachers is a significant domain which applies into practice the changes from the education sciences. The main goal resides into supporting the process of national education system and professional development improvement. The last ones represent a generator of performed, competitive, creative human resources involved in the development of the knowledge-based society which projects the personal and professional realization through the perspective of life-long learning, where science finds its reflection in each domain of the contemporary life. These modern society requests solicit new theoretical and methodological approaches of continuous education management. Moreover, taking into account that the fundamental science constitutes the basis of all subjects and of all industry domains, a special stress is given to promote the scientific education not only at the lesson or unit level, but at the level of developing an integral and competent personality for a new technological -scientific society.

To this extend, the science teachers assume responsibilities to develop these personalities within Physics, Biology, Chemistry classes, and for a more efficient realization of the educational process they personally need a professional competence-based education. This fact appears to be a challenge for the managers of high-education institutions which provide teachers' continuous education courses.

Nowadays, the concept of competence for each domain of activity represents the condition which ensures the performance and efficiency. Attributing this concept to the didactic staff, it reflects an indices of the instruction quality and professional success. Due to the significance, teacher's personality is always on the view of the scientific researchers.

Specialty reference proposes a range of definitions for the concept of teachers' professional competence. For this reason, I. Junga (2008) analyses the professional competence of a teacher as an assembly of the cognitive, affective, motivational and managerial capacities which interact with the personality traits of the educator to confer him/her necessary qualities to ensure the realization of the set objectives by almost all the students and the performance achieved by the students reaching closing the maximum level of the intellectual level of each of them. The author proposes three types of competences which form the professional competence of the didactic staff: ***specialty competence; psycho-pedagogical competence; psycho-social and managerial competence.***

S. Cristea (2008) mentions four types of teacher's general competences which are:

- Political competence, shown by the appropriate perceiving and assuming of the responsibilities transmitted directly or indirectly to macro-structural outcomes (pedagogical ideas- pedagogical goals);
- Psychological competence, shown by the appropriate perceiving and assuming of the responsibilities transmitted from the level of micro-structural outcomes;
- Scientific competence, shown by the quality of designed projects/planning to illustrate the continuity from the scientific science to the applied science;
- Social competence, dependant on the educational actors' adaptive resources to the always changing national educational community requirements.

Moreover, the didactic competence could be seen as an expression of the pedagogical mastery which consists of the skill to permanently and adequately react in each didactic situation for the successful realization of the educational objectives (Callo, 2007).

The teacher's professional competence is analyzed as a qualitative level specified in the occupational standards and represents a minimum professional standard each teacher needs to possess; thus protecting the society from the risk of unprofessional teaching. (Petrovici, 2006)

According to the researchers from the Institute of Educational Sciences from Moldova, teacher's professional competence represents an integral unit of the inner resources achieved by knowledge and mobilization in solving efficiently the educational situations to realize a quality education.(Pogolsa, Bucun, Botgros, Frantuzan, Simion & Prunici, 2012)

Knowledge represents the base of the social progress of the humanity, which research object is the explanation of the world. In knowledge activity we operate with data, theories and systems, theories and models, systems and structures; all these concepts being the constituted elements of the continuous chain of the cognitive acquisitions to generate new knowledge.

Scientific knowledge in Biology, Chemistry, Physics becomes an organized particular way of thinking, methodically oriented and lead to discover and understand the world and the man. This domain corresponds to concrete, rigorous, demonstrative knowledge of some valuable data on the objective truth of the reality. It expresses in a clear, coherent, and intelligible way the truth and laws which govern so as the objective physical reality of the exterior world as the subjective psychic reality of a human being. For this reason, the Science teachers develop their general competence – the one of the scientific knowledge which results from successive actions, thinking operations on surrounding reality phenomena, from a chain of rational to finally discover the truth.

One of the methods to get the scientific truth in Science is the experiment. Learning through experiment facilitates the scientific concept discovering and stimulates the science learning motivation.

Methodological fundamentation of the teacher's scientific knowledge competence is initially grounded within the university education, and then is developed along the whole professional activity where the teacher transmits the acquisitions of the scientific knowledge from Chemistry, Biology and Physics to the students.

The continuous education for Physics, Chemistry and Biology teachers has to ensure the development of the scientific competence constituted of five specific teachers' competences such as (Bocos, 2002; Bocos & Ciomos, 2002):

- **Epistemological competence** with there components:
  - ***Specialty component*** regards the system of contents, techniques, the specific subject scientific language, the corresponding conceptual schemes, the specific way to solve the problem;
  - ***Psycho-pedagogical component*** regards teaching-learning-evaluation methodology which helps students to build new knowledge according to their different learning styles;
  - ***Cultural component*** regards the degree of professionalism which results from teachers' education and general formation;
- **Communicative competence** regards the mastery of the didactic staff to elaborate the educational messages depending on psycho-pedagogical peculiarities;
- **Managerial competence** regards taking the adequate decisions to realize the objectives and obtain efficient results;
- **Investigative competence** allows the didactic staff to value the pedagogical researches to regulate and self-regulate the instructive process, in general;
- **Metacognitive competence** represents an assembly of knowledge the teacher has about the functioning of personal cognitions, and the controlling processes which direct the cognitive activities within their execution.

The recent research on developing teacher's professional competence shows that this is a complex and long lasting process. Thus, developing teacher's professional competence needs gradually passing through **four stages:**

i. Stage of fundamental knowledge;

ii. Stage of functional knowledge;

iii. Stage of interiorized knowledge;

iv. Stage of exteriorized knowledge.

These stages are indispensable in the process of forming a teacher competent.

The analytical approach of the specific scientific values of the teacher's scientific knowledge competence is based on the rational and empirical vision on nature knowledge. The process of scientific knowledge development has a significant progress along the evolution, being in a relative dependence with the degree of human psychic development. By interiorization, it is transformed from habits and models into beliefs which condition the intelligence mobilization and self-evaluation.

The development of Science teacher's scientific knowledge competence has as a goal:

- Understanding the mechanism of scientific knowledge values assimilation;
- Using the scientific investigation instruments;
- Checking the correctness of the scientific values of the topics;
- Operating with the idea that the scientific knowledge is also a result of a cognitive process of ideas' determination and justification after being analyzed;

The teacher's scientific knowledge competence is a structure of a very complex, self-constructive knowledge-centered personality.

In order to professionally form the didactic staff it was developed the Curriculum for Continuous Education for Physics, Chemistry and Biology teachers, which is a normative document describing the conditions of didactic staff development in terms of professional competence and is based on the SALiS philosophy. The curriculum promotes three essential ideas:

- Active learning;
- Constructivist learning;
- Experiment-based learning, using low-cost equipment.

If speaking about school curricula for Physics, Chemistry and biology, they were all modernized in the context of students' scientific knowledge development which supposes a systematic learning and reflects:

- Student-centered education, and respectively on his activity of knowledge construction;
- Discovering through natural processes, phenomena through experimental research.

The Curriculum for Continuous Education for Physics, Biology and Chemistry teachers meets the aspirations and current changes in education for teaching and learning natural sciences. This change in education requires a reflection reconstruction and metacognition of the teacher's professional competence in general, and specifically, of the scientific knowledge competence.

The own development helps the teacher to create and investigate, to check constantly his/her beliefs, attitudes and behaviors. The development of the competence requires a reassessment of the whole education system under certain coordinates of thought and action. The successful development of scientific knowledge competence of the teacher consists of the need to reflect on the experience of others and of his/her own one. This way, the idea of the reflection is the base of the professional development.

Also, the continuous education represents an individual or group professional change at the level of knowledge, attitudes and professional competence. In the system of the continuous education, there appears new characteristics of the training system such as: the need of m offer of multiple training to meet concrete needs; the possibility of a personalized option; changing the strategic focus from the knowledge acquisition to competence strengthening; combining external and external preparation; the convergence of the professional development with the personal development; the expansion of training to larger domains than the obtained academic specialty; focusing value on pluralism.(Callo, 2007)

The continuous education denotes a changing and improving character while meeting the requirements of the contemporary society. The goal of the scientific education continuous training (Physics, Biology, and Chemistry) is to develop the scientific competence of the teacher based on three pillars: knowledge, attitudes, and behavior. Thus, it might be concluded that the development of professional competence occurs if the transformation occurred at the level of knowledge, of attitude, and of behavior, which is adapted and demonstrated within a certain context situation.

The Curriculum for Continuous Education of the Physics, Chemistry and Biology Teachers tends to develop the professional competence and includes the following structure:

Preliminary;

I. Conceptual References.

II. Key Competences.

III. Specific Professional Competences;

IV. Management of Continuous Education Training, through three modules *(Psycho-pedagogy of Interactive Education; Axiology and Praxeology of Specialty Subject through SALiS; and IT Use and Implementation of Educational Software);*

V. Activities on process, contents and training acquisitions;

VI. Methodological Suggestions;

VII. Assessment Suggestions.

The teacher's continuous education places in the middle of the entire process the student's personality who passes the path of discoveries, and personal development, thus his success depends on the teacher's professional competence. The focus on developing competence in education, requires a different vision on the teacher's professional competence because only a competent teacher is able to develop student's competences specific for pre-university education.

To this extend, the continuous education is a dynamic process realized horizontally and vertically where the polyvalence and transdisciplinarity will be the basic coordinates of the teacher training. (Callo, 2007) This process solicits using the constructive methods which will generate the teacher to think, to concept, to interpret, to reflect, to elaborate, and to model his/her mental activity to finally activate the students.

The training tasks from the constructivist perspective, according to the researcher I.Jointa (2007), are solved by: activating mental mechanisms; constructing the alternatives and their progressive relationships around some cognitive conflicts; interpreting the tasks; direct experiences and the created representations, so that the understanding and resolving the cognitive tasks will be strengthen by exercising.

To this extend, it calls for the active methods appliance where participants discover themselves, analyze critically, argue their own decisions, so encouraging the cognitive and action autonomy. The key of the professional competence development is the self-analysis, cognitive or metacognitive self-control, allowing an internal mediation of the professional teacher training; thus acquiring the values to remove the knowledge errors. This way, the acquired knowledge becomes personalized as the teacher engages him/herself into new learning experiences, into new hypotheses check which are verbalized and negotiated in a group.

The architectonics of the scientific knowledge competence development of teachers include:

- Re-actualization of the prior acquisitions;
- Classification and ordering through differentiation analysis;
- Interiorization by exemplification, exploration, synthesis, rationalization;
- Generalizing by creating, designing.

In this context, the role of the trainer is to organize, structure, guide the trainee , giving supporting reference upon request.

In the process of developing the teacher's scientific knowledge competence it should be stressed on improving the thinking, attitudes, and respectively, the behavior shown within the learning activities.

The teachers' pedagogical thinking is updated while resolving the problems arising in various teaching situations. Therefore, the pedagogical influence is often reflected in the spiritual universe of the student. Thus, building the student's personality becomes a preserve of the education which will be achieved by the professional competence of the teacher, who must respond effectively to the change.

The interdisciplinary approach in teaching and learning Physics, Biology, and Chemistry contributes to create an overall vision in solving reality problems, thus updating prior knowledge and ensuring its awareness. The evaluation results indicate that this learning approach cultivates the mobility of thinking and the sustainability of the awareness.

Moreover, promoting the concept of integrated scientific education will lead to positive indices expressed by certain values and attitudes that can be made either to teachers or students. These are:

- Complex and creative thinking;
- High level of the objective image of reality knowledge and of the Self;
- The system of methods of the unitary knowledge of the reality and Self;
- Scientific language specific to the integrating knowledge.;
- Adequate behavior in resolving significant everyday situations.

The interdisciplinary correlations represent the logical links between subjects, meaning that the explanation of a certain phenomenon requires additional information and methods acquired in other domains. These could be spontaneous or planned, and could consist in defining some concepts, using some methods or tools in the new contexts, transferring some values and forming the attitudes through different subjects. Also, it is important to mention that the lessons with the interdisciplinary approach of the content correspond to the students' preferences and allow them to manifest themselves as special personalities.

Another issue in the management of the continuous education implementation represents the evaluation. In the process of the teacher's professional development the evaluation is relevant because:

- The adult enters into the educative process with his/her own beliefs, expectancies regarding the training course. He comes with his own experiences, goals he needs to accomplish, questions he needs to find answers to. This way, without an initial evaluation of the trainees the educational process might fail from the beginning.
- The evaluation in the adult education involves directly the trainee, transforming the evaluation into an internalized process of the assessment where the trainee actively participates. Moreover, the trainee represents by him/herself a partner of the assessment as it includes discussions, negotiations, clear motivation, and the most important, self-evaluation.

Therefore, the teacher training evaluation appears to be a very complex process, including:

- The initial evaluation of trainee's learning needs;

- The evaluation for identification of the dominant learning styles;
- The final evaluation of training's outcomes.

That's why the evaluation of the achievements in the process of teacher trainings should be directly related to the competences which this course intends to form and develop.

Regarding the valuable aspects of the evaluation, they appear to be more numerous and more diverse the adult education, being analyzed from more perspectives than the evaluation in school. For instance, there are distinguished four levels of evaluation related to each stage of training:

- Assessing trainee's reactions (if they liked the course);
- Assessing course learning(if they internalized the necessary acquisitions);
- Assessing post-learning behavior (if they show/manifest a current mode of the professional behavior);
- Assessing training's results in terms of profitability (if they realize the costs and the added value). (Palos, Sava & Ungureanu, 2007)

The evaluation of the teacher's scientific competence is authentic only in relation to the relativity of the cognitive situation, construction which has been achieved in the course of its understanding and resolving. Thus, the formative assessment of the teacher's scientific knowledge competence refers to checking and appreciation of the quality of the construction and knowledge process evolution; while the summative evaluation materializes value judgments on their achieved performance. The evaluation of this competence highlights not only the visible results of knowledge, but also the context in which knowledge is constructed (the organization of the situations, processes, factors, methods, tools).

The evaluative process of the scientific knowledge competence development within the continuous education courses involves:

- Criteria and descriptors that consider the individual performance in knowledge construction;
- Qualitative methods to assign the cognitive development progress; all related to the applying context;
- Check in authentic situations;
- Outcome analysis from multiple perspectives.

Also, it is based on the following principles:

- **The principle of fairness,** which offers equal opportunities for all candidates, puts everyone on equal terms with no disadvantage or advantage. The decision criteria are known by all candidates.
- **The principle of credibility,** which involves the use of methods that consistently lead to the same decision on the evaluated competence. The evaluators will demonstrate that they have experience in the competences they assess.
- **The principle of flexibility** adapts the evaluation process to the variety of contexts in which it is conducted.
- **The principle of validity** involves selecting the assessment methods that will offer the information relevant to what follows to be assessed. It presumes the fact that:
  - The evaluators know exactly what they evaluate(it is designed and conducted based on certain criteria, or based on pre-determined learning outcomes);
  - The collected evidence are the results of conducting the tasks relevant to what is going to be assessed.

To evaluate the scientific knowledge competence of the teachers there could be used the tools such as: portfolio including the teacher's portfolio developed within continuous education courses, the research paper and the report on teacher's professional development and career promotion.

All products made by the teacher are not just supporting reference of the didactic process, but evidences of it. In this term, we can say that the portfolio is a very important tool in gathering the information certifying the teacher's acquired acquisitions.

For the portfolio to be superior to any other ways of illustrating the trainees' progress, it should contain only really relevant products developed by the learners to highlight their creativity, self-direction, versatility, performance culmination of the extensive trainees' work.

All in all, the evaluation of the teacher's scientific knowledge competence, as well as training process, represents a result of the construction of a certain way of knowing, of solving effectively a particular problem in relation with the constructed values and valuable judgments.

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Student Active Learning in Astronomy

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Astronomy is the oldest of all sciences. For thousands of years, it has had a great influence on human perception of our surroundings and of ourselves. Astronomy education is currently enjoying a period of curriculum-driven exposure and development after having waxed and waned in popularity over the last 150 years. It enjoyed widespread popularity in the latter half of the 19th century (Harris, 1982); however, for much of the 20th century, astronomy became almost totally excluded from schools (Jarman & McAleese, 1996).

Recently, astronomy and astrophysics have come to play a central role in the natural sciences, with many direct links to other sciences (e.g. many aspects of physics, mathematics, chemistry, the geo-sciences). They have an important cultural content including our distant origins, the recognition of the location and restricted extent of our niche in space and time, cosmological considerations as well as philosophy in general. Its recent successes are largely dependent on advanced technologies and methodologies, e.g. optics, electronics, detector techniques at all wavelengths, computer techniques such as image processing and the transfer, storage and retrieval of very large data sets.

Astronomy is undoubtedly one of the sciences that enjoy intense public interest, as testified to by the very large number of popular astronomical journals, planetaria, amateur clubs and interested individuals in all countries. Trumper (2005) found that the three most interesting physics topics for junior high school boys and girls were „How it feels to be weightless in space", „How meteors, comets or asteroids may cause disasters on earth", and „Black holes, supernovas, and other spectacular objects in outer space".

As reported in different countries like the US (Zeilik et al., 1997), New Zealand (Taylor, Barker, and Jones, 2003), Cyprus (Diakidoy & Kendeou, 2001), and Estonia (Kikas, 1998), astronomy education, probably more than other branches of science education, is often characterized by an aggregation view of knowledge that is largely incompatible with current philosophy and practice. Overall, astronomical concepts are presented as facts, with relevant explanation either missing or taking the form of simple statements of causes with no further description of the underlying causal connections. Moreover, the sequence of the presentation does not appear to take into account (a) the interrelationships that exist among the different concepts, (b) that the acquisition of some concepts may be a prerequisite for the acquisition of others, and (c) that the students may have already formed their own conceptions.

A number of factors contribute to the potential of astronomy as an agent for change in students' conceptual frameworks:

1. New discoveries in astronomy create interest and can be exploited to increase students' motivation to learn science;
2. Other research fields in science can be incorporated in, and enriched by, the study of astronomy;
3. The study of astronomy can display the growth of knowledge as a process of developing, discarding and replacing explanatory models;
4. The study of astronomy can lead to a better understanding of the world in which one lives, just as the study of anatomy leads to a better understanding of one's body.

Students' Conceptions of Basic Astronomy Concepts

According to the constructivist perspective, humans are seen as subjects who actively construct understanding from experiences using their already existing conceptual frameworks (Vosniadou, 1991; Wubbels, 1992). What a student learns, results from the interaction between what is brought to the learning situation and what is experienced while in it. In many cases, students' naive notions are often misconceptions, or alternative frameworks, which may impede learning of appropriate concepts in the field despite best efforts by instructors (Redish & Steinberg, 1999).

High school, college, and university students' notions on astronomy concepts have been investigated far less than those of elementary school students, which have been researched extensively during the last thirty years (e.g., Baxter 1989; Jones, Lynch, and Reesink, 1987; Klein, 1982; Nussbaum, 1979; Nussbaum & Novak, 1976; Sharp, 1996; Sneider & Pulos, 1983; Vosniadou, 1992; Vosniadou & Brewer, 1992, 1994).

Lightman and Sadler (1993) found that students in grades eight to twelve shared some of the conceptions held by elementary school children. Though more than 60% of the students held the accepted scientific concept about the day-night cycle, less than 40% knew the correct characteristics of the Moon's revolution. Furthermore, less than 30% had the right conception about the phases of the Moon, the Sun overhead, and the Earth's diameter, and only 10% knew the reason for the season's changes.

Zeilik, Schau, and Mattern (1998) investigated the conceptions of science and non-science university majors on several physical and astronomical concepts. They found that before entering an „Introduction to astronomy" course at the university, only 10% of the students held the correct view of the Moon's rotation, 23% had the right conception of the Sun overhead, and about 30% knew the accepted scientific explanation of the phases of the Moon and the solar eclipse.

Very few studies investigating teachers' astronomy conceptions have been carried out. Bisard, Aron, Francek, and Nelson (1994) assessed suspected science misconceptions, including some astronomy conceptions, held by groups of students ranging from middle school through university. Regarding the astronomical topics separately, the main findings of these researchers were as follows:

1. Students generally performed quite poorly when asked about the Sun's position in the sky at specific times of the day and year.
2. Slightly fewer than 40% of all students correctly replied that the different phases of the Moon are caused by reflected sunlight.

Trumper (2001) carried out an assessment of students' basic astronomy conceptions from junior high school through university. He summarized the most widespread misconceptions at all educational levels as can be seen in Table 1.

Moreover, he found that university students, even if they did not study physics, achieved the highest correct response rate (51%), very similar to that obtained by senior high school physics students. The correct response rate of senior high school students was somewhat higher (44%) than that of future high school teachers (40%), but the same as that achieved by future high school science teachers. Future elementary school teachers got the lowest correct response rate (32%), even lower than that scored by junior high school students (36%). This suggests that future elementary teachers have more misconceptions about basic astronomy concepts than typical junior high school students.

Constructivist and Active Attempts in Teaching Astronomy

The public interest in astronomy seems to have grown since the upsurge of media reports of the different satellites and shuttles taking part in space research. In parallel, astronomy is being increasingly introduced in the school curriculum in different countries, including Israel. Nevertheless, very few teachers venture to teach astronomy since they lack the necessary knowledge and training for it; the majority of elementary and junior high school teachers have not studied astronomy in school or in college. Moreover, learning astronomy demands abstraction capabilities and a high understanding of space and time concepts, or alternatively, ways of teaching that explain phenomena as concretely as possible. These requirements increase teachers' lack of confidence and reluctance to teach astronomy.

Vosniadou (1991) held it is important to design curricula and instruction that aim at increasing students' conceptual awareness. Students often find scientific explanations incredible and see no reason why they should question their beliefs, which are more consistent with their everyday experience.

Table 1. *Most widespread astronomy misconceptions by groups, in percentages*

Subject	Misconception	Junior high school	Senior high school	Future primary teachers	Future high school teachers	Non-science univer-sity
Day- night cycle	Earth moves around the sun	36	30	51	37	34
Moon's phases	Moon moves into earth's shadow	19	27	16	25	29
	Moon moves into sun's shadow	25	17	29	23	16
Reason for seasons	Earth closer to sun in summer	45	33	37	32	32
Reason for it being hotter in summer than in winter	Earth closer to sun in summer	36	28	20	19	22
	Earth's rotational axis flips back and forth	20	23	31	29	23
Sun overhead at noon	Everyday	35	36	48	44	42
Moon's phase in solar eclipse	Full phase	74	77	71	75	70
Moon's rotation – same side visible	Moon does not rotate on its axis	54	57	51	47	50

In this constructivist spirit, Bisard and Zeilik (1998) found that allowing student groups to work on an activity for ten to fifteen minutes each class period could be very productive if the activity was well-structured and not too easy. In such a way they restructured their classes as what they called 'conceptually centered astronomy [classes] with actively engaged students' reporting significant students' conceptual changes (Zeilik & Bisard, 2000).

Morrow (2000) proposed and performed kinesthetic astronomy lessons in which, through a series of simple body movements, students gained insight into the relationship between time and astronomical motions of Earth (rotation about its axis, and orbit around the Sun), and also about how these motions influence what we see in the sky at various times of the day and year.

Diakidoy and Kendeou (2001) reported a study they carried out with fifth-grade students learning astronomy concepts such as the Earth's shape and rotational movement, and the day/night cycle. For example, in the activity dealing with the day/night cycle students were asked to express their ideas, and the cycle was demonstrated with the use of a balloon and a flashlight. The findings of the study showed that students who received experimental constructivist instruction of target astronomy concepts demonstrated significant improvement in their understanding and learning of these concepts, in contrast to students who received standard, textbook-based instruction.

Bakas and Mikropoulos (2003) developed an educational tool based on the technologies of Virtual Reality. The objective of this virtual environment was to create an interactive learning environment within which students aged 12-13 were able to come into immediate contact with the movements of the planets and the Sun and the phenomena occurring in our solar system, in particular the Earth-Sun system. The researchers' findings showed that after the interaction with the virtual environment, students created fewer, more concrete, and scientifically accepted mental models.

The Present Study

Bearing in mind the misconceptions that have been observed in the foregoing research studies, the purpose of the present study was to carry out a series of constructivist activities in order to change future elementary and junior high school teachers' conceptions about the reason of the seasonal changes, and several characteristics of the Sun-Earth-Moon relative movements like Moon phases, Sun and Moon eclipses, and more. The activities and results concerning the cause of seasonal changes are reported here.

Sample Characteristics and Research Methods

We carried out a research project with 138 university and college students, divided into four different classes, all of them studying introductory courses on astronomy for the first time in their lives. The experimental class comprised 19 junior high school technology teachers learning a semester course in their retraining for science teaching in primary and junior high schools in the framework of their B. Ed. studies at an academic college of education. There were three different control classes, which learned in the traditional lecture-based way, including use of audio-visual materials with computer animations and simulations, coupled with the use of demonstrations given by the lecturer: one comprising 83 university students learning a semester course in the Interdisciplinary Department of the Faculty of Humanities, 14 future high school physics teachers taking a semester course in the framework of their B. Sc. studies in the Physics-Mathematics Teaching department of the Faculty of Science and Science Education in the same university, and 22 future primary school teachers taking a year-long course in their training for science teaching in Bedouin primary schools as part of their Teaching Certificate studies at the same academic college of education as the experimental class.

The astronomy conceptions of the students were analyzed by means of a written questionnaire containing 21 questions presented to them at the beginning of the course. Five experts in physics education research and three experienced lecturers in Introduction to Astronomy courses judged the content validity of the questionnaire. After some minor changes as suggested by the judges, the test was deemed valid (see Appendix). Cronbach's alpha coefficient for reliability was found to be 0.62, a relatively high score considering that different questions were related to different astronomy concepts and understandings. Furthermore, we performed an item analysis that provided discrimination indices measuring the extent to which the test questions differentiated between students with the highest and lowest scores on the total test. All the questions discriminated positively, and for most of them the discrimination indices were in the range of 0.18 to 0.62 in respect of the upper and lower quarters of the sample, and 0.31 to 0.76 in respect of the upper and lower 10% of the sample.

Experimental Instructional Activities

The key aspects of constructivism that influenced the materials and activities for developing student' understanding can be expressed as the need:

a. to have knowledge of students' existing understanding in the targeted conceptual areas, and to use this as a starting point for the design of appropriate teaching materials;

b. to provide active experiences that will help students to change their views and conceptions, and accept the scientific view.

We kept to the general trend proposed by Vosniadou (1991) in science teaching in general, and particularly in astronomy. Aiming to replace well-established beliefs with a different explanatory framework, our experimental instructional activities tried to:

1. create some conditions for students to question their entrenched beliefs. Putting students in circumstances where they have to evaluate empirical evidence that is contrary to their beliefs can accomplish this;
2. provide a clear explanation of scientific concepts, preferably in the form of conceptual models or analogies;
3. demonstrate how the new conceptual models provide a better account of the available empirical observations than the entrenched beliefs.

The study began at the start of the semester, after the students completed the pre-test questionnaire, and ran for three months including only three periods of 45-minute classes. Most activities were assigned to the students as homework. The experimental instructional procedure was designed to be flexible and to proceed according to the students' time available for it. In the first activity, on February 16, students were asked to predict the path of the Sun in the sky during the day, marking a line representing its position on a clear plastic dome, as depicted in Figure 1, from sunrise to sunset through noon. The plastic dome represented the sky and the observer „stood" exactly at the center of the dome basis (the X position in Figure 1).

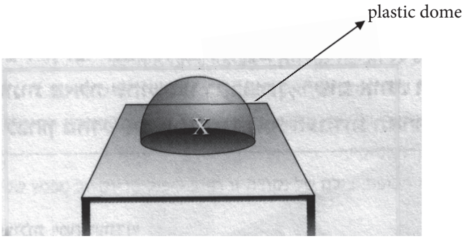

Fig. 1. The plastic dome

After a short class discussion, the students were assigned a series of once-weekly homework activities for two months:

1. Tracking the Sun's path in the sky: This activity allowed students to track the apparent motion of the Sun in the sky on a model in which the plastic dome represented the sky. To do this, they had to mark on the same dome they used in class the positions at different hours of the day that cast a shadow on the same central spot (X). For this activity, an outside level spot had to be picked which was not to be in shadow at any time during the day, and the dome had to be fixed on a piece of stiff cardboard. Using the compass, students had to mark a North-South arrow on a corner of the cardboard, trace its outline on the ground so that its position could also be verified before each observation, and anchor it with a brick to prevent it from blowing away. Students were asked to write answers to several questions after completing the activity: What sort of path does the Sun follow in the sky? Did the Sun travel directly over the top of the dome? Where did the Sun begin in the morning? Where was it in the afternoon? What about at noon? At midday? At sunset? How does the Sun's path change during the different observations? How do these paths compare with your prediction?

2. Tracking the Sun's shadows: Each student had to mount a short yardstick in clay at the edge of a piece of stiff cardboard and outline the yardstick position with a marker. They had to place the cardboard parallel to the plastic dome cardboard, trace its outline, and anchor it also with a brick to prevent it from blowing away. Students had to mark the position and tip of the shadow of the yardstick at regular intervals throughout the day, noting the time of each observation on the same days they tracked the Sun's path (see Figure 2). After a day of recording, students had to connect the shadow ends recorded near noontime with a line (if not measured, the locations of the noon and midday shadows could be estimated from the positions of shadows marked at nearby times). If a computer was available, the length of each day's shortest shadow had to be measured and entered, along with its time, onto a spreadsheet or graphing program. Students had to make a computer or hand graph relating the shortest shadow length to the day of each observation. Students were asked to write answers to several questions after completing the activity: How do shadow lengths change during the day? Why do they change? Is there a pattern as to where the shadows fall and their lengths? Why is there a pattern? Is the Sun directly overhead at any time? Why is the shortest shadow around noon? Why does the shortest shadow point north? Does the time of the shortest shadow remain constant or does it change? Is there any relation between these measurements and the Sun's path in the sky?

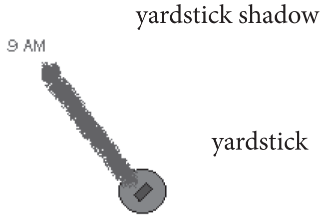

Fig. 2. Tracking the Sun' shadows

3. Recording daily temperatures: From newspapers or broadcast newscasts, students had to collect local high and low temperature readings for each day, on which they performed the above activities, and plot them on a graph. Students were asked to write if they found some correlation between the temperature measurements and the shadow stick and dome measurements.

4. Tracking sunrise and sunset times: From the appropriate Internet address (http://aa.usno.navy.mil/data/docs/RS_OneYear.html#formb), students had to collect the sunrise and sunset times on each of the days they performed the previous activities, by pointing out the exact longitude and

latitude of their location, and plot them on a graph. They were also asked to plot on a graph the number of daylight hours each day. Students were asked to write if they found some correlation between the number of daylight hours and the temperatures, the shadow stick, and the dome measurements.

Towards the end of the students' homework observations, a 45-minute class was dedicated to examining how an angle spreads a flashlight beam. Every pair of students took a sheet of graph paper attached to a piece of hard cardboard, held it perpendicular to the table in a darkened room, and shone the flashlight directly onto the graph paper from the side, about 1 meter away (see Figure 3), holding the flashlight parallel to the table. They were asked to trace the outline of the flashlight's beam on the graph paper, and then, maintaining distance from the paper to the flashlight, to swivel the board towards and away from the flashlight at different angles, and trace the outline of the flashlight's beam on the graph paper. By counting the squares on the graph paper enclosed or partially enclosed by the circle of light, they were able to quantify their observations. After the students made their measurements a discussion was held in an attempt to answer several questions: Does the area of the beam on the paper increase or decrease when the board is tilted towards and away from the flashlight? Does the illuminated spot on the graph paper always remain the same size? When is it larger? Smaller? Is the spot always the same brightness? When is it brighter? Fainter? The next activity explored just this question using the closest star, the Sun.

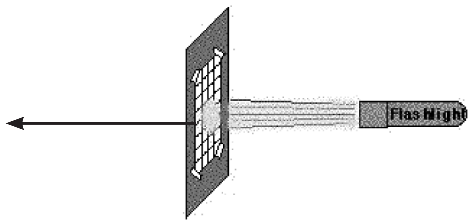

Fig. 3. Tracking the outline of a flashlight on a graph paper

On that day, May 4, (a very sunny day), we examined this „spreading out" of light by measuring how quickly and how much sunlight can warm two sheets of paper, one tilted, one not. At the beginning of the previously described activity, we went outside with the students and placed two pieces of stiff cardboard with thermometers on the ground (see Figure 4). We tilted one board to face the Sun and have the Sun's rays fall nearly perpendicular to it. The other was almost flat on the ground (actually, tilted slightly away from the Sun). We recorded the initial temperature of the thermometers, 30 °C, and did so again about twenty minutes later. The thermometer of the board facing the Sun's rays nearly perpendicularly showed 62 °C and the other one 53 °C. Further discussion was held in class connecting the results of the last two activities.

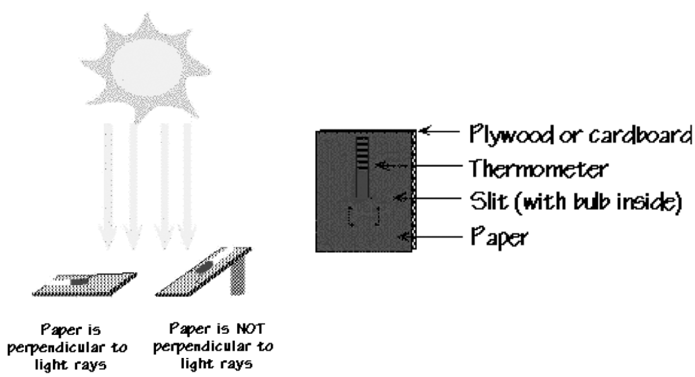

Fig. 4. Measuring the temperature change of two identical pieces of stiff cardboard on the ground

On May 18, 2003, students handed in their homework and performed the last activity, called „The angle of Sun's light rays relative to the ground at different Earth positions". In it they were presented with two different pictures of models, one of them with the rotational axis of the Earth perpendicular to the plane of its path around the Sun and one with the rotational axis of the Earth tilted at an angle of 23.5o (see Figure 5). For both models they were asked a long series of questions that were intended to lead them to the conclusion that only the tilted model could explain the seasonal changes, based on the measurements they had taken at home and in class.

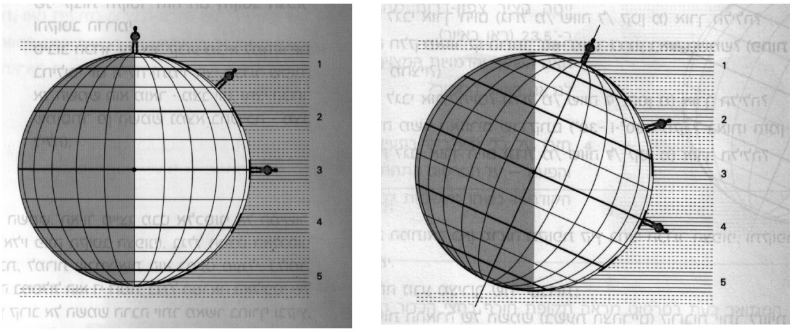

Fig. 5. *Two pictures of models, one with the rotational axis of the Earth perpendicular to the plane of its path around the Sun and one with the rotational axis of the Earth tilted*

Findings

Pre-Test Results

We see in Figure 6 the extent of success, that is the mean percentage of correct answers of the different groups in answering the whole pre-test questionnaire, and the mean percentage of correct answers to questions about phenomena related to seasonal changes (questions 1, 6, 8, 9,14 and 15), at the beginning of their introductory astronomy course.

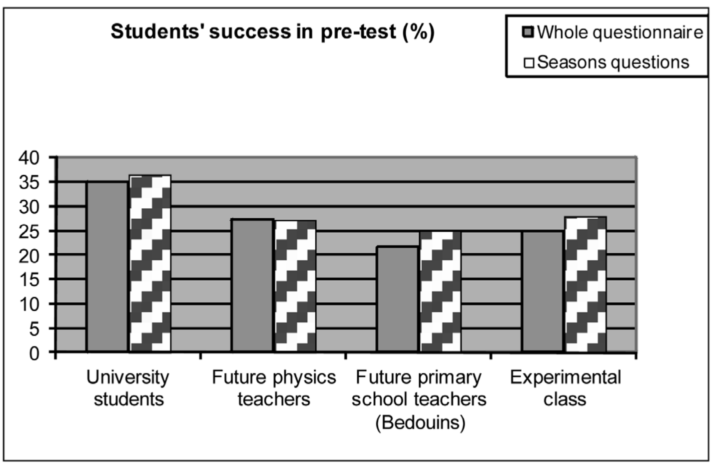

Fig. 6. *The extent of success of the different groups in the pre-test*

In the whole questionnaire, there was a statistically significant difference between the success of the university students and of all the other groups with the largest effect size for the future Bedouin primary school teachers (Cohen, 1988), as can be seen in Table 2, and for the seasons' questions we found a statistically significant difference only between the university students and the future Bedouin primary school teachers as can be seen in Table 3.

Table 2. *Statistically significant difference between the university students and all the other groups in the whole pre-test questionnaire*

	Mean group students' success	t - test	p-value	Cohen's effect size - d
University students	35.1	-	-	-
Future physics teachers	27.2	1.862	.004	.488
Future primary school teachers (Bedouins)	21.8	4.048	< .001	.872
Experimental class	24.8	3.048	.002	.684

Table 3. *Statistically significant difference between the university students and all the other groups in questions dealing with seasons in the pre-test questionnaire*

	Mean group students' success	t - test	p-value	Cohen's effect size - d
University students	36.3	-	-	-
Future physics teachers	27.1	1.544	.07	.397
Future primary school teachers (Bedouins)	25.0	1.962	.03	.548
Experimental class	27.8	1.648	.06	.382

Predictions of the Sun's Path in the Sky

After the students marked a line representing the Sun's position on the plastic dome from sunrise to sunset through noon, they were asked to write answers to the following questions: Where does the Sun rise and where does it set? Where is the Sun in sky at noon? How many daylight hours are today (February 16, northern hemisphere)? Their answers were as follows:

a. Fourteen students wrote that the Sun rises directly east, four pointed to a sunrise position left (north) of east and one student gave a position south of east (the correct answer).

b. Fifteen students wrote that the Sun sets due west, and four students pointed to a sunset position south of west (the correct answer).

c. Seventeen students wrote different expressions indicating that the Sun is directly above us at noon (e.g., in the middle between east and west, up in the center [of the dome], up above our heads, in the middle of the sky, up above), and two students pointed to the Sun's position at noon south of the center (the correct answer). One of these two students had written that the Sun rises south of east and sets south of west; the other pointed to sunrise north of east and sunset south of west.

d. Thirteen students wrote that there were exactly 12 daylight hours, one about 12 hours, one between 12 and 13 hours, one about 13 hours, and the last one wrote that it depended on the season.

In sum, only one student was able to predict correctly the path of the Sun in the sky during the day, and no one knew that in winter there are less than 12 daylight hours.

The Spreading of a Flashlight Beam and Sunlight at Different Angles

In this activity students arrived at the expected conclusion that when the flashlight beam „hits" perpendicular to the paper, the light spreads on a small area and then the light of the illuminated spot is brighter; the area of the beam on the paper decreases when the board is tilted and the illuminated spot is fainter. Next the students confirmed their conclusion by measuring the temperature change of two identical stiff pieces of cardboard on the ground, tilted perpendicularly and non-perpendicularly to the Sun's rays, as described earlier.

Tracking the Sun's Path in the Sky

Students tracking correctly the Sun's path in sky were expected to get the following conclusions:

1. Sun's path is <u>always</u> in a southern position respect to us, changing to a more northerly one when passing from winter to spring and summer.
2. The Sun is never above our heads at noon; it is always south of us.
3. Before the spring equinox, the Sun rises and sets southward to east and west, respectively.
4. After the spring equinox, the Sun rises and sets northward to east and west, respectively.

We first summarize the tracks as drawn by students on the domes:

- Five students drew 6 or 7 paths at different dates, including a correct follow-up to the extremes (sunrise and sunset). The tracks showed that the Sun's paths in the sky are always south to us, but every time in a more northerly position.
- Four students drew 4 or 5 paths on different dates correctly but they dragged the extremes to the center, that is sunrise exactly east and sunset exactly west.
- Three students drew 4 or 5 paths on different dates correctly, without extremes.
- Three students drew two paths on different dates correctly, with uncertain extremes.
- Three students drew 4 or 5 paths on different dates correctly, without extremes, but they did not align the dome to the north correctly.
- One student drew 7 paths on different dates, including an apparently correct follow-up to the extremes, but he did not align the dome to the north correctly.

After tracking the Sun's path in the sky, students were asked to compare it with their initial prediction. We quote some sentences written by students who drew correct tracks, as described above. Only one student referred to the whole path including the extremes (sunrise and sunset position):

- „There was a problem with my prediction where the Sun rises and where it sets. I thought that the Sun always rises and sets south of east and of west, and this is a mistake since this position moves towards north of east and of west, respectively".

Other students wrote about the Sun's paths they tracked without referring to the extremes:

- „In my prediction I drew the path of the Sun in the sky as if it was always in the same place. After the activity, I found that the path changes its direction from winter to summer".
- „The path I drew is a misconception (east-center-west). The Sun's path changes all the time".
- „My prediction was wrong since I drew the Sun's path up above our heads at noon

(in the middle of the sky). The paths I got after the measurements show that the Sun's paths is south of us and with time it changes to a more northern path".

After ending their measurements students were asked several questions; their answers show that most of them realized where the Sun's path is located and how it changes, including the position of the Sun in sky at noon, but they did not get to the correct conclusion with respect to the sunrise and sunset positions:

- What is the sunrise position? Is it permanent or does it change? Eleven students wrote that the Sun rises due east and eight students indicated that the sunrise location is north of east. Eight students claimed that these positions are permanent and eleven stated that these locations move to the north.
- What is the sunset position? Is it permanent or does it change? Eleven students wrote that the Sun sets due west and eight students indicated that the sunset location is north of east. Eight students asserted that these positions are permanent and eleven stated that they move to the north.
- Where is the Sun in sky at noon? Is it a permanent position or does it change? Sixteen students wrote that at noon the Sun is in a south position in the sky relative to us, and two students pointed out that it is directly above us. Six students claimed that this position is permanent and thirteen stated that it moves from south to north.

Tracking the Sun's Shadows
Together with the previous activity, students tracked the Sun's shadows during the day, mainly around noon, recorded the shortest shadow of each day on a table and plotted a graph relating the shortest shadow length to the day of observation. Students were asked several questions, and their answers were as follows:

- How do the shadow lengths change during the day? Fourteen students answered that the shadows are long in the morning, get shorter towards noon, and lengthen again in the afternoon. Five students wrote a similar answer but their description referred only to noon hours.
- Why do shadows' lengths change? All the students answered that the cause of the change is related to Sun's position in the sky during the day.
- Is there a pattern in where the shadows fall and their lengths? Seventeen students wrote an affirmative answer and two students did not answer the question.
- Why is there a pattern? All the students wrote that the reason is that the Sun rises in the east and sets in the west.
- Is the Sun directly overhead at any time? Fifteen students wrote a categorical negative answer. Four students were more cautious, writing that it had not happened in their measurements, but it could happen sometime.
- Why does the shortest shadow point north? All the students answered that it is because the Sun in the sky is in a southerly position relative to us.
- Why does the shortest shadow come out around noon but not exactly at 12:00? Four students answered that at noon (not 12:00) the Sun is exactly south of us, so the shortest shadow appears, and that noon is midday. Three students wrote that Israel is in a geographical position in which at 12:00, at noon, the shadow begins lengthening. Other answers were: „Because not always at noon (12:00) is the Sun in its highest position in the sky"; „The Sun is exactly south of us so we get the

shortest shadow"; „Geographically, in Israel we can see the shortest shadow at noon"; „It depends on Earth's position relative to the Sun"; „The Sun's position in the sky".

- Does the time of the shortest shadow remain constant? Seventeen students answered that the time of the shortest shadow changes. One student wrote that the time remains almost constant and one student did not answer the question.
- Is there any relation between these measurements and the Sun's path in the sky? Seven students answered that the shadow's length shortens and the Sun's path moves north when we pass from winter to spring and summer. Three students answered that in winter we get a longer shadow than in summer, and during the day Sun's angle relative to us changes and the shadow undergoes a V turn (the shadow's length and direction change). Three students wrote a short answer, namely that in winter we get a longer shadow than in summer. Two students wrote that the Sun's shadow shortens significantly when we pass from winter to summer because the Sun is in a higher position in sky. Two students answered that the shadow shortens in the passage from winter to spring and summer, and that this change is related to Sun's path in the sky because the path moves north. One student wrote that in winter the Sun's shadow is longer than in summer, and this is related to the Sun's angle in the sky. Finally one student did not answer the question.

Recording Daily Temperatures
The students recorded the local high and low temperature readings for each day; on the same days they performed the previous activities and plotted them on a graph. Afterwards they were asked to find some correlation between the temperature measurements, the Sun's shadows, and the Sun's path measurements. Only twelve students answered the question and three of them formulated it in an acceptable way:

- „There is a correlation. As the shadows get shorter the temperatures get higher. There is also a correlation between the temperature and Sun's path: when the Sun's path moves to a northern position the temperatures get higher, and this is because of the change of the Sun's angle relative to Earth. When the angle becomes wider, the temperature goes higher".
- „The low and high temperatures are on an increasing trend. The Sun's path becomes longer and moves to a more northerly position. During this time Sun's shadows shorten".
- „In the passage from winter to spring and summer, the daylight hours increase, the shadows become shorter, and the temperatures become higher".
- It seems that eight students did not succeed to distinguish between causes and effects:
- There is a correlation; when the temperatures get higher the Sun's shadows become shorter at noon. Regarding the Sun's path, when the temperatures become higher the Sun is located in a more northerly position, and as this happens the Sun's shadows become shorter (four students).
- Yes, there is a correlation with the passage from winter to spring and summer. Temperatures get higher, the Sun's path is nearer to the center of the sky, and the Sun's shadows get shorter (two students).
- As the temperatures get higher the shadow's length gets shorter when we are

around noon. As temperatures rise, the Sun's path moves to a northern position, that is, the angle is perpendicular above our heads, so the shadow's length shortens (one student).

- As the temperatures get higher the shadow's length shortens and the number of daylight hours increases (one student)

Finally, one student formulated an answer that did not indicate what he actually understood:

- Yes, there is a correlation: the moving of Sun's path from south to north in the passage from winter to spring and summer.

Tracking Sunrise and Sunset Times

The students recorded the sunrise and sunset times on each of the days they performed the three previous activities, and they plotted two graphs: one showing the sunrise and sunset times and one showing the number of daylight hours each day. Subsequently they were asked a question that was supposed to summarize and connect all their observations: Is there some correlation between the number of daylight hours and the temperatures, the Sun's shadows, and the Sun's path in sky?

Their answers showed that they understood the correlation between the different measurements they made, though they expressed in different ways:

- Since the daylight hours grow from winter to summer, and the angle of the Sun's path moves from south to north, so temperatures get higher in the passage from winter to summer. These two phenomena exert an influence because we get more daylight hours and Sun's angle is more perpendicular, so temperatures get higher as winter gives way to summer (four students).
- As daylight hours increase temperatures get higher (three students).
- As the daylight hours increase temperatures get higher. Furthermore, the Sun's path moves north and Sun's shadow becomes shorter (two students).
- As Sun's path moves to a more northern position the Sun's shadow becomes shorter at noon, daylight hours increase and temperatures get higher (two students).
- Temperatures get higher in the transition from winter to summer because daylight hours increase and the Sun's path in the sky (the angle) moves from south to north (two students).
- The day becomes longer and the temperatures get higher. The Sun's shadows get shorter and the Sun's path moves to the north (one student).
- When the day becomes longer the temperatures get higher, the Sun's shadows shorten, and the Sun's path becomes nearer to the top of the dome, the center (one student).
- The day becomes longer so temperatures get higher. The number of daylight hours increases as the Sun's path moves to the north, so the Sun's shadow gets shorter (one student).
- As the day becomes longer temperatures get higher, the Sun's shadows get shorter, and this happens when we pass from winter to summer (one student).
- The correlation is that as the Sun's shadows get shorter temperatures get higher. There is also a connection between the temperature and the Sun's path: as the Sun moves to the north temperatures get higher and this is because of the angle of the Sun rays relative to the Earth, so when the angle widens the temperature rises also (one student).

The Angle of the Sun's Light Rays Relative to the Ground at Different Earth Positions

In the last activity students were presented with two different pictures of models. One of them had the rotational axis of the Earth perpendicular to the plane of its path around the Sun, and the other had the rotational axis of the Earth tilted at an angle of 23.5o. This activity was intended to summarize all that the students had done so far, and it was performed in small groups in class; all groups were asked a to write answers to a long series of questions. For example, in the perpendicular rotational axis model they were asked to look at the three „persons" appearing in the picture and at the Sun's rays and to answer to the following questions: Which person sees the Sun's rays perpendicularly, exactly above his/her head? Which person sees the Sun's rays diagonally, shining on him/her from above? Which person sees the Sun shining horizontally, from his/her side, in parallel to the horizon? The students were asked to identify the size of the surface on Earth illuminated by the Sun's rays, and were asked the following questions: Are all the surfaces the same size? Where do the Sun's rays illuminate a smaller (and a larger) surface? Will all the surfaces get hot equally? What part of latitude 30o N (and also 60o N, 30o S and 60o S) is illuminated by the Sun (less or more than a half / exactly half)? Will the daylight hours be the same as the night hours at these latitudes? Do this model explain the results of your sunrise and sunset time measurements for several weeks? They were asked similar questions for the tilted rotational axis model.

All groups answered correctly the questions they were asked during the activity, particularly those that aimed at leading them to the conclusion that the reason for the change of seasons is the tilt of the rotational Earth axis relative to its path around the Sun, in contradiction to the widespread misconception that seasonal changes are due to the change in distance between the Earth and the Sun.

Post-Test Results

The post-test questionnaire (the same as the pre-test questionnaire) was presented to the experimental class and to the control groups on their examination day, that is, several weeks after finishing the course, and about a month and a half after the experimental class performed the last activity. We see in Figure 7 the extent of success of the different groups in answering the whole questionnaire, and the questions about phenomena related to seasonal changes.

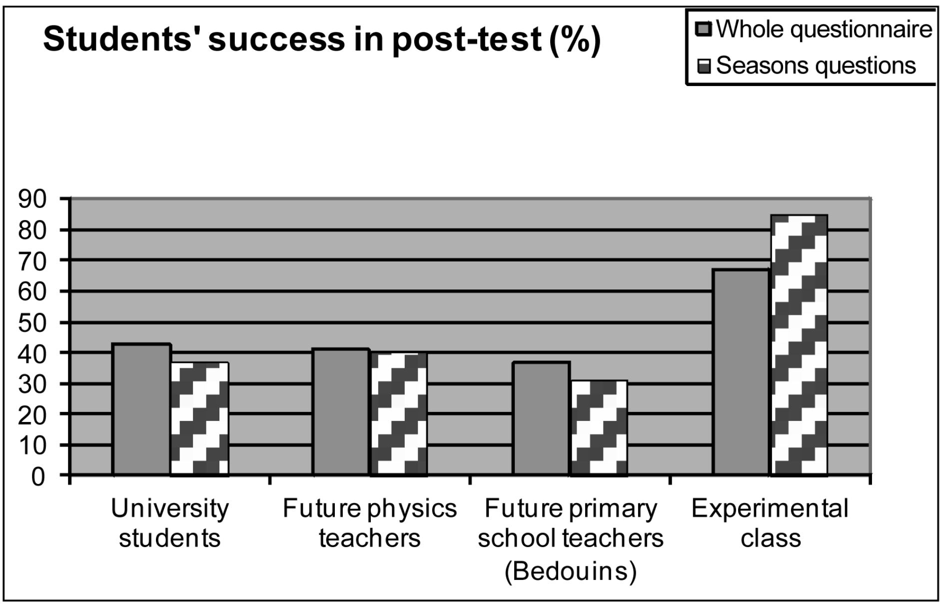

Fig. 7. *The extent of success of the different groups in the post-test*

In the whole post- test questionnaire, we found a statistically significant improvement in all the groups with the largest effect size for the experimental class as can be seen in Table 4, and for the seasons' questions we found a statistically significant difference for the experimental class and for the future primary teachers group, as can be seen in Table 5. The significant improvement of the control groups in the whole questionnaire can be explained as follows: (a) their instructors were very experienced lecturers covering most topics based on well-structured lectures with a descriptive (phenomenological) rather than conceptual approach to astronomy, and (b) the questionnaire comprised several non conceptual questions that required only factual recall. The significant improvement of the future primary teachers group can be explained by the fact that they learned a whole year course, and not a one semester group as all the others,

Table 4. *Comparison of the total success in the whole questionnaire (pre- and post-test) for all the groups*

	Mean group pre-test total success	Mean group post-test total success	t	p-value	Cohen's effect size - d
University students	35.1	42.5	2.003	.025	.370
Future physics teachers	27.2	40.9	2.222	.023	.921
Future primary school teachers (Bedouins)	21.8	36.8	4.607	< .001	1.165
Experimental class	24.8	67.0	10.19	< .001	4.083

Table 5. *Comparison of the success in the questions dealing with seasons (pre- and post-test) for all the groups*

	Mean group pre-test success	Mean group post-test success	t	p-value	Cohen's effect size - d
University students	36.3	37.1	.167	.43	.04
Future physics teachers	27.1	40.5	1.712	.06	.725
Future primary school teachers (Bedouins)	25.0	43.5	5.51	.001	.346
Experimental class	27.8	85.1	14.29	< .001	4.152

Discussion and Educational Implications

Understanding the solar system involves a number of related conceptual areas that are clearly of importance in relation to student's existing frameworks and are difficult to explain since they do not match their daily observations. They include a perception of spatial aspects of the Earth, a conception of day and night, of seasonal change, etc., which include compound movements of the Moon, the Sun and the stars. In this study we can see clearly that many students were not post-Copernican in their notions of planet Earth in space and held alternative notions to the accepted scientific concept, in various basic astronomy subjects.

The findings of this study support the constructivist approach in teaching, in which students are confronted with their alternative conceptions in a conceptually centered learning environment that actively engages them. Although, both the experimental class and the control groups improved their basic astronomy concepts in a statistically significant way, the experimental class made the most impressive improvement of all. Moreover, regarding the subjects relevant for this study (seasonal changes), only the experimental class showed a statistically significant improvement.

For the students participating in this study, the introductory astronomy course was the first time they learned some basic astronomy concepts. The experimental instructional activities applied in the experimental class were designed to deal with students' alternative conceptions and to help them understand the accepted scientific concept. In parallel, they showed future teachers alternative (constructivist) ways of teaching. Good teachers need to possess not only a detailed and subtle understanding of the subject matter, but also in-depth knowledge of how best to present it in the classroom setting, what is currently called „pedagogic content knowledge" (Shulman, 1987; Parker and Heywood, 1998). This means that teachers need to be in control of their own learning and develop an understanding of how they might learn effectively (metacognition).

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APPENDIX: Questionnaire – The Earth and the Universe
(√ - indicates the correct answer)

1. As seen from your current location, when will an upright flagpole cast no shadow because the Sun is directly above the flagpole?

A. Every day at noon.
B. Only on the first day of summer.
C. Only on the first day of winter.
D. On both the first days of spring and fall.
E. Never from your current location. √

2. In order to have a total solar eclipse, the Moon must be at what phase?

A. Full.
B. First quarter.
C. At no particular phase.
D. New. √
E. Last quarter.

3. Imagine that you are building a scale model of the Earth and the Moon. You are going to use a basketball with a diameter of 30 cm to represent the Earth and a tennis ball with a diameter of 7.5 cm to represent the Moon. To maintain the proper distance scale, about how far from the surface of the basketball should the tennis ball be placed?

A. 10 cm.
B. 15cm.
C. 90cm.
D. 9 m. √
E. 90 m.

4. What causes night and day?

A. The Earth spins on its axis.√
B. The Earth moves around the Sun.
C. Clouds block out the Sun's light.
D. The Earth moves into and out of the Sun's shadow.
E. The Sun goes around the Earth.

5. The diagrams here show how the Moon appeared one night, and then how it appeared a few nights later. What do you think best describes the reason for the change in the Moon's appearance?

A. The Moon moves into the Earth's shadow.
B. The Moon moves into the Sun's shadow.
C. The Moon is black on one side, white on the other, and rotates.
D. The Moon moves around the Earth. √

6. The main reason that it is hotter in the summer than in winter is that

A. The Earth is closer to the Sun in summer.

B. The Earth is farther from the Sun in summer.

C. The Earth's rotational axis flips back and forth as the Earth moves around the Sun.

D. The Earth's axis points to the same direction relative to the stars, which is tilted relative to the plane of its orbit. √

E. The Sun gives off more energy in the summer than in the winter.

7. Where does the Sun's energy come from?

A. The combining of light elements into heavier elements. √

B. The breaking apart of heavy elements into lighter ones.

C. The glow from molten rocks.

D. Heat left over from the Big Bang.

8. Imagine that the Earth's orbit were changed to be a perfect circle about the Sun so that the distance to the Sun never changed. How would this affect the seasons?

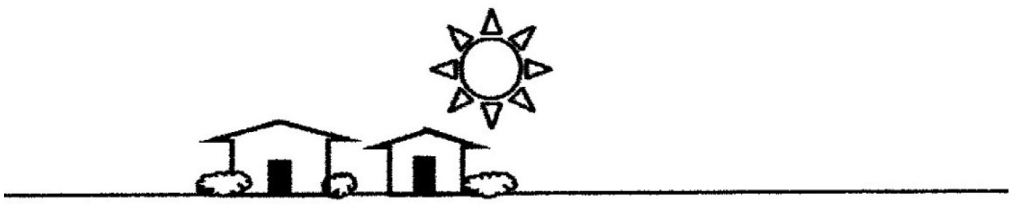
A. We would no longer experience a difference between the seasons.

B. We would still experience seasons, but the difference would be much less noticeable.

C. We would still experience seasons, but the difference would be much more noticeable.

D. We would continue to experience seasons in the same way we do now. √

9. On about September 22, the Sun sets due west as shown on the diagram below. Where will the Sun appear to set two weeks later?



⇐South **West** **North ⇒**

A. In the same place.

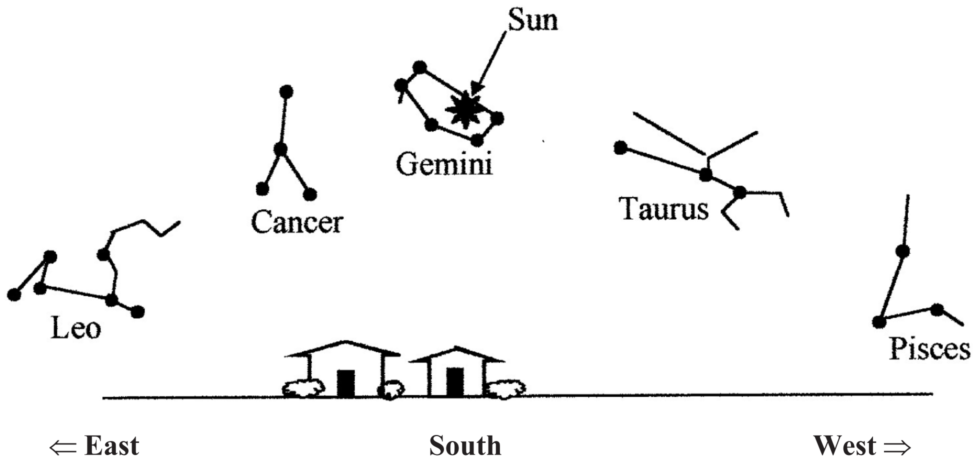
B. Northward of the equinox position.

C. Southward of theequinox position. √

10. If you could see the stars during the day, this is what the sky would look like at noon on a given day. The Sun is near the stars of the constellation Gemini. Near which constellation would you expect the Sun to be located at sunset?

A. Leo B. Cancer C. Gemini √

D. Taurus E. Pisces



11. When you observe the Moon from the Earth, you always see the same side. This observation implies that the Moon.

A. Does not rotate on its axis.
B. Rotates on its axis once a day.
C. Rotates on its axis once a month. √

12. As viewed from our location, the stars of the Big Dipper can be connected with imaginary lines to form the shape of a pot with a curved handle. Where would you have to travel to first observe a considerable change in the shape formed by these stars?

A. Across the country.
B. A distant star. √
C. Moon.
D. Pluto.
E. America.

13. Which of the following lists is correctly arranged in order of closest-to-most-distant from the Earth?

A. Stars, Moon, Sun, Pluto.
B. Sun, Moon, Pluto, stars.
C. Moon, Sun, Pluto, stars. √
D. Moon, Sun, stars, Pluto.
E. Moon, Pluto, Sun, stars.

14. When is the longest daylight period in Australia?

A. March.
B. June
C. September.
D. December. √

15. As you face directly east, where is the rising Sun on June 21 as seen from the Haifa area?

A. To the left of due east. √
B. To the right of due east.
C. Due east.
D. It varies with the phase of the Moon.

16. According to modern ideas and observations, which of the following statements is correct?

A. The Earth is at the center of the Universe.

B. The Sun is at the center of the Universe.

C. The Milky Way Galaxy is at the center of the Universe.

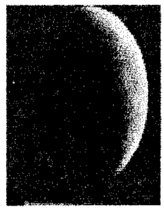
D. D. The Universe does not have a center in space. √

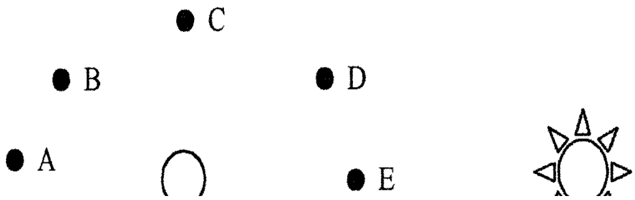
17. The hottest stars are what color?

A. Blue. √ B. Orange. C. Red.

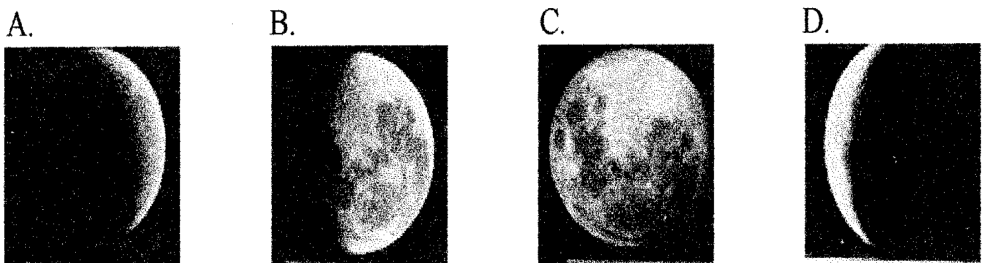
D. White. E. Yellow.

18. The diagram below shows the Earth and Sun as well as five different possible positions for the Moon. Which position of the Moon would cause it to appear like the picture at the right when viewed from Earth?





19. You observe a full Moon rising in the east. How will it appear in six hours?



20. With your arm held straight, your thumb is just wide enough to cover up the Sun. If you were on Saturn, which is 10 times farther from the Sun than the Earth, what object could you use to just cover up the Sun?

A. Your wrist. B. Your thumb. C. A pencil.

D. A toothpick. √ E. A hair

21. Global warming is thought to be caused by the

A. Destruction of the ozone layer.

B. Trapping of heat by nitrogen.

C. Addition of carbon dioxide. √

Stakeholders' Views on Desirable Science Education in Georgia

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Introduction

In the course of the National Educational Reform in Georgia, which has begun in 2004, several versions of new national curricula for both elementary and secondary schools are being piloted and implemented (Ministry of Education and Science of Georgia). One of the focuses within these processes is the current situation of science education and the importance of a scientifically literate society. Much attention is paid to the development of new science curricula and the acknowledgement of more inquiry-based and student oriented approaches. In view of these developments, an important consideration is to establish a modern and contemporary understanding of desirable science education at schools of general education. For a differentiated approach to such a discussion, it is necessary to bridge the gap between different groups in the society that are involved with science and science education (termed as „stakeholders"), taking into account their views and opinions about aspects of modern and desirable science education. This is realized by carrying out a curricular Delphi study (Bolte, 2008; Häußler, Frey, Hoffmann, Rost, & Spada, 1980; Mayer, 1992; Osborne, Ratcliffe, Collins, Millar, & Dusch, 2003) that is conceptualized by the Freie Universität Berlin (FUB), collecting and analyzing in three consecutive rounds systematically stakeholders' opinions concerning desirable science education. The aim of the „Curricular Delphi Study on Science Education" conducted by Ilia State University (ISU) is to engage different stakeholders in reflecting on contents and aims of science education as well as in outlining aspects and approaches of modern science education. In this regard, the Curricular Delphi Study on Science Education in Georgia as well as in other countries (PROFILES Consortium, 2012) offers comprehensive insights into the set of opinions of different stakeholders in the society who are concerned with sciences and science education (such as: students, sciences teachers, science education researchers and scientists). The outcomes of the Georgian Curricular Delphi Study on Science Education will be used to prepare teacher training courses and to provide guidelines to improve the science curricula. In the first round of the „Curricular Delphi Study on Science Education", the following question is addressed:

What kind of opinions and expectations of desirable science education exist among the different stakeholder groups?

Method

The central aim of a Delphi study is to collect the opinions and the knowledge of stakeholders (`experts`) from different areas and classify them in a systematic and appropriate way in order to gain insights about aspects that are difficult to predict (Linstone & Turoff, 1975). The Delphi method is characterized by several distinguishing features (Häder, 2009). In general, a Delphi study involves a fixed group of participants (´experts`) who are asked about a certain topic in several consecutive rounds. After every round, statistically confirmed group answers of the respective preceding round are calculated and reported back to the participants. In this way, the participants are, in the light of the „general" opinion, able to reflect on both the general and their own opinion and, if applicable, adjust or reinforce their opinion. Through these steps, the general question is in terms of content gradually processed. Furthermore, the participants interact and cooperate anonymously among each. This serves to avoid the participants being influenced or affected by particular opinions of well-known or other individual participants (Häder, 2009; Linstone & Turoff, 1975). As for the curricular elements of this Delphi study following Häußler at al. (1980), the working group applies certain criteria for selecting the participants dealing with curricular matters in the course of the study and the general question is specified within a formal question and answer format (Häußler et al., 1980).

The Curricular Delphi Study on Science Education carried out by ISU is structured into three rounds (Figure 1). The first round offers the participants the possibility to express their ideas about aspects of contemporary and pedagogically desired science education in three open questions regarding „motives, situations and contexts", „fields and methods" and „qualifications". The participants' statements of the first round are processed through qualitative and quantitative analyses (see Table 1 and Table 2 as well as Figure 2). The targeted sample size is a number of 100 participants representing the following groups of stakeholders: students (n≈25), science teachers (n≈25), science education researchers (n≈25) and scientists (n≈25).

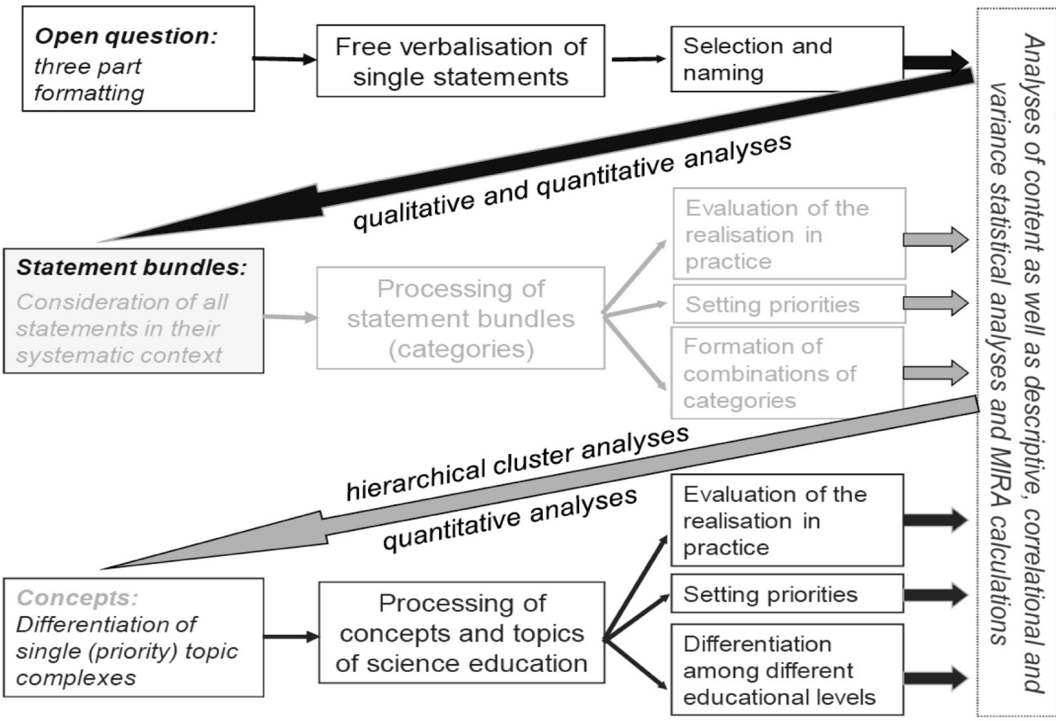

Fig. 1. *Methods of data collection and analysis in the Curricular Delphi Study on Science Education (Bolte, 2008)*

Results of the First Round of the ISU Curricular Delphi Study on Science Education

Between March and April 2012, a total of 156 potential participants ('experts') in Georgia were asked via e-mail to fill out the Delphi questionnaire (first attempt). As shown in Table 1, 72 stakeholders took part in the first round of the Curricular Delphi Study on Science Education.

With a total of 30 participants, the group of *teachers* makes up the largest sub-sample group, followed by the group of scientists (27 participants). The group of *science education researchers* contains 13 participants and in the group of *students,* 2 participants took part so far. Regarding the group of *students*, more participants will be added to this sub-sample during September and October 2012. As can be seen in Table 1 as well, the participants made 807 statements altogether, featuring an average of 11 categories per participant.

[1] More participants in the group of students will be added in September/October 2012

Sub-sample group		Number of participants		Number of statements	Average number of statements per person
Students[1]		2		22	11
Teachers	Education Students	6	30	362	12
	Trainee teachers	2			
	Teachers	14			
	Teacher Educators	8			
Education Researchers		13		147	11
Scientists		27		276	10
Total		72		807	11

Table 1. *Number of participants, number of statements and average number of statements per participant*

In the course of the qualitative analysis, a final classification system for the analysis of the participants' statements was established. The classification system consists of 99(+9) categories (Table 2). For part I (situation, context, motive) 19 categories were developed. Part II (field) contains a total of 55 categories (the sub-parts IIa (basic concepts and topics) and IIb (scientific fields and disciplines), consists of 21 and 34 categories respectively). Part III (qualification) contains 25 categories. The additionally established part referring to methodical aspects (part VI) consists of 9 categories.

In the course of the quantitative analyses, the frequencies of how often the categories were mentioned by the participants were determined. The diagram in Figure 2 shows those categories that were mentioned particularly rarely (ft<5%) or rather often (ft>20%) by the total sample (not taking into account multiple entries of a category by the same participant).

As Figure 2 shows, 15 categories are mentioned by more than 20% of the participants in the total sample. It can be seen that especially more general and overarching aspects of science education such as „Everyday life", „Environmental awareness" and „Students' interests / motivation" are mentioned by a very high percentage of participants (more than 30%) as important aspects to be considered in science education. Also, a number of inquiry related aspects of science education such as „Being able to experiment", „Inquiry skills", „Inquiry-based science learning", „(Specialized)knowledge" and „Experiment / practical works" can be found among those categories mentioned by more than 20% of the participants. Among those categories mentioned by less than 5% of the participants are categories referring to specific aspects of scientific disciplines but also referring to aspects that are in the course of the National Education Reform in Georgia considered as important, e.g. „Interdisciplinary learning".

I: Situations, contexts, motives	II: field		III: Qualification	IV (Addition): Methodical aspects
	IIa: (Basic) concepts and topics	IIb: Scientific fields and perspectives		
N = 19	N = 21	N = 34	N = 25	N = 9
• Education /general pers. development • Emotional personality development • Intellectual personality development • Students' interests • Curriculum framework • Nature / natural Phenomena • Everyday life • Medicine / health • Technology • Society / public concerns • Global references • Occupation • Science - biology • Science - chemistry • Science - physics • Science – interdisciplinarity • Out-of-school learning • Science development perspectives • Experiments, practical works	• Matter / particle concept • Structure / function / properties • Chemical reactions • Energy • Scientific Inquiry • Cycle of matter • Food / nutrition • Health / medicine • Matter in everyday life • Technical devices • Environment • Safety and risks • Occupations / occupational fields • New Technology and its Application/ Industrial processes • Modern scientific achievements/ scientific investigations • Agriculture • Universal science laws • life processes • Physical Phenomena • Chemical Phenomena • Connections between phenomena	• Botany • Zoology • Human biology • Genetics /molecular biology • Microbiology • Evolutionary biology • Ecology • Inorganic chemistry • Organic chemistry • Biochemistry • Mechanics • Thermodynamics • Atomic / nuclear physics • Astronomy / space system • Earth sciences • Mathematics • Interdisciplinarity • Consequences of technol. developm. • History of the sciences • Ethics / values • General chemistry • Applied Chemistry • Cell biology • Life science • General biology • Relativistic theory • Electricity • Optics • Molecular physics • General Physics • Quantum mechanics • Biophysics • Cosmetology • Pharmacology	• (Specialized) knowledge • Applying knowledge / thinking abstractly • Judgment / opinion-Forming / reflection • Formulating scientific questions /hypotheses • Being able to experiment Rational thinking /analysing / drawing conclusions • Working self dependently/ structuredly / precisely • Reading comprehension Communication skills • Social skills / teamwork • Motivation /interest / curiosity • Critical questioning • Acting reflectedly and responsibly • Inquiry skills • Civic • Environmental awareness • Observation, perception • Classification • Finding information • Creativity • Safety skills • Life skills/ First-aid • Problem solving • Numerancy • Metacognition	• Interdisciplinary learning • Inquiry-based science learning • Using new media • Learning based on previous knowledge • Project learning • Learning in small groups • Individual works • Using visual resources • Students based learning

Table 2. *Classification system for the analysis of the participants' statements - ISU*

Conclusion

In the first round of the Georgian Curricular Delphi Study on Science Education conducted by ISU, 72 stakeholders participated and returned so far their responses regarding aspects of desirable science education. With regard to the group of students, the data acquisition appeared to be difficult so that more participants in this group will be added through September and October this year. The final results of the first round will be presented as soon as the data collection among Georgian students and the additional analyses are finished.

The qualitative analysis of the participants' statements led to a classification system consisting of 3(+1) parts with the second part being furthermore subdivided onto two parts (IIa and IIb). All in all, the classification system contains a number of 99(+9) categories. In most cases, the categories agree with categories established in previous Delphi studies in sciences (Bolte, 2008; Häußler u. a., 1980; Mayer, 1992, Schulte & Bolte, 2012) and refer to guidelines and aspects of modern science education stated in didactic literature (Bybee, McCrae, & Laurie, 2009; Fensham, 2009). With some categories, an addition of further aspects has been included.

The 72 participants have in a comprehensive and multi-facetted way expressed their ideas and opinions in a total number of 807 statements. In the descriptive statistical analyses it can be seen that the group of teachers responded in the most differentiated way, followed by the students and science education researchers. The responses of the group of teachers and the group of students are remarkably less differentiated. The calculation of the different frequencies illustrates the emphases made in the statements of the participants. As the quantitative analyses show, a tendency towards IBSE-related and more general and overarching aspects of science education such as „Everyday life", „Environmental awareness" and „Students' interests / motivation" can be identified. Regarding the differences in the category frequencies, it can at present not be said to what extent the categories mentioned particularly rarely and particularly often actually reflect what is considered as important or in how far these findings are also influenced by the extent in which these aspects are realized in educational practice. These questions will be addressed and investigated in the course of the second round (Schulte & Bolte, 2012).

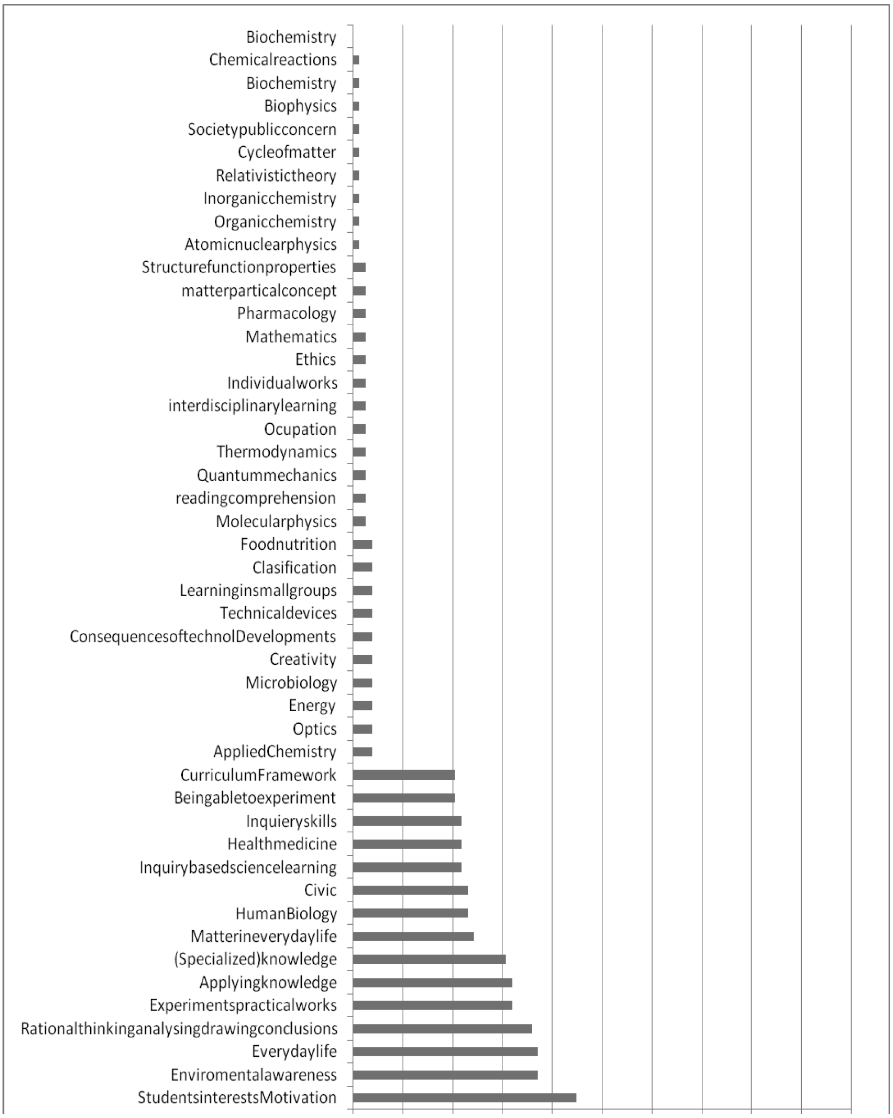

Fig. 2. Overview over the categories that were mentioned rarely (<5%) or often (>20%)

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How to analyse and assess students' motivation for learning chemistry

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To answer the question, 'How to analyze and assess students' motivation for learning chemistry'.we recommend to use the „Questionnaires for the Assessment of the Motivational Learning Environment (MoLE)" developed by Bolte (1995; 1996; 2006). This instrument has been successfully been adapted in diverse studies to evaluate specific approaches – such as SALiS – promoted by science education research in different intervention projects (Bolte&Streller, 2008; Bertels&Bolte, 2009; Bolte&Kirschenmann, 2009; Streller 2009; Streller& Bolte, 2012).

Some Reflections on the Theoretical Basisof the Motivational Learning Environment (MoLE)

The „Motivational Learning Environment Questionnaire„(MoLE-Questionnaire) was specifically designed for a systematic analysis of the students' perceptions of the atmosphere in their classroom and their preferred learning environment. The questionnaire is 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" and lead to the seven variables (scales):

1. Comprehensibility/requirements,
2. Opportunities to participate,
3. Subject relevance regarding the scientific contents and concepts (in general),
4. Subject relevance regarding everyday life and socio-scientific contexts,
5. Class cooperation,
6. Individual student's willingness to participate and
7. Satisfaction.

Between these variables, causal connections were assumed and were validated by statistical analysis (Bolte, 1995; 2006: 2010). Both the theoretically-sound assumptions and the empirically invested relationships between the important aspects of motivation led to the *Model of Motivational Learning Environments* (in short called: MoLE), shown in Figure 1.

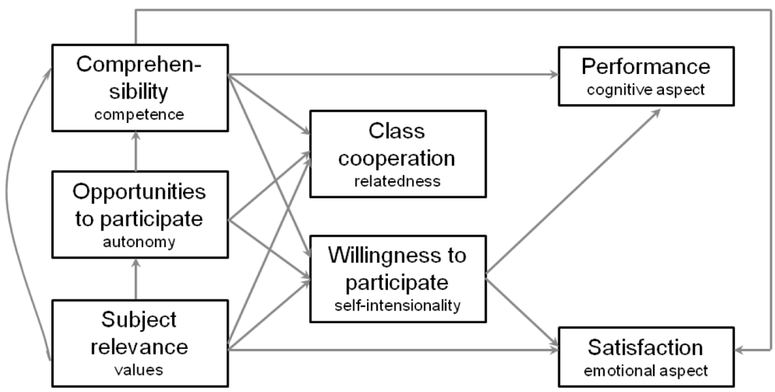

***Fig. 1**. Model of the Motivational Learning Environment*

Let us explain this MoLE model: the first three independent variables (*comprehensibility, opportunities to participate* and *subject relevance*) are reliant upon the teacher's behaviour, whereas the four remaining dependent variables (*class cooperation*, *willingness to participate*, and *performance and satisfaction*) are reliant on the class in general and for an individual student. The variable *requirements/comprehensibility* describes the intellectual level of the instruction and the standards of the topics taught. It is well known from theories of enhancement of motivation (Heckhausen, 1991), that setting a certain standard increases students' efforts and performance. A similar notion is that of high expectations. The variable *opportunities to participate* indicates to what degree the teacher is susceptible to students' ideas and opinions. *Subject relevance* indicates whether the students judge the topics chosen by the teacher to be relevant with regard to their everyday life. These three variables are likely to influence students' behaviour during the lessons. A suitable standard, a high level of relevance and the opportunity to participate are stimuli for an increase of the variables *class cooperation* and *student's willingness to participate*. Furthermore, a suitable standard results in an increase of student performance. A higher perception of relevance of topics presumably entails a higher satisfaction with the instruction. Finally, active *class cooperation* is a probable stimulus for an increase in the individual student's willingness to participate. The increase in his/her willingness to participate will also increase his/her performance and satisfaction (Bolte, 2006).

It is suggested, that applying this model to classroom situation, in our case to chemistry lessons, can help chemistry teachers to promote their students' motivation. To keep a long story short, using this model calls for balancing the intellectual requirements, choosing educational approaches which offer opportunities to participate actively in the classroom, and relating science content and concepts with topics which are perceived to be relevant, meaningful, and important to the student (Bolte, 1995; 2010).

Some Reflections regarding the Method of Analysing the Motivational Learning Environment (MoLE) in Chemistry Classes

From research on the Learning Environment we know that it is helpful and useful to know about the students' assessment concerning their motivation in chemistry classes but also to have further information, such as how they wish their chemistry lessons should be. For example: some students – maybe most – like to work on tasks and issues which are related to their everyday life and/or to socio-scientific questions (subject relevance regarding everyday life and socio-scientific contexts), but there are also other students who really want to know more about the theories and the theoretical concepts of the natural sciences (subject relevance regarding the scientific contents and concepts), and these students might not prefer so much to deal with the relationship between science and society or everyday life issues. Therefore, the MoLE-Questionnaire consists of at least two different questionnaire versions, namely the REAL- and the IDEAL-version:

- The REAL-version investigates the actual characteristics of the instruction in general and
- the IDEAL-version investigates the desired characteristics.

Beside these two questionnaire versions, a third version was developed which focus on a specific chemistry lesson. This version was named as the TODAY-version. This is a useful questionnaire version if someone wants to know how effective a specific lesson has been regarding the motivation of his/her or the students; for exampleif he/she has tried out special methods of e.g. inquiry based scienceteaching or if he/she offers more open or guide tasks to the students.

All the three versions focus on the same MoLE-Variables (scales or 'aspects') and every aspect of a questionnaire version contains only two items (which is the minimum to receive reliable results). Each item aims at a certain instructional feature, which is assessed between two poles (and regarding the different versions,from two or three different points of view). There is a seven point rating scale to evaluate the 14 items of a questionnaire version. 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:

Item No. 3 in the REAL-version:
The topics in chemistry lessons are...
very difficult for me to understand [1] [2] [3] [4] [5] [6] [7] very easy for me to understand.

Item No. 3 in the IDEAL-version:
I wish the topics in chemistry lessons to be...
very difficult for me to understand [1] [2] [3] [4] [5] [6] [7] very easy for me to understand.

Item No. 3 in the TODAY-version:
The topics in chemistry lessons today were...
very difficult for me to understand [1] [2] [3] [4] [5] [6] [7] very easy for me to understand.

With the help of the MoLE-Questionnaires teachers (or science education researchers) are able to collect data concerning the specific learning environments of a class or different classes by focusing on the three following perspectives:

1st on the students' perceptions and assessment of their learning environment in general,
2nd on the students assessment of how they would like the motivational learning environment in their science lessons to be and
3rd on the assessment of students, how they perceive a specific (a just experienced and/or tried out) science lesson.

To obtain specific insights into the assessment and the development of the motivational learning environments we recommend questioning the students at least two – better three – times.

1st Before the start (t0) of your instruction the students should be questioned on

- how they, looking back at their previous science lessons, regarded the motivational learning environment in general (t_0-REAL) and
- how they would like the motivational leaning environment in their science lessons to be (t_0-IDEAL).

2nd In the course of your instruction – for example, if you try out a specific approach, teaching/learning methods, special student centred topics or materials (t_1 to t_{n-1}), the students are asked to evaluate

- how they, looking back at the just experienced science lesson, regarded the motivational learning environment specifically (t_1 to t_{n-1}-TODAY)

3rd At the end (t_n) of you intervention or an instructional period the students could be asked to evaluate

- how they, looking back at all the last science lessons, regarded the motivational learning environment in general (t_n-REAL)

This course of action provides a lot of insight into the motivational learning environment during past lessons. This can be an insight into the lessons before a treatment starts (t_0-REAL) or the chemistry lessons in general (t_n-REAL) or into specific lessons planed for the purpose to enhance the motivation of the students (t_1 to t_{n-1}-TODAY). Additionally, statements can be made on how students would generally like their science lessons to be (t_0-IDEAL).The comparison of the data from each of the questionings provides insights into several differentiated aspects. This can be, for example, in how far „wish" and „reality" coincide when considering the science lessons:

- before a treatment starts (t_0-IDEAL / t_0- REAL) and/or
- of(a) specific lesson(s) (t_0-IDEAL / t_1 to t_{n-1}-TODAY) and/or
- at the end of a treatment in general (t_0-IDEAL / t_n-REAL).

Furthermore, the procedure of analysing the data further allows the comparison of previously experienced science lessons with your science lessons, so as to prove the impact of a treatment, e.g.:

- comparison of the previously experienced science lessons with the science lessons of a treatment in general (t_0-REAL / t_n-REAL),
- comparison of specific science lesson(s) with science lessons in general (t_1 to t_{n-1}-TODAY / t_n-REAL),
- comparison of specific science lesson(s) with the previously experienced science lessons in general (t_1 to t_{n-1}-TODAY / t_0-REAL).

Of course this course of action of analysing the data also allows the comparison of specific cohorts, such as:

- male and female students,
- well-performing and less well-performing students,
- students with and without a migration background,
- students of different age groups,
- specific class types (single-sex and co-educational; differently combined student populations; different types of teacher personality),
- classes from different types of schools, and/or classes from different grades,etc.

In addition to all the aspects which could be investigated with the help of the MoLE instrument focusing at the analysis of the real and ideal learning environments, the so-called Wish-to-Reality-Differences (WRD) can be calculated by taking the difference between the ideal and the real value.

As it is easy to get so much information by analysing all the single items that someone can easily get lost,and we further recommend the calculation of the 'mean-score of a MoLE-variable'. This is easy to do: just add the values of the specific item assessments and divide the sum by the number of items (here 2) and the number of students who assessed the variable's items.

After knowing the potential of investigations by means of the MoLE-Questionnaire versions, one might to want to know more about the results and findings one can receive by using the MoLE-instrument. In the next section we would like to introduce some findings from a previous study.

Sharing some Experiences and Findings by Analysing the Motivational Learning Environment in Chemistry Classes

As mentioned above the authors have used the different MoLE-Questionnaires in various studies over approximately the last 20 years(Bolte&Streller, 2008; Bertels&Bolte, 2009; Bolte&Kirschenmann, 2009; Streller 2009; Streller& Bolte, 2012). First we can assume that the „Questionnaires for the Assessment of the Motivational Learning Environment (MoLE)“ are versatile and universally applicable. Questioning the students using the MoLE questionnaires is not particularly time consuming. Thus, further assessments can be added to the analyses of the learning environment in order to link verifiable effects (e.g. the correlation between the MoLE dimensions and the different dimensions of scientific competence and/or dimensions of scientific literacy), but this is another topic.

Regarding the criteria of scientific quality,there is evidence that the scales of the different questionnaire versions are of high reliability (Cronbach's alpha range from 0.59 to 0.82; Bolte, 2006) and the empirical structures fit to the theoretical assumptions, which have been tested by means of factor- and structure-analyses (Bolte, 2006; Bolte, 2010).

Our analyses show that chemistry lessons (in general) are assessed by students differently. Taking into consideration the students' assessments (N = 2,336) some reasons for 'unsuccessful chemistry lessons' become obvious. The comparison of the students' inclinations with their perceptions of the MoLE-Variables indicates that wish and reality deviate considerably. Most frequently, chemistry lessons do not live up to students' wishes. While chemistry lessons to the satisfaction of students are not a likely event, the comparison of students' wishes with their perception of real instruction offers teachers substantial help for improvements. The greatest differences instruct teachers about the situations that are in the most urgent need for changes. Our analysis locates the most important differences in the field of satisfaction, requirements/comprehensibility, science orientation and relevance of the topics (see Figure 2). Furthermore, the analysis indicates significant differences in the assessments of boys and girls. If one evaluates the data for the chemistry instruction one can see that the girls of our sample assessed their instruction more unfavourable than the boys. The biggest differences in the assessments of boys and girls occur in the field of satisfaction, comprehensibility and relevance of the topics (see Figure 2).

In addition, the analyses of the available data reveal that teachers frequently have an incorrect anticipation [* in Figure 2] concerning the assessment of their instruction by their classes. In three out of seven cases, the difference in the assessments of teachers and students are statistically significant (see Figure 2).

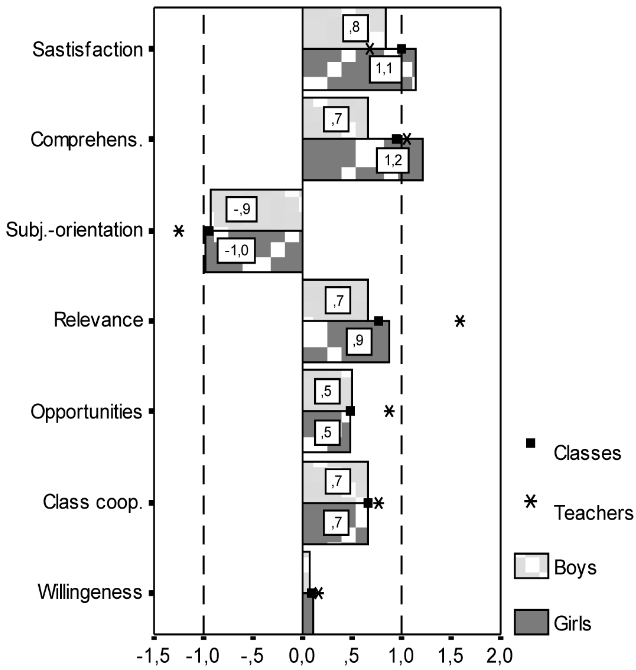

Fig. 2. *Comparison of the Wish-to-Reality-Differences in relation to the assessments of the MoLE-Variables for chemistry classes in Sek. I*

Conclusions

The MoLE-Instrument provides questionnaires for data collection and analyses that, by employing only two items per scale or sub-scale (MoLE-Variable), are an exceptionally efficient but yet scientifically reliable analysis of the obtained insights in the learning atmosphere of one's own classes.

A comparison of Wish-to-Reality-Differences points to the reason why many students (male and female) end their education in chemistry at the earliest possible grade. Especially in the areas of the relevance of topics (from the students' perception) and in balancing the requirements of the lessons teachers of chemistry are advised to change their practice.

Concerning the motivational learning environment in chemistry classes, a less favourable assessment of the learning environment by female students has to be stated. For this reason changes in the subject's contexts are requested and approaches should be adapted that esp. the female students will experience success and satisfaction with regard to chemistry instruction; this will enhance the boys' motivation to participate in chemistry lessons as well.

The assumption that teachers are not in any need for instruments of evaluation like this, because they can 'intuitively' assess the learning environment in their classesproperly, is incorrect. Teachers' anticipations differ significantly in many cases from the actual assessmentsof their classes. Rather interesting is the question why chemistry teachers are not easily inclined to change the subject'stopics of their instruction to contexts of increased students' relevance although their own estimation would recommend such a change as needed. Our findings suggest that this is the question requiring action most strongly (cf. MoLE-Variable „Subject-Orientation" and „Subject Relevance" in Figure 2).

Educational and Scientific Importance of analysing students' motivation to learn chemistry

It is part of the professional tasks of a teacher and the research in science education to ascertain the quality of (their own) instruction, and if necessary to take measures for its improvement. The MoLE-Questionnaires satisfy scientific criteria for objectivity, reliability and construct-validity. They provide, for teachers as well as for researchers, a useful, informative and efficient instrument to evaluate the quality of (their own) science instruction.Ifsomeoneis interested in assessing the „Motivational Learning Environment" in his/her science classes feel free to contact the authors.

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Teachers' Professional Development for Inquiry-Based Learning

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Introduction: The Science Laboratory

Laboratory activities have long had a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging students in science laboratory activities (Lazarowitz & Tamir, 1994; Hofstein & Lunetta, 2004). More specifically, they suggested that, when properly developed, designed, and structured laboratory-centered science curricula have the potential to enhance students' meaningful learning, conceptual understanding, and their understanding of the nature of science. Also, Inquiry-type experiences in the science laboratory are especially effective if conducted in the context of, and integrated with, the concept being taught.

Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals. These studies were critically and extensively reviewed in the literature (Lunetta, Hofstein, & Clough, 2007). From these reviews it is fairly clear that in general, although the science laboratory has been given a distinctive role in science education, research has failed to show simplistic relationships between experiences in the laboratory and student learning. Tobin (1990) suggested that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials so as to be able to construct their knowledge of phenomena and related scientific concepts. In addition, it was suggested that, if designed properly the science laboratory has the potential to play an important role in attaining cognitive skills and metacognitive skills (Baird, 1990). Metacognition involves elaboration and application of one's learning, which can result in enhanced understanding. In the laboratory we provide the students with opportunities to take control of their own learning in the search for understanding. In this process it is vital to provide opportunities that encourage learners to ask questions, suggest hypothesis, and design investigations '*minds-on as well as hands-on*". Baird (1990) suggested that this could only be accomplished if the laboratory learning environment will undergo a radical shift from teacher-centred learning to purposeful inquiry that is significantly more student-cantered. It should be noted that *inquiry* refers to diverse ways in which scientists study the natural world, propose ideas, and explain and justify assertions based upon evidence derived from scientific work. The laboratory is important in the current era in which *inquiry* has re-emerged as a central style advocated for science teaching and learning (Bybee, 2000). A *constructivist* model currently serves as a theoretical organizer for many science educators who are trying to understand cognition in i.e., learners construct their ideas and understanding on the basis of series of personal experiences. Moreover, there is a growing sense that learning is contextualized and that learners construct knowledge by solving genuine and meaningful problems (Brown, Collins, & Duguid, 1989) Experiences in the school laboratory can provide such opportunities for students if the expectations of the teacher enable them to engage intellectually with meaningful investigative experiences upon which they can construct scientific concepts within a community of learners in their classroom (Roth & Roychoudhury, 1993).

Inquiry-based experimentation in the chemistry laboratory

The Development of Inquiry-Type Experiments

In Israel, in the Department of Science Teaching,The Weizmann Institute of Science, about 100 inquiry-type Chemistry experiments were developed and implemented in 11^{th} and 12^{th} grade chemistry classes in Israel (for more details about the development procedure, assessment of students' achievement and progress, and the professional development of the chemistry teachers, see Hofstein, Shore & Kipnis, 2004). Almost all the experiments were integrated into the framework of the key concepts taught in high-school chemistry, namely: acids-bases, stoichiometry, oxidation-reduction, bonding, energy, chemical-equilibrium, and the rate of reactions. These experiments have been implemented in the school chemistry laboratory in Israel for the last five years (about 125 teachers in about 82 schools, and about 3500 students). Only teachers who underwent an intensive professional development (for more information see: Taitelbaum, Mamlok-Naaman, Carmeli, & Hofstein, 2008) were involved in teaching the inquiry laboratory program. In these professional development initiatives the teachers were given the opportunity to conduct all the stages of the inquiry experiments as will eventually be done by their own students.

Typically in this chemistry laboratory, the students perform the experiments in small groups (3-4), by following the instructions in the laboratory manual. In the first phase (the pre-inquiry phase), the students are asked to conduct the experiment based on specific instructions. This phase is largely 'close-ended', in which the students are asked to conduct the experiment based on specific instructions given in the laboratory manual. Thus, this phase provides the students with very limited inquiry-type experiences. The 'inquiry phase' (the second phase) is where the students are involved in more 'open-ended-type' activities such as: asking relevant questions, choosing a question for further investigation, planning an experiment, formulating an hypotheses, conducting the experiment (including observations) to accept or reject the hypothesis, and finally drawing conclusions about scientific phenomena.

Clearly these experiences are very student-cantered in which the teacher serves as a support and guidance throughout the various stages of the inquiry-based experimentation.

Teachers' behavior in an inquiry-type classroom laboratory learning environment.

Accomplished teachers who are involved in inquiry program should have the following skills and abilities:

- Encourage students to interact professionally, including sharing knowledge with their peers, community members, or experts.
- Help students: solve problems, ask high-level questions, and hypothesize regarding certain unsolved experimental problems.
- Assess students continuously using a variety of alternative assessment methods.
- Customize the new activities according to their needs, and make decisions regarding the level of inquiry that is suitable for their students.
- Align the experiment with the concept taught or discussed in the chemistry classroom.

As suggested before, inquiry-type laboratories are very much student-centered. The skills and abilities in which the learners are involved are of high-order learning skills (e.g. asking questions and hypothesizing). The science (in our case chemistry) teacher operates in avery demanding teaching and learning environment in which they may be faced with unplanned and new situation. For example students might ask questions to which the teacher has no immediate answer.In such situations, the teachers should be very open-minded regarding their role, and more tolerant, encouraging, and flexible.

Many of these skills mentioned above are new to many teachers and thus, those involved with science curricula development and implementation should provide teachers' with professional opportunities to develop these higth level teaching skills.

A model of CPD (continuous professional development) for science teachers.

We are operating in an era of new standards in science education (e.g. NRC, 1996) these standards specify the content knowledge, the pedagogical content knowledge, the experiences, dispositions and ownership that science teachers must have if they are to become accomplished science teachers in general and to be able to engage in teaching science by inquiryin particular.(NSTA 2004:http://www.nsta.org/about/positions/inquiry.aspx)

What are the nature and characteristics of CPD models?

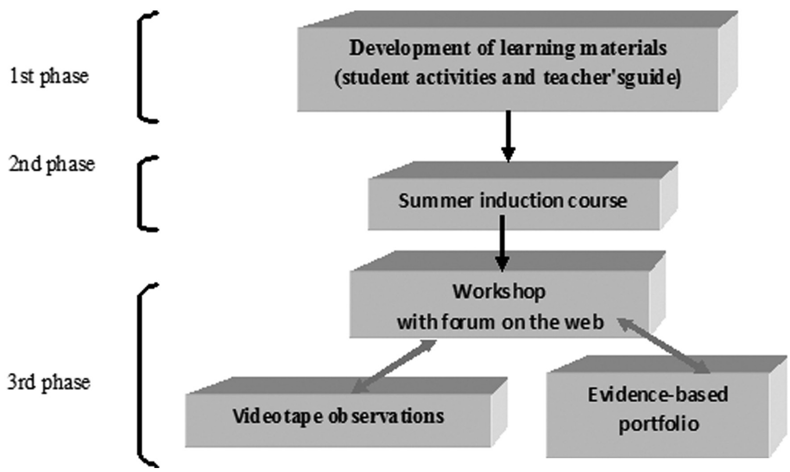
Effective CPD needs to provide an opportunity for teacher reflection and learning about how new practices can be evolved or molded from existing classroom practice.Teachers need to familiarize themselves with new ideas and also understandthe implications for themselves as teachers and for their learners in the classroombefore they adopt and adapt them. If the new approach differs greatly from theirprevious practice, this involves them reshaping their own beliefs regarding scienceteaching and learning. It thus involves both considering core principles and issuesas well as contextualizing these in developing practice and approaches. The challengecomes when teachers return to their schools, where their ideas developedduring the CPD sessions might falter outside the supportive climate of the teachermeetings.. Conventional methods of conducting CPD have usually been too short and occasionalto foster change in teacher classroom practice (Loucks-Horsley, Hewson,Love & Stiles, 1998).

The nature of the CPD models:

- Engaging teachers in collaborative long-term inquiries into teaching practice andstudentslearning;
- Situating these inquiries into problem-based contexts that place content as centraland integrated with pedagogical issues;
- Enabling teachers to see such issues as embedded in real classroom contextsthrough reflections and discussions of each other's teaching and/or examination ofstudents' work;
- Focusing on the specific content or curriculum teachers will be implementingsuch that teachers are given time to work out what and how they need to adaptwhat they already do.

The main difference between short-term professional development of teachers and CPD is the fact that during the later the teacher is provided with a lot of opportunities to reflect on his/her classroom practice. They become reflective practionaires. In addition, CPD models are effective sources to what is fondly called life-long-learning. Figure 1 is schematic representation of the CPD model developed and conducted among chemistry teachers in the Weizmann Institute (Taitelbaum, Mamlok-Naaman, Carmeli, & Hofstein, 2008).

***Figure 1**. The components of the CPD model.*



Phase 1: was mainly devoted to the development of learning materials for the CPD this was mainly done

by a group of leading teachers in the national center for chemistry teachers.These materials served as background for both phases 2 & 3.

Phase 2: The initial objective of the 5 days long summer induction course was exposure to basic methods of using inquiry approach in the chemistry laboratories. More specifically teachers learned inquiry skills by having firsthand experience in all the cognitive dimensions and the practical stages.

Phase 3: was mainly conducted throughout the school year. The objective of the workshop (meeting once a month in the afternoon),was to assemble a small group of teachers who were novice in the inquiry approach and that will be able to reflect on their experience and share experiences with their colleagues (creation of a platform for feedback and reflection).In these meetings teachers presented artifacts from their classes (e.g. posters, students' reports, video vignettes,etc.).They were provided time and platform for reflections on their classroom practice, they presented the artifacts and transferred them into evidence, and discussed problems and challenges related to their school experiences in the chemistry laboratories. From time to time, the teachers were observed (video-recorded as a tool for observation) by a tutor. These recordings were discussed F2F with the tutor regarding the development of inquiry skills difficulties the students had. In addition, some scenes from the videos were used by the participating teachers as evidence of their practice in the personal evidence-based-portfolio.

We found that during the CPD initiative the teachers had gained more self-confidence to criticize their own work and to understand their teaching strategies in leading and tutoring students who work in small collaborative groups, or to develop the investigative skills of students, such as discussing the types of questions posed, the nature of the hypothesis raised, the questions selected for further investigation, and the process of planning more experiments.

Finally, to demonstrate the idea for teachers' professional development is is worthwhile to quote from one of the in-depth interviews conducted with a teacher that participated in the CPD program:

> „At the beginning I thought that if I will summarize everything by lecturing to the class; that will be the right thing to do. But that not enough… later I said to myself lets change let the students talk. Than I thought, that I will let them present, and indeed it became more varied more colourful, with power-point-presentations. I started with a dry routine discussion, but than I moved on…" passed them the ball" I made them more and more active".

Summary

Introducing evidence from the classroom-laboratory was not a trivial task, but the fact that the teachers were encouraged to document their work, together with the process of investigating their work during classroom-laboratory (reflecting and watching the videos), significantly contributed to their work. Among the benefits, the teachers mentioned the exchange of ideas, as well as getting relevant feedback and support.The model implemented in this study could be adopted effectively for other instructional techniques and pedagogical interventions used by science teachers in general and by chemistryteachers in particular. Supporting teachers continuously (like in this study or by teacher-leaders) has potential in enhancing teachers professional practice in our attempt to attain new, higher pedagogical standards.In summing up this paper the authors feel that more research should be done in order to fully understand the dynamics of CPD programs in general and in the science laboratory in particular. More methodologies should be explored and more CPD models should be investigated and developed.

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E-learning for promoting inquiry learning: The project „Virtual Science Fair„

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Science Fair – Virtual Science Fair

Science fairs are exciting, hands-on, competitive-collaborative ventures for middle school students. Many American schools conduct traditional science fairs each year. In Germany, only a very few schools conduct science fairs. There is no tradition of science fairs in schools. Today's middle school students are growing up in a digital environment vastly different from twenty years ago. The students easily master the technologies of chat, instant messaging, blogs, streaming video and e-mail. Utilizing the powerful online tools provided by Moodle™ interactive software, Dr. Stuart Fleischer from The American International school in Israel, developed a „virtual" science fair with student projects hosted online with digital images and streaming video. This is a new type of science fair that reflects today's reality: the age of communication and collaboration. The embedding of e-learning tools into the traditional science fair fosters self and group-directed student inquiry and investigation. New participants in a virtual science fair are so called „e-mentors". They are science teacher students from a university. Each e-mentor works together with his given team from the beginning of the project until the project is completed and the science fair takes place at a school.

The e-mentors are skilled in science inquiry and in science education. They interact with their team of middle school students throughout the design, research, experimental and analytical phases of the science fair project. Using Web 2.0 Learning Tools and a password-protected Moodle web space, the students report the progress to their e-mentor by posting to a wiki, and reflect on what they are learning or challenging by posting to their blog. How might such cross-institutional, tele-collaborative (Harris, 1995) teams be brought together? One response lies with the NESA Virtual Science Fair (NVSF) project, invented by Dr. Stuart Fleischer, launched in fall 2004 for American International Schools (AIS). The Near East South Asia Council of Overseas Schools (NESA) is a non-profit, voluntary association of more than 75 international schools in the Near East and South Asia, a region stretching from Greece and Egypt in the west, to Nepal, Bangladesh, and Sri Lanka in the east. Member schools follow a US-style curriculum and typically serve students of more than three dozen nationalities. The NVSF is designed to implement a science fair that encompasses hundreds of students, e-mentors, judges and teachers from schools crossing geographic and geopolitical zones. What was once considered impossible can be accomplished with today's e-learning tools and e-mentoring - pairing science teacher students with middle school students. In doing so, it helps establish content-related, curriculum-based „teleapprenticeships" (Levin, 1987), or what Riel & Harasim (1994) refer to as „electronic mentorships." The author, Dr. Jonas-Ahrend from Technische Universitaet Dortmund in Germany, adopted the „NESA virtual science fair" project and established it in Germany („vsf-Germany") the first time in 2009 (Jonas-Ahrend, 2011). E-mentoring, as defined for this project, is the „use of e-mail or computer conferencing systems to support a mentoring relationship when a face-to-face relationship would be impractical" (O'Neill, Wagner, & Gomez, 1996, p. 39). The virtual science fair project is also a research effort, examining the nature of adult-child interactions and collaborative, asynchronous teaching and learning in primarily text-based, computer-mediated environments (Harris & Jones, 1999). The participating middle school students are encouraged to inquire about their science fair topics of interest, and the classroom teachers help shape these interactions, helping students face-to-face in a classroom learning environment. Recognizing that today's middle school students are growing up in a digital environment, a „virtual" science fair using Internet technologies and digital tools is not daunting to them.

For NVSF, every year about 600 students attending about 12 American International Schools in 12 countries participate in their school science fair and the NVSF. About 400 science and science education students serve as e-mentors. The e-mentors are assigned randomly to teams of students with unique password and login access to the team web space. For vsf-Germany, about 120 students from 2 German schools participate each school year in the virtual science fair Germany. About 60 preservice science teachers studying at TU Dortmund serve as e-mentors.The team with the best result of the virtual science fair project has the option to participate in the 2nd round of NVSF. About 20 international teams go on in 2nd round, again 10 teams go on in 3rd round. In Germany, only 1st round of virtual science fair exists so far. If more school will be involved, also 2nd and 3rd rounds can get accomplished.

Procedure of Virtual Science Fair

The middle school students follow the same protocol as for a traditional science fair. While the students design and implement their science experiments at home or in the science classroom, the e-learning component is transparently embedded into the process: teams communicate about twice a week with their e-mentors with questions, post interim experiment reports, and share their digital and photograph video galleries. Simultaneously, the e-mentors have a unique opportunity to not only help collaborate on a research project, but also explore how a middle school student „thinks about science“ in a rich exchange of knowledge.

In their own reflective thinking and in the given questionnaires, the e-mentoring teacher students who participate state that they learn a lot about how to communicate with middle-school students as they attempt to focus their teams on their investigations, suggest project resources for background information, and explain complex science concepts effectively during the data analysis. Some e-mentors are engaged in extensive online discussions with their teams during the project, and the feedback from the middle school students indicates a positive outcome.

The participating schools are working on their own given schedule. Normally the entire process of a virtual science fair takes about 2-3 months. The actual Science Fair, the exhibition of the projects, takes place at the schools and is organized by them. At the end, a team of judges evaluates all projects and the presentation of the projects and prices are given to the best teams.

E-mentoring Tool: Moodle

Moodle is a user-friendly, Web-based, interactive learning system. For the virtual science fair, a special course page was developed. It is used to structure the exchange of science inquiry activities and feedback between middle school students and e-mentors. Each team of students opens an own forum in this course. The students post their planned project and all questions they might have, then the e-mentors respond with appropriate feedback, such as websites, print references, scientific or methodological explanations and so on. This exchange interface facilitates a comfortable, ongoing dialogue also for sharing data tables, images, videos, and charts. Furthermore, the course page is used to post the time schedule of the virtual science fair and messages from the teachers to students and e-mentors. All persons who belong to the course can read all of the discussions of every team, but only the e-mentors and the students themselves can write into their own forums.

Analyses of the dialogs

All of the posted discussions between e-mentors and their teams have been analyzed. The length of the dialogs is very different between the teams. However, the best teams have had always long dialogs. Very important is an honest and trusting relationships between e-mentors and their team. Even during introductory exchanges, the middle school students were excited about working with university students to plan and complete their science investigations. Many teams create and share a short video to explain their proposal for a science fair project. Although not required, most of the e-mentors mention their ages and indicate the kind of help they want to give with their science inquiry activities. The students discuss plans and dreams, ask personal questions, and identify strengths and weaknesses. Comfortable with technology, instant messaging, emailing, and submitting work online, the university student e-mentors enjoy communicating and also share some personal information. Answering questions with details, alluding to cultural backgrounds and sometimes language differences, and sharing music and food preferences suggest that these preservice teachers are using discourse to create personal profiles and to establish personal connections with the students of their team. It is possible that the distance created online rather than face-to-face allowes such honesty to emerge. Some e-mentors find the line between teacher, e-mentor and friend somewhat fuzzy – a line that is especially difficult to negotiate for novice school teachers. Slowly they learn how to be supportive and understanding while maintaining their „authority-like“ position. In almost all relationships e-mentor – middle school student, the e-mentors develop a strong responsibility for their team and their science project.

Initially, all e-mentors experience difficulties providing effective and useful feedback assisting their teams to revise their hypotheses. Trained in a workshop style, they give extensive feedback to students in the form of questions seeking clarification and elaboration of content in order to aid their teams in developing their ideas. However, sometimes the middle school students do not understand their e-mentors' comments.

Implications: Lessons Learned

The evaluation shows that the virtual science fair project not only engages diverse students in science learning in ways that students themselves found more powerful than the typical science classroom, but also teach students 21st century skills. Most importantly, the science investigation broadens students' perspectives about scientific experimentation and exploration and the value of learning science in their own lives. Several important lessons and questions emerge from this analysis 1) the effectiveness of e-mentoring in improving science inquiry and preservice teacher training; 2) importance of preservice teachers learning to provide effective feedback; and 3) the affective component of online mentoring. The preservice teachers experience an authentic context for teaching and improving students' science inquiry activities skills. Although e-mentors are initially overwhelmed by the talents and abilities of middle school students, as the project progresses they become more competent in providing balanced feedback and learning which comments were perceived by their teams as most helpful.

The participating e-mentors also value the benefits of developing a meaningful relationship with interesting, engaged, and engaging adolescents. Developing a genuine regard for their students as people rather than just students, they learned how to detect and address clues that focus on academic and emotional difficulties while exploring the boundaries of teacher/friend and adult/authority at a comfortable distance. What is most significant is that preservice teachers discover ways that technology-based strategies motivate students, experience network opportunities that require instructional assessment and decision making, and learn flexibility and patience. The middle school students trust their e-mentors and look forward to discuss with them their project.

Collaborative Agents of Change

All participants in the virtual science fair project are collaborative agents of change. The classroom teacher, university instructor, middle school students, and preservice teachers work to develop a collaborative model for using technology to facilitate improved students' skills in science inquiry activities. Communication is and continues to be a critical factor in the collaboration in the form of clear directions to e-mentors, consistent feedback to the middle school students, and effective pedagogical strategies for the classroom teacher and teacher educators. The embedding of e-learning tools into the traditional science fair fosters self and group-directed student inquiry and investigation. In this learning environment, scientific habits of mind are nurtured, and the tools and tactics for manipulation of information, discovery and sharing of science knowledge are highlighted. Students are encouraged to investigate science problems at multiple levels of complexity, thereby deepening their understanding of scientific concepts. The virtual science fair helps middle school science students to develop and design more authentic, „real world“ science investigations, reflect on skills used to manage their own learning, address misconceptions in their thinking, and categorize inquiries around themes and concepts.

Virtual Science Fairs seem to be on a bright and exciting path. They are going where no science fair has gone before: Inquiry based learning combined with communication skills of the 21st century!

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SALiS and Educational Policy in Georgia

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In Georgia, as well as in all the Post-Soviet countries, content-based learning has been established for many years. The current article offers a description of the stages of the Educational Reform, educational policy trends and SALiS program's contributions in science education.

Stages of Educational Reform in Georgia

In Georgia, as well as in all the Post-Soviet countries, content-based learning has been the main approach for many years. The system of education was highly centralized and there were unified methodological approaches across all the Soviet Union countries. Ongoing reform radically changed the educational system. The modern educational system in Georgia is based on a number of important normative documents which are novelty. Among them should be mentioned the National Goals of General Education (2004), which defines what kind of citizens should we have after graduating the school. The General Education Law (2005) is based on the National Goals of General Education. Later, in 2004-2005, the first National Curriculum was developed.

There were particular changes in the content of education. It was approved requirement of student-centered teaching. Learning - teaching approaches fundamentally were changed. The subject programs became outcome based.

The new requirements were suggested for natural science teaching as well. Inquiry-based learning, discovery learning, problem-based learning were main methods suggested in Science Curriculum (subject programs) nowadays.

Consequently, teachers' qualifications requirements were changed. There were approved new standards for science teachers (Science teacher's Standard. Professional standards in Science for teachers of primary grades[I-VI grades]). The standard specifies the competencies required to science teacher, that should be able to achieve outcomes of the National Curriculum.

Policy strategies for Successful Implementation of National Curriculum and SALiS

The process of implementation of the National Curriculum which began in 2006, was accompanied by the introduction of many difficulties. There was a big verity of factors that influence upon the implementation process: different sizes of schools, teacher qualifications and etc. (Table 1). Therefore, the implementation of the National Curriculum should be fit to these circumstances.

Table 1. *Some important statistical data on Georgia's educational system (data for 2012)*

	Category	amount
1	population	4 497 000
2	students	561911
3	schools	2317
3.1	public schools	2087
3.2	privateschools	235

The Ministry of Education and Science allocated a number of priorities for successful implementation of Science Curriculum. Those are:

a. Guidelines for Inquiry-based learning.

b. Teachers' qualification development programs.

c. Appropriate equipment and laboratories for inquiry-based learning.

However, only the State interventions for successful implementation are not enough. It is very important to enrolment of the other educational actors. Student Active Learning in Science (SALiS) project is a successful example of such collaboration. The project is in full consistent with the implementation strategy carried out by the Ministry of Education and Science in science learning approaches. Project activities are very important and cover all three implementation strategy directions. In particular, SALiS project:

a. develops guidelines for inquiry-based learning. Gives particularly significant methodological recommendations on the use of low-cost technologies for science lessons.

b. has developed training courses in active learning and provides teacher's qualification development programs.

c. has established two (Tbilisi and Kutaisi) equipped laboratories for inquiry-based learning.

Based on the above mentioned, we believe that the long-term outcomes of the SALiS project will positively influence upon the successful implementation of Science Curriculum in Georgia.

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