Report

S-TEAM

Preliminary report:

Work Packages 2 & 3

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The S-Team project has received funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement n °234870.

S-TEAM

FIRING UP SCIENCE EDUCATION

SEVENTH FRAMEWORK PROGRAMME

This report has been collaboratively produced by work package (WP) 2 and work package (WP) 3 of the S-TEAM project, following the programme of national workshops conducted between July and December 2009 in the S-TEAM partner countries. The report combines S-TEAM deliverable 2a (preliminary report from Work Package 2) with deliverable 3a (preliminary report from Work Package 3), for the reasons stated below.

The original workshops plan called for WP 2 and WP3 to hold separate programmes of events, but feedback from the national partners indicated that potential participants would prefer them to be run as combined events. This proved to be beneficial to the overall objectives of both WP2 and WP3, as the SINUS model provided a stimulus for policy discussions, whilst these policy discussions provided useful feedback for future development of SINUS and its modification within S-TEAM. The combined workshop format also led to greater consistency in data collection.

This report therefore combines S-TEAM deliverable 2a with deliverable 3a. The factual or supporting material concerning national education systems and policies (Section Two) is common to both work packages, and this combined material will provide a basis for further analysis of policy and practice in IBST and teacher professional development. It will also inform future development of SINUS modules and models, as well as S-TEAM products and deliverables in general.

In Section Three, we have included additional material from current literature reviews in Work Package 6 to provide further background to some current S-TEAM activities and themes.

Acknowledgements

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List of abbreviations used

CPD -- Continuing Professional Development
ECTS --- European Credit Transfer & Accumulation Scheme
IBST/E --------------------------------------- Inquiry-Based Science Teaching/Education
ITE/ITT -------------------------------------- Initial Teacher Education/Initial Teacher Training
OECD --- Organization for Economic Cooperation & Development
PISA-- Programme for International Student Assessment
S-TEAM -------------------------------------- Science-Teacher Education Advanced Methods
TIMSS --------------------------------------- Trends in International Mathematics & Science Study
TPD -- Teacher Professional Development

Section One: Summary and Introduction

Summary

- This report shows that the Bologna process has introduced a tendency in initial teacher education towards a five-year masters-level qualification throughout Europe. Senior secondary teachers usually start their studies with a subject specialization followed by pedagogical training. On the contrary, primary teachers seem to be generalists with little or no subject specialization. Generally, the status of secondary teachers (with respect to salaries, appreciation by the general public, etc.) seems to be higher than the status of primary teachers.

- In many European countries, IBST is included in science teacher education but not necessarily as described in the S-TEAM definition. However, on a national level usually no specific directive exists.

- National and local curriculum frameworks for science in schools do place an emphasis on both the products and processes of science. In national workshops, however, we heard that when teachers implement the science curriculum, they seem to lack the necessary skills to incorporate IBST ideas into their teaching methods.

- Few (if any) national strategies for teacher professional development (TPD) of science teachers could be found. Where countries have national institutes for TPD, there seems to be little emphasis placed on science TPD. TPD is usually offered by the universities and other providers in the form of short, stand-alone courses focusing on content knowledge (what to teach) rather than combining content knowledge and teaching methods thus enabling teachers to create good and efficient opportunities for student learning (how to teach). It is missing the important features of efficient TPD found in the literature and implemented in the SINUS model: collaborative, school based, long-term, linked to the curricula, and focusing on student learning. In almost all countries, there is an astonishing gap between the importance of TPD for implementing educational change and the lack of effective and sustainable models for TPD.

- Countries reported that new teachers are more likely to adopt the culture of their schools and hence the “traditional” teaching approaches rather than to introduce innovative teaching methods as learned from initial teacher education. This is attributed to the lower status of the new teachers coming into an established social structure and their lack of experience compared to colleagues. This stresses the need for an effective TPD system where goals need to be closely connected to the goals of an up-to-date pre-service teacher education. In addition, an effective TPD system must also be closely linked to the culture of schools, including support by leadership and time for reflection between teachers.

Introduction

This report will present an overview of science education policy with respect to the structure and quality of schooling as well as pre-service and in-service teacher education within the 15 European countries participating in the EU-project "Science-Teacher Education Advanced Methods (S-TEAM)". The information in this report was partly provided through a questionnaire with open questions that was jointly developed by S-TEAM work packages 2 and 3. This questionnaire was administered to the national S-TEAM partners who are regarded as experts in the field of science education. Additional information was gathered during one- to two-day seminars (or 'national workshops') that were organised by the national partners in the respective countries. The seminar participants came from different areas concerned with educational policy in general and teacher education in particular, such as Ministries of Education, teacher and science education institutions, industry, trade unions, parents associations etc. The seminars generally comprised two parts. In part one, work package 2 provided an overview of European educational policy and best practice in science education with a special emphasis on inquiry-based science teaching (IBST). In part two, work package 3 presented the German SINUS model as one successful approach to teacher professional development (TPD) and initiated discussions as to whether components of this model might potentially be used to improve TPD in the respective countries.

This report describes the starting point of the S-TEAM project and first reactions in the participating countries following the national seminars. A common understanding shared by the project partners is that we have to make fundamental changes in the way we educate science teachers (pre-service and in-service) in order to achieve improved outcomes of science teaching in schools. Research-based knowledge and expertise gathered in the S-TEAM consortium will provide a direction for change in participating countries. During the next two years we will continue to work on implementing these ideas.

About school quality

Theoretical goals and desired outcomes of science education as outlined e.g. in national curricula might – and very often do – differ from the actual way of teaching in the classroom and the scientific knowledge and competencies actually acquired by students. Since the S-TEAM project is not funded to carry out large-scale quantitative studies, it requires existing indicators or instruments to measure the quality of schooling in the participating countries. The PISA 2006 assessment of scientific literacy was therefore chosen as an indicator for the quality of science education[1]. With the exception of Cyprus, all S-TEAM countries participated in PISA 2006. It has to be kept in mind, however, that PISA is based on a clearly defined framework of scientific literacy that undoubtedly covers important aspects of science education but should in no way be regarded as comprehensive and the only benchmark or criterion.

The PISA data are scaled to an OECD average of 500 score points and a standard deviation of 100 score points. In addition to mean values in science performance and gender differences, PISA also

[1] See: http://www.oecd.org/document/2/0,3343,en_32252351_32236191_39718850_1_1_1_1,00.html

reports distributions of students to so-called proficiency levels that allow for a more detailed description of the knowledge, competencies and skills students possess. Whereas the high-performers are located at proficiency levels 5 and 6, students at proficiency level 1 or below show such a low science performance that they are heavily in danger of not being able to participate actively in life situations related to science and technology.

About inquiry

A project involving countries from all over Europe faces the challenge of developing a common terminology and a common understanding of its basic ideas. Although the roots of IBST as the main approach to improving science teaching and learning in S-TEAM lead back to the early 20th century (Minner. Levy & Century, 2009), the seminars showed that no common definition currently exists at a European level. In many of the participating countries appropriate translations of the term in the national language were not found. In S-TEAM the following definition of IBST given by Linn, Davis and Bell (2004) was chosen as a common basis for discussion:

> [Inquiry is] the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers and forming coherent arguments.

The S-TEAM proposal described inquiry-based science teaching as being characterised by activities that engage students in:

- authentic and problem based learning activities where there may not be a correct answer
- a certain amount of experimental procedures, experiments and "hands on" activities, including searching for information
- self regulated learning sequences where student autonomy is emphasised
- discursive argumentation and communication with peers ("talking science")

The existence of working definitions of inquiry or IBST is not in itself sufficient to begin the process of change in science education. Science teachers need the confidence to allow what McNally (2006) calls ”loose opportunism in the classroom”. In other words, they need to be open to changes in the direction of activities, or to be able to discuss topics which may be outside the lesson plan or the curriculum itself. This confidence might be acquired through experience, but it would be much more effective to develop it through professional development activities.

S-TEAM begins from the assumption, which the national workshops have confirmed, that there is a lack of professional development activities aimed specifically at improving the teaching of IBST. In order for such activities to be provided in national contexts, there is a corresponding need for materials to be available which address the foundational concepts of IBST. These concepts include:

- Argumentation and the use of evidence
- Scientific literacy
- Dialogic teaching
- Nature of Science

- Teacher collaboration in curriculum and pedagogical development
- Student motivation and inquiry

All the S-TEAM partners have previously been working in areas related to IBST and the project provides a major opportunity to combine their experience and knowledge into a coherent framework. The current phase of the project has been concerned with gathering data and the views of key players on the situation regarding IBST in their own countries. The next phase involves the production and adaptation of the S-TEAM materials on the basis of information from the national workshops, feedback from teachers/teacher educators and the incorporation of current research including results from current or completed projects in the same field. The final phase will involve the dissemination of materials into the national contexts.

About Teacher professional development

Given the rather fragmented nature of TPD across the European countries represented in S-TEAM, and elsewhere[2], it is not possible at this stage to propose or implement a single method of introducing the S-TEAM teacher development materials into the countries involved. It is, however, possible to suggest principles or models which would provide an overall context for their introduction, or simply for better TPD generally. In a report for the Mind the Gap project, Lipowski & Seidel (2009) come to similar conclusions:

> Currently, the knowledge on teacher professional development is fragmented and nonspecific. The European countries lack knowledge and evidence concerning the efficiency of traditional approaches as well as new models for TPD and in- service training. While, for example, traditional approaches to TPD often follow a top- down strategy and the sessions are organized as stand-alone events, current practices of effective TPD follow the idea of teachers becoming members of a community of learners (Jorde & Klette, 2008).

The SINUS approach to TPD is an example of this type of collaborative practice, which has been extensively tried and tested in Germany (Prenzel et al 2009; Prenzel & Ostermeier, 2006; Ostermeier & Prenzel 2005).

The individual country summaries later in this report demonstrate that possible improvements to TPD will require negotiation with national training providers, teacher education institutions and schools themselves, in order to give teachers the time and space to collaborate on developing effective inquiry-based practice in science. The dissemination activities of S-TEAM will be planned on a country-by-country basis to make the most of the networks initiated by the national workshops, existing contacts and emerging policy agendas in science education.

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[2] See, e.g.: OECD (Organization for Economic Cooperation & Development) (2009) *Creating Effective Teaching and Learning Environments: First results from TALIS*, Paris, OECD. http://www.oecd.org/dataoecd/17/51/43023606.pdf

Outlook and future developments

As a consequence of the S-TEAM project and the national workshops, actions have been initiated in some member countries to bridge the gap between IBST and teacher professional development. In Norway, a one-year project has started adapting the SINUS model to the situation and the needs of Norwegian science teachers. Six school networks (or nodes), where teachers will work on a set of five modules towards fostering the use of IBST in their classrooms, will be initiated. The Lithuanian and Turkish S-TEAM partners intend to set up small trials with some schools in order to find out whether the SINUS approach works with their teachers. In Spain the Ministry of Education intends to translate basic information about SINUS into the national languages and discuss the model with representatives from the autonomous regions. In Cyprus the Ministry of Education showed an interest in a proposal on how to use the ideas of the model to enhance TPD in Cyprus. In Scotland the objectives of S-TEAM are seen as coherent with those of the Science Action Plan[3] and we are involved in discussions about future collaboration.

Based on the national seminars and the information provided in this report, the following tasks should be addressed urgently:

1. Describe a framework for a model of sustainable TPD integrating the main results from research
2. Adapt the framework to the particular situation in the partner countries who are willing to initiate trial projects
3. Connect the work of implementing IBST in a particular country with relevant SINUS modules
4. Conduct small-scale trials of the national models, evaluate them, develop the models further and show the results to stakeholders in all participating countries

It is our belief that these steps should help to raise the awareness of the importance of a national strategy for TPD for science teachers.

S-TEAM has already outlined a set of actions, which can be adapted to carry out the above programme, as per the S-TEAM Technical Annex (STAN). Specifically, in respect of item 1 above, Work Package 2 will produce its final report in M33 (Jan 2012). This will extend the model of sustainable teacher development described in this report and will provide a definitive basis for future models of TPD. It will take into account the various trials and pilot implementations being carried out under item 4 (above). These trials are not themselves part of the S-TEAM workplan, given that S-TEAM is a coordination and support action (CSA), but will be conducted by relevant national bodies as described in this report.

[3] http://www.scotland.gov.uk/Topics/Education/Schools/curriculum/Actionplan

Outlook on WP3 tasks

Connecting TPD models (model here meaning the organizational practice of TPD in a certain country, whereas the 'definite basis for future models of TPD' means a set of criteria regarding quality, efficiency and sustainability) with relevant SINUS modules and SINUS/S-TEAM material means that in WP3 we have to describe how quality criteria for effective and sustainable TPD can be met in the respective organizational setting. This not directly connected to the modules but to the other principles of the SINUS approach (teacher collaboration, quality development over a longer period of time, support of teacher groups). The extent to which a particular system can incorporate these criteria depends on the available experience with them and the flexibility of the system and its openness towards change. One intention of WP3 is encouraging the participating countries to develop their TPD models towards more sustainability referring to the positive experience with SINUS. The quality aspects are the first set of ideas that should go into the training packages. In our view these changes are a prerequisite to effective and sustainable dissemination of any teaching method/approach (like for instance dialogic teaching or argumentation).

The SINUS modules are the second set of ideas for the training packages. They describe areas in which teachers can work for improving their instruction and provide ideas on how to do it (initially tailored to the German situation in the 1990s). Each module addresses the development of certain teaching skills (pedagogy) in direct relation to (science) subject content. When I take for example dialogic teaching, pedagogical challenges faced by a teacher who wants to develop his skills in dialogic teaching can be found in the SINUS modules. There is a connection to module 2 (scientific inquiry and experiments) because dialogic teaching aims at initiating and supporting discourse between pupils (and the teacher), module 8 (developing tasks for student cooperation) because collaborative approaches might be useful, and module 9 (strengthening students' responsibility for their learning) because the method gives responsibility to the pupils. The modules can help to clarify that dialogic teaching is not just another (more or less exchangeable) method that can be used in a mechanical way but that it has the goal of supporting pupils' learning. Put in a nutshell, the modules try to shift the teachers' focus from 'pure' content knowledge and 'pure' methods knowledge towards a purposeful selection of methods regarding content and pedagogical aims. This is important to overcome the frequently reported problem that teachers are not able to transfer their knowledge from TPD courses into suitable learning environments in their classrooms.

In respect of items 2 and 3, Work package 3 will be responsible for adapting and connecting TPD models with the relevant SINUS modules and SINUS or S-TEAM materials, as described under deliverable 3b in STAN. Given the divergence of approaches described in the 'countries' section of this report, it will not be possible to fit every SINUS module or S-TEAM 'training package' into every national context. As with inquiry-based science teaching itself, the dissemination process of S-TEAM is necessarily opportunistic, and has to take account of shifts in policy direction, new research results, or simply the attitudes of key players to innovative practice.

As part of the dissemination process, Work Packages 2 and 3 will be hosting an international policy conference in Glasgow (14-15 October 2010), which will report on progress towards sustainable and effective models of TPD in the partner countries. The conference will also provide a further opportunity for policymakers to engage in dialogue with teachers and researchers on the way forward for IBST. Other FP7 projects in the field of IBST will be invited to participate, in order to contribute to a long-term network of practice and policy in inquiry-based science education.

Section Two: Country Summaries

Cyprus

The Education System

Basic Structure of Schooling

According to the 2009 Eurydice summary of the Cypriot educational system:

> Pre-primary education is part of Basic Education, which includes kindergartens and primary schools. […] Children between 4 and 5 years are obliged to attend either public kindergartens, or community or private schools. Younger children between 3 and 4 years take up vacant places in public kindergartens and pay fees as set by the Ministry of Finance. A number of children are exempted partially or fully from educational fees.

Compulsory education in Cyprus starts with kindergarten at the age of 4 and encompasses primary school (children aged 5-11) and general lower secondary school (ages 11 -15). Mathematics & science are core curriculum subjects in compulsory school (Eurydice 2009). From the age of 15 to the age of 18 or 19 (depending on type of education) pupils usually attend either general or vocational & technical upper secondary education.

The following link gives a chart picturing the Cypriot educational system: http://www.dr-bongardt.de/uni/bongardt/archiv/projekte/schule_in_europa/staaten/zypern.htm.

Information about Quality

Cyprus has not been participating in PISA. They have, however, participated in TIMSS from the beginning of the study in 1995. In the 2007 TIMSS science assessment of students in 8th grade, students in Cyprus (452 points) performed significantly below average. Girls reached significantly higher competency values than boys.

The Teacher Education System

Initial Teacher Education (pre-service education)

The structure of the education system in Cyprus is very different within the various levels of education. At the pre-primary and primary level (up to grade 6), teachers need to have a four-year B.A degree in Educational Sciences which they can acquire from a (public or private) university in Cyprus, a university in Greece, or a university abroad (with the possibility of taking some additional courses from a university in Cyprus). Teacher students in pre-primary and primary education can choose a 'partial' specialisation (language and literacy, mathematics, science, special education, art, music or physical education) by selecting optional specialist courses from within the general syllabi.

At the secondary level (middle and high school) science teachers need to have a BA in the particular area that they will be teaching (e.g., physics, chemistry, biology, mathematics, etc) and an additional year of pedagogical studies as part of their pre-service education. The pre-service education at the University of Cyprus (48 ECTS) consists of: 3 compulsory courses (12 ECTS); 1 restricted choice (4

ECTS); 1 content knowledge course in the specific subject (4 ECTS); 2 courses in didactics of the specific subjects (8 ECTS) and school practicum (20 ECTS).

Status of the Teacher Profession

The teaching profession in elementary education in Cyprus is a popular career choice and competition for places in teaching programmes either at universities in Greece or at the University of Cyprus (entry through the National Pancyprian Exams) is high, thus ensuring that the highest achieving students are accepted to these programmes. The demand for student teaching positions is due in part to the security (lifetime tenure once a teacher is appointed within the national education system) and benefits (holidays, promotion, salary, and working hours) offered by the national education system.

Recently, with the advent of three new, private universities in Cyprus offering nationally recognised teacher education programmes, there has been a tendency to admit students with an average general grade on their leaving certificate and with the successful completion of an interview only (no admission exam is necessary). At the European University-Cyprus the lyceum leaving certificate requirement is currently 17 of 20 points or higher for entry to the B.A. primary education course.

Teacher Professional Development-Models/Institutions

Teacher Professional Development (in-service education)

In Cyprus, official in-service training for the c.99% of teachers working in public schools is currently offered primarily by the Pedagogical Institute of Cyprus, and to a lesser extent by the Inspectorate. Courses are open to consultants and interdepartmental committees from the Ministry of Education and Culture for support and feedback. The Pedagogical Institute offers professional training courses to pre-primary, primary, secondary and vocational educators, through a series of optional seminars after school hours (Georgiou *et al*., 2001). The seminars focus on school subjects, social and psychological issues, educational research skills and information technology. Additionally, school-based seminars are organised on specific topics of interest to the staff of a school by agreement with the Pedagogical Institute.

The Pedagogical Institute also organises seminars, one-day workshops and conferences in cooperation with the teachers' unions and teachers' associations of specific subjects (Pedagogical Institute, 1999). The only courses offered by the Pedagogical Institute that are compulsory for public educators, in agreement with the existing educational legislation and service schemes, are those for teachers who have been promoted to administrative posts. In-service courses for educational administrators focus on the theoretical principles of administration and school management, the analysis of duties, effective practice and specific innovations.

Inspectors also offer short seminars that are mandatory for teachers. These seminars have a consulting rather than a training character (UNESCO, 1997). In general, the training system seems to be controlled by the Ministry of Education and Culture with limited school input. It is centrally determined, supply-driven and functions on a purely individual basis, ignoring identified individual and school needs.

The departments of educational sciences of various universities as well as some teacher organizations sometimes offer seminars that are related to professional development of teachers at different levels of education. The *Learning in Science Group* at the University of Cyprus has been trying to provide at least one seminar or workshop per year that addresses current approaches to teaching sciences. Usually, the seminar is related to various research projects undertaken by the *Learning in Science Group* and its local collaborators.

Status of Teacher Professional Development

The content as well as the organisational structures of the Cyprus in-service training do not satisfy the needs of elementary school teachers to a great extent (Charalambous & Michaelidou, 2001). In a similar mode, the Committee on Educational Reform (2004), in their report on the Cyprus educational system, mentions that the 'in-service programmes can only satisfy a rather limited percentage of teachers (p. 238), while the Elementary Teachers' Union identifies them as insufficient due to lack of vision and planning (POED Work Committee for In-Service Training, 2004). Studies on specific innovations such as ICT implementation also indicate problems in the provision of in-service training and point to the need for different national professional development plans (Kanaris *et al*., 1995; Charalambous & Karagiorgi, 2002). Finally, compulsory training programmes for teachers promoted t*o* administrative positions are also insufficient as they are not undertaken during the first year in the promoted post but often delayed for several years, and the potential of administrators to get involved in school development and improvement, which require expertise in these aspects, is thus limited (Celikten, 2001; Theofilides *et al*., 2004).

Inquiry Based Science Teaching

Inquiry in the School Curriculum

The curriculum attempted to define a philosophy based on hierarchical-developmental views of learning (mainly Piagetian) and a philosophical perspective of *guided discovery*. This approach emphasises the engagement of students in discovering science concepts for themselves, guided by careful planning and direction towards the desired objectives and conclusions. The current policy statements on science reflect this view and show the emphasis of the new philosophy on both the acquisition of scientific facts and principles and the implementation of scientific methods and skills.

Inquiry in Teacher Education

The degree to which IBST is introduced and developed in teacher education programmes depends to a great extent on the lecturers of the courses who interpret and implement the curricula. There is no directive from the Ministry specifically for IBST.

The Czech Republic

Education System

Basic Structure of Schooling

Pupils attend compulsory school from the age of 6 to the age of 15 in the Czech Republic. It is divided into two levels, the primary level from the first to the fifth grade, and the lower secondary level from the sixth to the ninth grade. In the former, all subjects are usually taught by a generalist teacher. In the latter, subjects are taught by teachers specialising in two subjects or, exceptionally, in one (The Ministry of Education, Youth and Sports of the Czech Republic, 2009). Mathematics is a core subject in both primary and lower secondary school, whereas the teaching of science subjects (physics, chemistry and biology) starts in lower secondary school.

After the completion of compulsory education pupils may continue in upper secondary education, usually from the age of 15 to the age of 19. In addition to general studies there are 12 fields of study at upper secondary school, including mathematics and natural sciences. During the first three years, mathematics and the science subjects (physics, chemistry and biology) are compulsory. In the fourth and final year of upper secondary education, mathematics is still a core subject, but the teaching of the natural sciences is optional for each school (The Ministry of Education, 2009).

Demographic processes have caused a decrease in the annual numbers of new schoolchildren, leading to a relative over-abundance of schools in the Czech Republic. There are many schools for a comparably small number of students in some regions. This leads on the one hand to there being many very small schools, and on the other hand to growing competition between schools.

The following link gives a chart picturing the Czech educational system:
http://www.czechinvest.org/data/files/fs-10-bildungssystem-74-de.pdf

Information about Quality

In the PISA 2006 assessment of scientific literacy, students in the Czech Republic showed a performance (513 score points) significantly above the OECD average. No significant gender differences in performance were observed. The amounts of low- (at proficiency level 1 or below) and high-performing students (at proficiency levels 5 and 6) are comparable to Germany. There are significantly less low-performing students compared to the OECD average (15.5 % vs. 19.2 %) and significantly more high-performing students (11.6 % compared to 9.0 %).

Almost 75% of students in the Czech Republic pass the matriculation exams. These exams are school-specific. In the nineties, mathematics was removed as an obligatory subject in the final school leaving exams. One of the reasons might be to allow as many students as possible to pass the exams in the subjects seen as the most important for their professional life. A state matriculation exam is to be introduced in the next school year.

The Teacher Education System

There is great variability in teacher education programmes in the Czech Republic, as the universities are quite autonomous and there are no national frameworks, except for recommendations concerning the content of the programmes.

Initial Teacher Education (pre-service education)

According to the Ministry of Education, Youth and Sports of the Czech Republic, teachers for the primary level usually have a four- or five-year Master's degree from the faculty of education. Mathematics is among the core subjects in this teacher education programme. As mentioned above, teachers at the primary level are generalists, whereas teachers at the lower and upper secondary level are specialists, usually in two subjects. To be a teacher at the secondary level requires a five-year Master's degree, often based on a subject oriented Bachelor's degree. At the Master level the courses are usually more focused on the pedagogical aspect. Training is also provided by the faculty of education, but teacher training at other faculties can be concurrent or consecutive (Ministry of Education, 2009).

Standards for the Quality of the Teaching Profession are currently being developed and are supposed to be implemented in the years 2012-2015. An obligatory curriculum should then be derived from the standards. At the moment the curriculum is regulated by the Accreditation Commission.

Status of the Teacher Profession

In general, the situation for teachers in the Czech Republic is difficult. They are facing much additional work with the introduction of the new curriculum; support is missing, resulting in low motivation for new developments. Teachers often feel exhausted, partly due to the fact that they are working in isolation. There is hardly any collaboration. To motivate them to adopt new ideas, all stakeholders need to come together to negotiate how their goals might be reached without putting additional workload on the teachers.

Teacher salaries are low compared to other professions requiring a university degree. Generally, it is not the high achieving students who decide to become teachers.

There are movements in the Ministry to remove unqualified teachers (15% of all teachers) from the teaching profession. A better approach might be to give these teachers opportunities to qualify themselves. In the process, teachers should be given ownership of the changes.

Teacher Professional Development-Models/Institutions

Teacher Professional Development (in-service education)

Teacher Professional Development is rather loosely regulated. The Pedagogical Workers Act states the duty of continuing further education (=TPD), but it is declared that this further education can be provided by higher education institutions and other educational facilities, or by self-education.

Generally, pedagogical staff who participate in further education are entitled to twelve working days off per academic year and the headmaster should organise further education of pedagogical staff in accordance with a plan of further education laid down after negotiations with a relevant trade union body. There are 1,064 providers of in-service teacher education programmes and courses in the Czech Republic. Money is available for TPD but at the moment it dissolves into a huge variety of small and separate projects and activities.

Compulsory TPD content is required by Regulation No. 317/2005 Sb. only for teachers in special positions like Educational Counsellor or Headmaster, or for teachers who are performing specialised, teaching method related, or management activities like ICT coordinator, school education programme coordinator, coordination of social pathology prevention etc. For these qualifications, sets of aligned courses are provided by universities, otherwise individual courses are offered by universities and other educational facilities accredited by the Ministry.

Status of Teacher Professional Development

As a coordinated system of in-service education does not exist, provision depends on local conditions and may differ from school to school. Schools are trying to arrange for mentoring and subject teaching committees on their own, and cooperation between schools is based on collegial cooperation rather than systematic support.

The success of TPD is highly dependent on school planning of TPD in connection with local networks comprising the regional schools administration, the local providers of in-service training, the local Department of Czech School Inspection and the overall teacher community, including their professional associations (association of teaching profession, associations of teachers of specific subjects – e.g. association of mathematics teachers, etc.)

There is a serious lack of systematic TPD provision for different teachers' needs, support of teacher cooperation and mentoring for new teachers. Therefore legislative and financial changes are necessary.

Moreover, it is important to see pre-service and in-service teacher education as a whole, as the continuing development of what it means to be a professional teacher. This conception of lifelong learning is also considered crucial by the Ministry.

There is a lot of current activity with respect to TPD under way in the Czech Republic. This is a crucial situation because the opportunity for sustainable changes might easily be missed and may not recur for some time. Therefore, a lot of effort should be put into promoting teacher professional development now.

The workshop participants see a chance that some ideas from the SINUS approach might be adopted in the Czech Republic. This will probably be piloted initially on a small scale (using the Pedagogical Faculties and their partner schools) to produce some evidence of its effectiveness. The approach might then be used e.g. to introduce the new standards for TPD.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

Video studies show that there is little IBST actually practised in classrooms in the Czech Republic. The workshop participants felt that teacher education students should get more experience of this type of teaching in their courses to be able to translate it into their teaching practice. It was stressed that it is really important to find out why IBST is not taking place in the classroom. Video studies might be a good way to identify typical features of IBST, analyse how classrooms operate and show good or bad practice. It is important not only to think about what is hindering IBST but also how teachers can be supported in enabling IBST to take place.

Inquiry in Teacher Education

Usually there is a mixture of approaches both in science itself and in subject didactics – some courses have theoretical and practical parts, some are experience oriented (e.g. courses *Basic measurements I –IV* in physics, field practice or biocenological[4] seminars in biology; in didactics these are experience-oriented courses of school experiments). This mixture of approaches is also found in mathematics. Teacher students learn the pedagogical and psychological background of IBST, and they study and practice didactical techniques that will help them to introduce IBST in class, but not to a sufficient extent. The mentoring of new teachers is necessary to support their readiness and willingness to adopt inquiry-based teaching.

Curricular reform and teacher training (USB)

The reform of the education system is currently being completed and the goal is an increase in the independence and competencies of schools and teachers (Bilek et al., 2007). The basic document determining the goals and the content of the curriculum is the Framework Educational Programme (Jerabek, Krckova & Slejskova 2007, Jerabek, Tupy 2007). Previously the education system divided science education into distinct subjects, more recently there is an effort for the integration of subjects or at least several themes (Smidl, 2007; Bilek, Rychtera & Slaby 2008b). It is thus necessary to prepare future teachers for this new situation, and to consider what can be done for in-service teachers.

in the Czech Republic, teacher education is provided by universities. The content of the education is determined by universities or by their accreditation committees. At the national level it is determined only at a general level (Collective, 2007). The provision of quality teachers depends on the status of the teaching profession as high status equates to the provision of adequate numbers of high-quality teachers.

Traditionally preparation of subject-specialist pre-service teachers has been emphasised over pedagogical or instructional preparation. Professional development of science teachers is also discussed at the level of individual subjects (biology, chemistry, physics, and mathematics). There has been a search for optimal models of teacher education (Svec 1999; Nezvalova et al. 2007, Nezvalova 2008; Trna 2005). Individual education institutions providing science teacher education proceed in similar ways, although they may emphasise different elements of teacher education (Svecova, Horychova 2007).

The most urgent problem among individual science disciplines is the problem of preparing biology and/or natural history teachers. Papacek (2006) identifies two main reasons: a) biology is more

[4] The study of ecological communities and of interactions among their members

closely related to the ordinary lives of people and to society as bio-technology and b) its content is not circumscribed as biology teachers have more freedom to teach different topics. Even though we focus on biology here, the situation is similar in other disciplines.

Biology (as with other subjects) is often understood by students as facts to be memorised in a static way rather than as a process of discovery and current methods of biology instruction confirm this belief. Yet current biology is a discipline with an integrative character, for example, the study of organisms and their functional subsystems uses mathematical, physical and chemical methods. Additionally the rapid expansion of molecular biology, genetics, genomics, evolutionary biology, sub-ecological disciplines and mathematical biology, significant interdisciplinary scientific domains are being formed, e.g. biodiversity, biocomplexity and integrative biology, where mathematical verification of results has become a necessity. These changes in biology as a scientific discipline, and the exponential growth of biological knowledge mean that the curriculum and teachers' content knowledge has to be continually renewed through lifelong education.

Didactics should then contribute to: (i) continuing progress in the conception of professional education (ii) the choice of content for innovative studies (iii) how to transpose new knowledge, trends and methodical procedures (iv) the development of evaluation mechanisms (Papacek 2005).

Universities in the Czech Republic unfortunately pay less attention to courses of biology teaching than to those of biology studies. However, teaching courses should be subject to proper demands for quality and rigour, and in addition to lifelong education and the practice of teachers, require more distinctive evaluation. The efficiency of several evaluation tools has been studied by e.g. Cizkova & Bednarova (2005).

Didactics of biology as a domain of an interdisciplinary character is now in a difficult or even critical situation: (i) as yet, PhD studies have not been accredited at universities in the Czech Republic, (ii) publications focus only on practical problems of instruction, monitoring of empirical phenomena or comparison of textbooks, (iii) almost only Czech-Slovakian forums are a communication platform, (iv) the representatives of the domain have been trying to redefine its concept for a long time (Papacek 2006).

The quest for new forms of instruction and improved biology teacher education is not restricted to the local level, but can be placed in an international context (Markkola, 1997; Souter& Gray 2000; Yournes, 2000; Sundberg, 2002; Svecova, 2005). This has led to efforts by several institutions to accredit PhD studies in biology didactics. The most recent initiative by the consortium of faculties of the University of South Bohemia and Charles University has been assessed by the relevant accreditation committee.

Denmark

The Education System

Basic Structure of Schooling

According to the Danish Ministry of Education, compulsory education in Denmark includes both one year of kindergarten or pre-primary education and nine years of basic education, in Denmark named Folkeskolen, which equals primary education (grades 1-6) and lower secondary education (grades 7–9). Most institutions offering basic education also offer a voluntary 10th grade. Children start their basic education at the age of seven. The curriculum is comprised of three subject blocks: The humanities, practical/art subjects and science. The science block consists of mathematics (all pupils), science/technology (1st to 6th grade), geography (7th to 9th grade), biology (7th to 9th grade) and physics/chemistry (7th to 9th grade) (Eurydice 2009).

After the 9th or 10th grade pupils can choose to continue with upper secondary education. General upper secondary education is divided into four programmes, three 3-year programmes for pupils with nine years of basic schooling and one 2-year programme for pupils with ten years of basic schooling (Eurydice 2009). One of the core subjects studied at different stages of general upper secondary education is science.

The following link gives a chart picturing the Danish educational system: http://www.dr-bongardt.de/uni/bongardt/archiv/projekte/schule_in_europa/organigram/Danmark.gif

Information about Quality

In the PISA 2006 assessment of scientific literacy, students in Denmark performed within the OECD average (496 score points). Boys reached significantly higher values (by 9 score points) than girls. The amount of students at or below proficiency level 1 (thus showing a weak performance in science) is slightly lower than the OECD average. There are, however, significantly less students at proficiency levels 5 and 6 (6.8 % compared to an OECD average of 9 %), which means that there are comparatively fewer high performing students in Denmark.

The Teacher Education System

Initial Teacher Education (pre-service education)

According to the Eurydice national summary on the educational system in Denmark (Eurydice, 2009), teachers practicing at the Folkeskole (grades 1-9) complete a four-year degree at a university college. A reform of the qualification programme for teachers in primary and lower secondary school, which took effect in the academic year 2007/08, recommended that teachers at this level should concentrate on two or three main subjects (Ibid). According to the Eurydice summary “the reform also entails a general strengthening of the natural sciences, a general strengthening of the didactic training, tighter admission requirements and compulsory attendance during the first year”.

To teach in upper secondary school requires a Master's degree. Teachers at this level specialise in one or more subjects, and they undergo a specially organised postgraduate teacher-training course, which has to be completed in parallel with teaching and takes one year to complete (Eurydice 2009).

Teacher Professional Development (in-service education)

According to the Danish S-TEAM partners it is up to the individual school to decide how much in-service education each teacher can or should follow. There is no central budget for in-service training, which means that each school has to finance it by itself.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

Aspects of IBST are present in science education in Denmark, but it is not an explicit part of this education and it is therefore difficult to entangle IBST from other parts of this education. Questions about inquiry in the school curriculum are therefore difficult to answer and the presence of inquiry in school seems to depend to a great extent on the individual teacher, and his/her chosen teaching methods.

Inquiry in Teacher Education

This differs between the eight university colleges offering teacher education, as no standard curriculum exists. Practical work is however a central part of the curriculum, but this is not explicitly addressed as IBST.

England

Education System

Basic Structure of Schooling

Compulsory education in England is divided into four key stages (KS) (see table below). The first one includes grade one and two, for pupils aged 5-7. The second key stage includes grade 3 through 6 (age 7-11), and the third key stage includes grades 7-9 (age 11-14). In the first KS pupils are subject to national tests and tasks in English and mathematics. In KS 2 and 3, national tests are arranged for the subjects English, mathematics and science. In 10th grade some pupils take their General Certificate of Secondary Education (GCSE), but most pupils take GCSEs or other national qualifications in the 11th grade. From the age of 16 pupils may attend post-compulsory education.

According to the University of Bristol, science is taught generally at KS3 and distinctly at KS4 and A-levels. Science is a part of a comprehensive educational model up to the age of 16. Specialization starts in year 12, i.e. the first year of post-compulsory education.

Table: The Education system in England (Source: University of Bristol (Mind the Gap-project))

Age	**Stage**	**Year**	**Test/Qualifications**
3-4 **4-5**	Foundations	Reception	n/a
5-6 **6-7**	Key Stage 1	Year 1 Year 2	National tests and tasks in English and mathematics
7-8 **8-9** **9-10** **10-11**	Key Stage 2	Year 3 Year 4 Year 5 Year 6	National tests in English, mathematics and science
11-12 **12-13** **13-14**	Key Stage 3	Year 7 Year 8 Year 9	National tests in English, mathematics and science
14-15 **15-16**	Key Stage 4	Year 10 Year 11	Some children take GCSEs Most children take GCSEs or other national qualifications
16-17 **17-18** **18-19**	Post-compulsory education/or training	Year 12 (College year 1) Year 13 (College year 2)	Learning programmes leading to general, vocationally-related and occupational qualifications for example A-level, vocational A level, NVQ, modern apprenticeship

The following link gives a chart picturing the educational system in England: http://www.dr-bongardt.de/uni/bongardt/archiv/projekte/schule_in_europa/staaten/england.htm.

Information about Quality

The mean competency value in the PISA 2006 assessment of scientific literacy of students in England is 516 score points which is significantly above the OECD average and comparable to the result in Germany. Boys significantly outperform girls by 11 score points. Compared to the OECD average there are fewer students at proficiency level 1 or below (low performers) and more students at proficiency levels 5 and 6 (high performers).

The Teacher Education System

Teacher education in England is provided according to the key stages which the students want to teach. According to the Training and Development Agency for Schools[5] (TDA), every teacher trains to teach at least two key stages.

Initial Teacher Education (pre-service education)

Students who want to be a primary teacher, i.e. to work with children between age 3 and 11, will train to teach all the national curriculum subjects. According to the TDA "primary school teachers are expected to demonstrate a sound, basic knowledge of all the subjects in the curriculum for key stages 1 and 2. A degree is required, though not in a specialised subject".

Table: National curriculum subjects for key stages 1 and 2

Status	Subject
Core subject	English
	Maths
	Science
Non-core foundation subjects	Design and technology (D&T)
	Information and communications technology (ICT)
	History
	Geography
	Modern foreign languages (MFL)
	Art and design
	Music
	Physical education

Source: TDA

Teachers at the secondary level, that is teachers at key stages 3 and 4 as well as at the post-compulsory levels, specialise in teaching one or two subjects from the national curriculum. These students should have a degree relevant to the subject they want to teach. The TDA offers a list of examples of the way the degree subjects can relate to the curriculum:

[5] http://www.tda.gov.uk/

Table: Degree discipline according to curriculum subject

National curriculum subject	Degree discipline
Design and Technology (D&T)	Food science, engineering, electronics, home economics, product design, textiles, jewellery and metalwork.
Information and communications technology (ICT)	Computer science, ICT.
Mathematics	Economics, mathematics, statistics and accountancy.
Modern foreign languages (MFL)	Welsh, French, German, Italian, Spanish, Portuguese, Polish, Chinese, Japanese, Arabic, Bengali, Gujarati, Punjabi, Biblical Hebrew and other European languages.
Music	Performance studies.
Science subjects	Biology, marine biology, sports science, environmental science, chemistry, physics and chemical engineering.
Religious education (RE)	Anthropology, citizenship, cultural studies, philosophy, theology, Jewish studies.

Source: TDA

There are several ways of becoming a teacher in England. Firstly, students can train to be a teacher by completing a Bachelor of Education or a Bachelor of Arts or Science with qualified teacher status (QTS). Secondly those who already have a (subject) degree can train to be a teacher by obtaining a postgraduate certificate in education or by attending school-centred initial teacher training. In addition to these "traditional" forms of teacher education, people can train to be a teacher through employment-based teacher training or assessment-based teacher training (TDA).

Status of Teacher Professional Development

(Note: due to the complexity of the English system, and the high profile of the relevant government agencies, the English National workshop will take place in April 2010, after which this section will be updated)

Lipowski & Seidel (2009) summarise the professional development situation in England as follows:

Lots of opportunities for teachers for PD:

- Culture for Professional development
- Long tradition of activity based science teaching
- Close cooperation between science learning centers and universities
- PD is semi-compulsory
- Majority of courses are single day sessions

Main problems:

- Large number of institutions which offer PD -> difficult for teachers to choose
- In-service-training is mostly based on the short term model
- Strong focus on content rather than practical work
- Very assessment driven culture in UK
- Very content driven curriculum

Shaping in-service professional development for dialogic education

Any initiative on teacher professional development, especially for in-service practitioners must consider the continuing professional development (CPD) context in which it will be implemented. Since 2005, the main push in in-service teacher training in England has been provided by the Regional Science Learning Centres, which are spread across England, and the National Science Learning Centre, (http://www.sciencelearningcentres.org.uk) based in York in the North of England (Ametller et al., 2006)

Science learning centres are a national network for professional development in science teaching. The centres support teachers in enhancing their professional skills by learning more about contemporary scientific ideas and in experimenting with effective teaching approaches and gaining experience of modern scientific techniques. The National and Regional centres are based on a cascade model (Gilpin, 1997; Hayes, 2000), which we think would be useful for an in-service professional development initiative in dialogic education.

An aspect of teacher training courses that has been seen to be effective in the development of complex skills is the use of video recording of classroom practice (Brophy, 2004) and the use of video material has become commonplace in professional development material in England, e.g., Interactive Teaching Project (Scott et al, 2007). This material uses excerpts from classroom practice and teachers' comments on the use of dialogic and authoritative communicative approaches in the teaching of particular science topics.

Research on the user of this type of material suggests it can be effective (Giza et al, 2008). Reflection on the teachers' own practice achieves higher levels when lead by video recordings of their own practice as compared to others' practice (Rosaen et al., 2008). Such reflection must be part of any professional development programme that aims at changing aspects of the teaching, as entrenched in personal beliefs (Desimone, 2009), as the use of discourse in the classroom.

Therefore, the use of video in professional development resonates strongly with the idea of dialogic education. Any programme of in-service teacher training in this area will probably benefit from an intensive use of video material, both exemplary and from the participant teachers, in order to introduce and reflect about the discursive practices in an environment prone to dialogic engagement.

Professional development initiatives in connection to dialogic teaching

Teachers´ professional development in science education, both pre- and in-service, has paid little attention to dialogic teaching and the aspects related to the use of classroom discourse. Furthermore we have found few teacher training initiatives in the literature focusing on the issue of classroom discourse in science teaching. Nevertheless the importance of communication in defining good practice is more widely accepted now and there are a large number of programmes that provide insights on the shaping of such courses. We present here two different lines of interest for dialogic education.

Professional development on argumentation in science classrooms

Argumentation is one of the aspects of discourse in science classrooms that has received more attention in research, especially since the seminal paper by Driver and colleagues (2000), and has, on the whole, dealt with the study of the use of argumentation in the classroom and of ways to improve it (Osborne et al., 2001). However, much less has been done in relation to the teacher training needed to equip practitioners with the necessary tools to face this endeavour.

The conceptualisation of argumentation of some authors (see for instance Zohar & Nemet, 2002) does align with a cognitive perspective of learning and hence does not easily fit with the socio-cultural perspective of dialogic education. As Sadler (2006) argues:

"Viewed from this framework [sociocultural perspective] argumentation is no longer just the expression of reasoning, which implies that reasoning is the significant process and argumentation is just a reporting mechanism. In a sociocultural framework, argumentation assumes a fundamental position in the collective process of making meaning and affecting learning." (p. 325)

The research in this latter perspective presents many points of contact with dialogic education and, hence, the insights coming from professional development initiatives to improve teachers' use of argumentation are very useful when approaching the professional development on dialogic teaching.

Although argumentation is already part of the curriculum of many teacher training programmes, we suspect that in most cases these courses focus on formal aspects of argumentation rather than on helping teachers develop a mastery of its discursive use. Furthermore there are few examples in the literature where these courses are clearly presented and/or researched. Two exceptions to this rule are the material IDEAS (Osborne et al., 2004) and the research by Sadler (2006) on pre-service teacher training.

Professional development on the use of communicative approaches

Argumentation shares some characteristics with dialogic education. A perspective more centrally related to dialogic education and the subject of research and development on teacher training is the idea of communicative approaches (Mortimer and Scott, 2003).

The use of this concept in connection to teacher development started with EPSE (Millar et al., 2006). A similar approach was used in the Interactive Teaching project (Scott et al., 2007) with exemplary classroom videos complementing the written material. Nevertheless the impact of this material has not been yet assessed.

Jouni Viiri and colleagues have worked on pre-service courses for science teachers that have as one of their main foci the use of communicative approaches to plan and analyse the teachers' own practice. Their research (Viiri and Saari, 2006; Lehesvuori et al., unpublished manuscript) suggest that teachers benefited from the use of this concept and pointed to the importance of being able to analyse more experienced teachers' talk with this tool. Furthermore it coincided with Sadler (2006) on the fact that changes in teachers' discourse take time.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

According to the University of Bristol[6] inquiry has been integrated in the national curriculum. For key stage 3, the national curriculum addresses the importance of science education and learning goals using IBST: The study of science fires pupils' curiosity about phenomena in the world around them

[6] The information is collected by the EU financed research project "Mind the Gap", coordinated by the University of Oslo. See Lipowski & Seidel (2009).

and offers opportunities to find explanations. It engages learners at many levels, linking direct practical experience with scientific ideas (problem based learning). Experimentation and modelling are used to develop and evaluate explanations, encouraging critical and creative thought (hands-on activities). Pupils learn how knowledge and understanding in science are rooted in evidence. They discover how scientific ideas contribute to technological change – affecting industry, business and medicine and improving quality of life. They trace the development of science worldwide and recognise its cultural significance. They learn to question and discuss issues that may affect their own lives, the directions of societies and the future of the world (argumentation and communication).

More specifically, Key Stage 3 curriculum requires pupils to have:
1) Practical and enquiry skills
Pupils should be able to use a range of scientific methods and techniques to develop and test ideas and explanations [problem based learning]; assess risk and work safely in the laboratory, field and workplace; plan and carry out practical and investigative activities, both individually and in groups (hands-on activities).

2) Critical understanding of evidence
Pupils should be able to obtain record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations; evaluate scientific evidence and working methods [hands-on activities].

3) Communication
Pupils should be able to use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues [argumentation and communication].

Inquiry in Teacher Education

There are undoubtedly some CPD courses available in inquiry[7], and there is also a framework (Chartered Science Teacher) to encourage teachers to engage in professional development in science[8], although this is optional. What appears to be lacking is a systematic professional development framework for enabling teachers to apply inquiry-based methods within the current curriculum and assessment regime.

[7] Known as 'enquiry' or 'investigation' in e.g. the TDA database of professional development courses: http://www.tda.gov.uk/teachers/continuingprofessionaldevelopment/find_cpd.aspx
[8] http://www.ase.org.uk/htm/cpd_services/csciteach/index.php

Estonia

Education System

Basic Structure of Schooling

In Estonia compulsory or basic education is provided between the ages of 7-15/16. Those who do no not manage to acquire basic education during this period are obliged to study up to the age of 17 (Eurydice 2009). Compulsory (basic) education includes both primary education (grades 1-6) and lower secondary education (grades 7-9). Upper secondary school covers grades 10-12.

Estonia has a uniform curriculum for all levels of education. All pupils have science throughout schooling (grades 1-12). At the primary level science is taught as an integrated subject. From grade 7 onwards, this changes to science subject studies, beginning with biology and geography and introducing physics and chemistry at grade 8. At the upper secondary level pupils have to take one course in chemistry, 5 in physics, 4-5 in biology and 4-5 in mathematics.

In 2010 the government is suggesting the establishment of separate upper secondary schools (Gymnasiums) throughout the country. It is feared that this might impede the access of students from rural areas to upper secondary education. Moreover, a new school law is proposed that will reduce the number of obligatory subjects at Gymnasium level.

The subjects of the national final school leaving examinations (at upper secondary level) are chosen by the students. They need to take 5 exams with only the mother tongue as obligatory. 70% of Estonian students chose the academic line (compared to vocational lines).

The workshop participants felt that state exams are the best way to dictate teaching – they influence content and teaching methods far more than national curricula. Teaching to the state exams is very dominant in Estonia since the quality of a teacher is measured in terms of how many of his/her students pass the exam (league tables).

The following link gives a chart picturing the Estonian educational system: http://www.hanse-parlament.eu/mediabig/372A.pdf.

Information about Quality

Estonian pupils did well in the international studies TIMSS 2003 and PISA 2006. Estonian students reach a mean competency value of 531 points in the PISA 2006 science assessment, which is comparable to Canada and Japan and places them within the internationally top performing countries. The number of pupils at or below level 1 in PISA is very low, well below the OECD average – next only to Finland. Compared to this very low percentage, the number of pupils at levels 5 and 6 is, however, also comparatively low – although it is still well above the OECD average. No significant gender difference is observed. Estonian pupils and teachers have a positive attitude towards schooling, and it is said that education is the national religion in Estonia. On the other hand comparative data show that Estonian pupils do not enjoy science and feel pressured by schoolwork.

The Teacher Education System

The Estonian S-TEAM partners report that the Estonian teacher education for all school levels consists of three parts: general studies; special studies; and general studies in educational science, psychological and didactic studies and practical training. The studies build on “framework requirements of teachers’ training” from the year 2000.

Initial Teacher Education (pre-service education)

There are two types of teacher education programmes in Estonia, class teacher education for those wanting to practice in grades 1-6, and subject teacher education for teachers practicing in lower and upper secondary school. In the former, professional and educational studies take place concurrently. This programme leads to a Master’s degree equalling 300 ECTS with education as a major. Science is included as part of this educational programme. The class teacher is qualified to teach in all subjects at grades 1-6.

The subject teacher programme leads to a Master’s degree equalling 300 ECTS as well, but with a major in the subject they will teach in school. Included in this programme are 60 ECTS of pedagogical studies.

After having achieved their Master’s degree all teacher students have to complete an apprentice year in school, also called the induction year programme (effective from 2004 on). During this year they need to put together a portfolio to be examined, in order to obtain their final teaching certificate.

Status of the Teaching Profession

It is generally accepted that the weaker students are the ones who choose teacher education in Estonia. Nevertheless, teachers in Estonia have a very high level of content knowledge. Furthermore Estonia is experiencing problems with getting enough physics and chemistry teachers at upper secondary level, as recruitment to science teacher education is low. There are even financial incentives from the government to foster science teacher recruitment.

Teacher salaries are generally not high in Estonia (below the country average). The overall working time is 35 hours a week. Officially, a full workload in front of class means that there are 18-24 working hours in a week. However, there are teachers who do not teach their full workload, and in some cases teaching may exceed 30 hours.

There is an accreditation scheme for teachers. There are five categories in the Estonian school system, namely “teachers without qualification”; “novice teacher”; “teacher”; “senior-teacher” and “teacher-methodologist”. Most teachers are at level 3 (teacher). From this level no fall back is possible. Senior teachers (level 4) get a 10-15% raise in salary. This position is given for 3-5 years, than they have to reapply. Authors of textbooks or members of exam boards can become nationally acknowledged teachers – teacher methodologist (level 5). This position is also subject to reconsiderations.

More than 20% of the science teachers in Estonia are older than 55, over 50% have teaching experience of more than 10 years. These teachers are often not very open to new approaches and methods and heavily dominate the teaching culture in schools. In the educational system, the influence of the former Soviet system is still visible.

Teacher Professional Development (in-service education)

In general, the system of TPD in Estonia is very heterogeneous and competitive. There is a competition between universities and private providers for TPD courses. Science courses, however, are provided mainly by universities. Tallinn University is a main provider of TPD courses. In theory, teachers need to accumulate 160 hours in courses every 5 years as a part of their professional development and as a prerequisite to move to another level. A minimum of 160 hours of professional training is needed to secure the occupational grade of senior teacher and teacher-methodologist. These numbers are controlled and a list of attended certified in-service courses is stored in a central database at the Ministry of Education (EHIS) for each teacher. In practice, however, this model seems to have little effect. Theoretically, 3% of the teaching staff salaries are dedicated to TPD in any type of work, but schools have been known to appropriate the money for other purposes.

Status of Teacher Professional Development

The programmes for teacher education and TPD are not very flexible in Estonia. This is problematic for teachers without a teaching qualification who want to get a teacher qualification while they are working full-time. Some of the TPD courses are held in the spring or fall break, but these are not continuous and the quality is poor.

By implementing a new teacher education strategy in 2009 the situation should improve in the future, but there is still a need for more inquiry based teaching approaches.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

The science subject syllabi (2002) mention laboratory work, discussions and science-related project work, which might be seen as 'inquiry approaches'. They list a number of inquiry activities such as "formulating hypotheses and verifying them through experiments", "making scientific observations", and "communicating with other pupils". Nevertheless, these activities are not very common in Estonian science classrooms. Additionally, the science syllabi do not emphasise the role of science in society and its relation to daily life.

New national curricula for basic and upper secondary education are to be implemented in the years 2011-2013 incorporating a list of practical science activities, laboratory work, and descriptions for their implementation. They will hopefully strengthen the use of inquiry approaches.

Inquiry in Teacher Education

There are no special regulations or detailed official recommendations specifically relating to training in scientific experimental/investigative skills for science student teachers in Estonia. Inquiry based science is represented to some extent in the teacher education programmes.

Finland

"The teacher profession in Finland has always enjoyed great public respect and appreciation (Simola, 2005). Teachers have independence in selecting the most appropriate pedagogical methods. The teacher profession, especially at primary level, is also very popular and teacher-education departments can select among the nation's best students and highest scores on university entrance examinations (Jakku-Silhvonen & Niemi, 2006)" (Lavonen and Laaksonen, 2009)

Education System

Basic Structure of Schooling

From birth to the age of 6, children can attend day care centres or the like. At the age of 6, children can attend pre-school classes in school, free of charge (Eurydice, 2009). About 90 % of 6-year-olds participate in pre-primary teaching either in day centres (80%) or in school (about 20%) . Apart from publicly provided services, the church and some voluntary organisations provide various teaching services.

Compulsory education starts at the age of 7 and lasts for nine years. All compulsory education is free of charge. Amongst the compulsory core subjects we find mathematics, physics, chemistry and biology.

Students who have successfully completed compulsory education are eligible for general and vocational upper secondary education. The National Board of Education decides on the general objectives and core content for both general and vocational upper secondary education. Based on the national core curriculum, each provider of education (i.e. municipality or other local authorities) prepares the local curriculum. The compulsory subjects in general upper secondary school include studies in mathematics and natural sciences. The core curriculum for students attending a vocational institution includes mathematics, physics and chemistry. In primary school a tendency is observed to concentrate on biology and leave out physics and chemistry when teaching integrated science.

In general, Finland has a very traditional way of teaching (teacher-centred, lecturing). This is, however, the way Finnish students want their teaching to be.

The following link gives a chart picturing the Finnish educational system: http://www.minedu.fi/export/sites/default/OPM/Koulutus/koulutusjaerjestelmae/liitteet/finnish_education.pdf.

Information about Quality

According to Lavonen and Laaksonen (2009), "Finnish students got the highest score (563 points) in the PISA 2006 scientific literacy assessment and the second lowest standard deviation (SD= score points) between all OECD countries" (the latter meaning that the difference between high and low performing students is comparably small). This study also shows that variation between schools is lowest in Finland among all OECD countries, in other words that schools are very similar in Finland (Ibid). The PISA 2006 study also indicates that Finnish student's performance profile is different from any other country profile in that the "low achievers" have a high score compared to other countries.

According to the PISA student questionnaire Finnish students almost never plan their own experiments, there is little debate in Finnish classrooms (debating is not part of the Finnish culture, it is difficult for teachers to initiate classroom discussions) and the students are not interested in learning scientific topics – the least interest is observed for inquiry activities. A multivariate regression analysis shows a negative correlation between inquiry/debate and performance.

The Teacher Education System

Finnish universities are largely free to organise their teacher education programmes as they please, but the Ministry of Education offers some national guidelines and the universities collaborate between themselves. Hence, there are only minor differences between the universities.

Prospective subject teachers are selected using the results of the matriculation examination and an entrance examination. The entrance examination has two parts: (1) a written test on the subject (referring to the national framework curriculum) and (2) an interview. The interview aims to indentify the student's social and communication skills and motivation to become a teacher. Additionally, it evaluates their perceptions of the teacher education programme.

Initial Teacher Education (pre-service education)

There are two teacher education programmes in Finland: one to become a class teacher and one to become a subject teacher. Both lead to a master's degree. The class teacher programme qualifies students for teaching in primary school at grades 1-6 (i.e. pupils 7-12 years old). Hence, it appears as if the class teacher students study nearly all of the subjects taught in primary school. Through the subject teacher programme students are qualified for teaching at grades 7-9 (pupils 12-16 years old) in lower secondary school and at grades 10-12 (pupils 16-19 years old) in upper secondary school. Subject teachers typically have one major and one minor subject. Additionally, subject teachers have some courses that make a connection between subject and pedagogy and they try to show the difference between, for instance, physics as a science and physics as a school subject.

Class teacher education is organised at the department of teacher education in all universities. The structure of a master's degree of a class teacher is quite similar to the structure of the degree of the subject teacher (see below). From the 140 credit points (cp.) allocated to education as a main subject, 50 cp. can be considered as studies of the actual knowledge base like understanding of the cultural, psychological and pedagogical features of teaching and instruction. As much as 70 cp. are used for methodological studies. It is important that student teachers study quantitative, qualitative and mixed methods to create a proper understanding of methodological issues in pedagogical studies. A class teacher student carries out a master's thesis (M.A.) of 40 cp. during these studies. Conducting a research process of one's own improves the relationship between the theoretical knowledge base and practice, as well as bringing the perspective of a reflective practitioner-researcher to teachers' everyday work. In addition to the major studies in education, the class teacher programme includes 60 credit points of subsidiary subject studies. Within these 60 credit points, 16 credits are allocated to studies in mathematics (7cp), chemistry (3 cp), biology (3 cp) and physics education (3 cp). These studies focus on the pedagogical content knowledge of these school subjects, based on previous studies in upper secondary school. In the basic courses on chemistry and physics education, the focus is on the basic concepts and principles or models in science. One of the aims within the courses is to help teacher students to understand explanatory models appropriate for school pupils on certain developmental levels. Additionally, it is important that students understand that physics and chemistry are experimental sciences with special characteristics as school subjects. The contents to be studied are e.g., Newtonian mechanics, electric circuits, chemical reactions, energy and thermodynamics as well as various skills, including laboratory and social skills. Knowledge of mathematics, chemistry and physics education is also strengthened within teaching practice modules included in the programme. Altogether 20 cp. are allocated to teaching practice during the studies.

The education of subject teachers in mathematics and science is organised in co-operation with the Faculty of Science and the Faculty of Behavioural Sciences as described in Figure 1 (Kaivola, Kärpijoki & Saarikko, 2004). Studies are divided into two parts: the subject is studied at the department of the particular subject (e.g. Physics) and the pedagogical studies at the Department of Applied Sciences of Education and in two Teacher Training Schools. These pedagogical studies give the students the qualification necessary for teaching positions in all types of schools in their major and minor subject. (Figure 1)

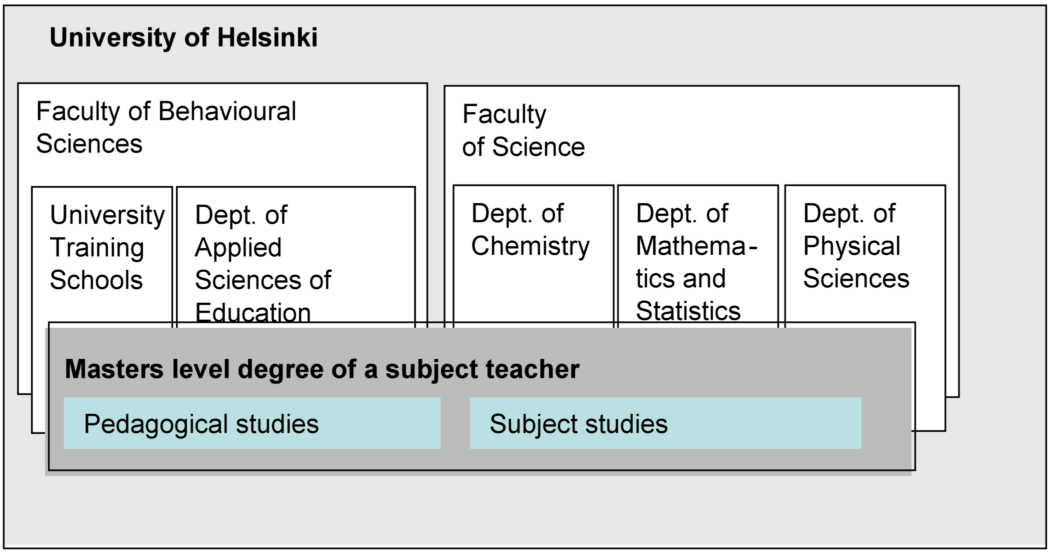


Figure 1 Organisation of subject teacher education at the University of Helsinki.

Students in subject teacher education programmes take a major and a minor in the subjects they intend to teach in school. Typical combinations in so-called 'mathematical subjects' are mathematics – physics, mathematics – chemistry, mathematics – computer science, physics – chemistry and chemistry – biology. However, the students are free to choose other combinations of subjects, like mathematics – home economics. In figure 2, a typical structure of a master's degree for a subject teacher is described and how credit points are allocated to master's and bachelor's level studies.

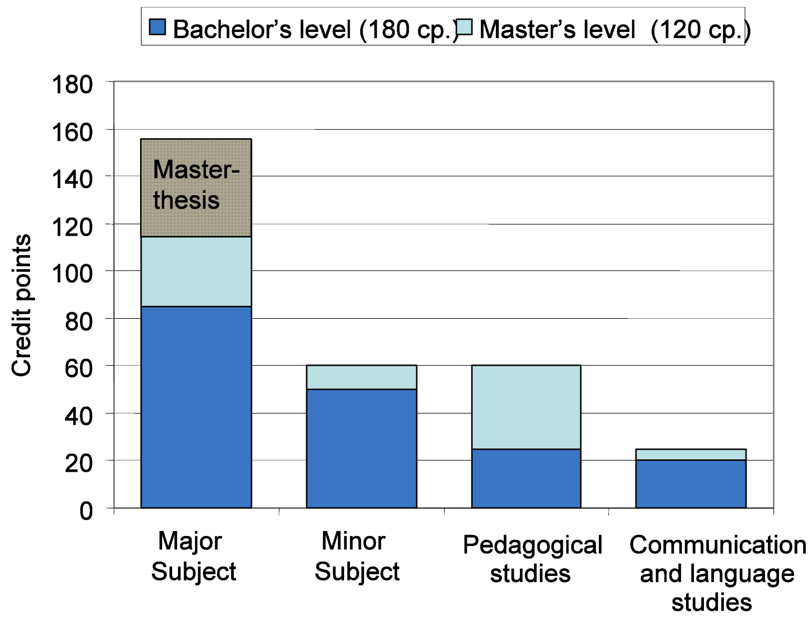


Figure 2 Typical structure of a master's degree of a subject teacher.

Basic studies in the subjects at the department of chemistry, mathematics and statistics, and physical sciences are typically the same for teacher students as for other students at bachelor's level. Special laboratory courses are included in physics and chemistry programmes. Especially at master's level, there are special courses for teacher students. The subject teacher students can choose either a pedagogical orientation, or a subject orientation for their master thesis (40 cp).

The workshop participants felt that teachers in lower secondary education do not get enough pedagogy or learning theory courses in their training.

Status of the teaching profession

According to the PISA 2006 School Questionnaire data, 97.2% of Finnish schools reported that there was no serious lack of physics, chemistry, or biology teachers (OECD average 81.9%). On average, only 10% of full-time teachers in the participating schools did not have an appropriate qualification. Consequently, in most of the schools there are highly educated and qualified teachers with an in-depth subject matter and pedagogical knowledge. Since there are no inspectors, no national evaluation of learning materials and no national assessment, teachers take much of the responsibility for pupils' learning.

Teacher autonomy is regarded as crucial by the workshop participants. Teachers should have the opportunity to decide what works best in their classrooms.

Teacher professional development (in-service education)

In the 1970s there was a reform in TPD in Finland aiming at making it more coherent. Because of some reluctance to compulsory in-service education, teacher associations offered in-service days that were accepted by the teachers. After some years the attitudes of teachers towards TPD changed. Today TPD seems to be quite well accepted.

Status of Teacher Professional Development

In Finland municipalities and local education providers are in charge of TPD. The extent to which IBST is incorporated into TPD depends on the individual provider. The list of necessary conditions for continuous learning of teachers indicates that there is already a model for TPD, at least at Helsinki University. Many of these conditions resemble features of the SINUS approach. Additionally, there are projects in Finland that use teacher networks, as in SINUS. To put it in a nutshell, there seem to be successful activities comparable to SINUS but sufficient funding for a more general use of the model is lacking. There are no centralized evaluations of TPD in Finland.

It seems as if TPD in Finland should be more informed by research in the future, although the pre-service teacher education courses are already research-based. Fields for further improvement of TPD in Finland are the pedagogical use of ICT (that means using ICT to support learning), a deeper understanding of the nature of science, and raising interest in science.

Teachers' In-Service Training in Finland

Officially, teachers have to take part in in-service training for three days per year. This is called VESO training. There are no national, regional or school directions as to what this should involve and training is very flexible and individualistic.

In 2005 among comprehensive and upper secondary school subject teachers the rate of non-participation in in-service training was 13.6% (Piesanen, Kiviniemi & Valkonen, 2007). Piesanen et al. found also that participation in in-service training had decreased between years 1998 and 2005 due to the economic constraints in municipalities, regional inequalities, teachers' attitudes, and lack of planning of in-service training. Teachers' needs for in-service training varied including curricular and subject-specific training, supporting student's efforts and preparation for working, multicultural and ICT training. Opetusministeriö (2007) highly recommends developing teachers' in-service education so that there is a systematic continuum in teacher training from the first year induction phase to follow up training during the whole teaching career.

Science Teachers' Professional Development in Finland

In Finland, there is no systematic in-service training for science teachers. It is not compulsory nor does it have any effect on salary. However, several institutions organise in-service training for science teachers supported, for example, by The National Board of Education and The National Centre for Mathematics and Natural Sciences which organises in-service teacher education courses (see http://www.helsinki.fi/luma/english/index.shtml). Thus, there is a lot of in-service training for teachers free of charge. In Finland, teachers are considered to be professionals when they actively develop their own skills and knowledge. Thus, they are assumed to participate in professional development courses, seminars, and projects

Several problems have emerged, in bridging the gap between educational research and praxes as teachers tend to express opposition to innovations suggested by researchers. In the context of the versatile use of ICT by science teachers, Lavonen, Juuti, Aksela, and Meisalo (2006) emphasise that regardless of their formal training, teachers have difficulty in integrating educational innovations into the classroom. Organising effective professional programmes for the development of education is difficult, and the questions of how to offer adequate guidance, in-service training or to facilitate the professional development of teachers are still unsolved in Finland as in other countries.

Lavonen, et al. (2006) suggest that when planning a professional development (PD) project for science teachers, facilitators should consider empowerment, communication, and finally context. On a more general level, teachers are professionals with autonomy in their work which must also be remembered in PD projects in science education.
Tobin, et al. (1994) summarise the relationships between teachers' beliefs and reform efforts: "Many of the reform attempts of the past have ignored the role of the beliefs of teachers in sustaining the status quo. The studies ... suggest that teachers' beliefs are a critical ingredient in the factors that determine what happens in classrooms." In order to make such demanding reform among teachers in Finland, Juuti, Lavonen, Aksela, and Meisalo (2009) propose that informal discussion in small groups during the coffee breakes and industrial visits were seen important by participating teachers. It can be concluded that in PD projects, there should be plenty of room for informal communication between teachers.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

The following goals for inquiry are integrated in the national core curriculum:

In grades 1-4, pupils will learn to obtain information about nature and the environment by observing, investigating and using a variety of source materials; to represent information about the environment and its phenomena by different means; and to perform simple scientific experiments.

In grades 5-6, in physics and chemistry, the pupils will learn to make observation and measurements; to weigh the reliability of the information; to make conclusions about observations and measurements and recognize the causal relationships; to carry out simple scientific experiments clarifying the properties of phenomena, as well as correlations. In biology the pupils will learn to observe and investigate outdoors.

In grades 7-9, in physics, pupils should learn scientific skills, such as the formulation of questions and the perception of problems; learn to make, compare and classify observations, measurements, and conclusions; to present and test a hypothesis; and to process, present and interpret results; they should learn to plan and carry out a scientific investigation; to formulate simple models and use them in explaining phenomena, to make generalizations, and to evaluate the reliability of the research process and results. The pupils should also learn to work and investigate natural phenomena safely together with others; and to use various graphs and algebraic models in explaining natural phenomena, making predictions and solving problems.

In chemistry the approach in grades 7-9, as in physics, is an experimental one. The starting point here is the observation and investigation of substances and phenomena associated with the living environment. The pupils' progress from that point, to the interpretation, explanation, and description of phenomena, and then to modelling both the structure of matter and chemical reactions with the symbolic language of chemistry. The pupils will learn to work safely and follow instruction; to use research methods appropriate for acquiring scientific knowledge, including information and communication technology (ICT), and evaluating the reliability and importance of knowledge. The pupils should also learn to carry out scientific investigations and to interpret and present the results.

In biology the instructional method in grades 7-9 must be inquiry-based learning to develop the pupil's thinking in the natural sciences. The pupils will get to know the principles of growing and cultivating plants and take an interest in growing plants; learn to identify species, to appreciate biodiversity and to take a positive stance towards its preservation; and they will learn to recognize environmental changes in the pupils' home region, to consider the reasons for them, and to present possible solutions to problems.

An integrated approach to bring Finnish students in contact with modern science and scientific work is to engage schools and industry, because industrial contexts can make science relevant. One of the questions is how teacher training can promote this engagement. It is perceived by the workshop participants that students should be made aware of the integrated nature of science. The pure separated subjects – as they are taught at school – no longer exist like that in "real life".

Stakeholders must be aware that there often is a conflict between what we want students to learn and looking at teachers as professionals with schools as their workplaces (e.g. teachers might need time for IBST, which they don't have because they have so many other obligations).

Inquiry in Teacher Education

At the University of Helsinki, in the subject teacher education programme, in studies of general education, student teachers are presented with the basic ideas of progressive inquiry. This introduction is on a very general level. However, examples are typically provided from the science point of view. In the physics and chemistry departments, there are courses on laboratory-based teaching and learning. In subject studies the focus is on the empirical basis of physics and chemistry concepts (guided inquiry) and during studies in education, the focus is more on open inquiry. In mathematics education courses the emphasis is on problem solving in mathematics learning.

France

The Education System

Basic Structure of Schooling

Education is compulsory between the age of 6 and 16. From the age of 6-11 pupils attend primary education and from the age 11-15 they attend lower secondary education (Eurydice 2009). The primary school curriculum concentrates to a large extent on the basic skills of reading, writing and arithmetic.

At the age of 15, students can start upper secondary education for three years. Mathematics and physics or chemistry and life and earth sciences are among the core subjects in the first year of upper secondary education.

The following link gives a chart picturing the French educational system: http://en.wikipedia.org/wiki/File:EducationFr.svg.

Information about Quality

In the PISA 2006 assessment of scientific literacy, students in France performed within the OECD average (495 score points). No significant gender difference in science performance was observed. Compared to the OECD average there are slightly more students at proficiency level 1 or below (low performers) and slightly less students at proficiency levels 5 and 6 (high performers).

The Teacher Education System

Initial Teacher Education (pre-service education)

To enter pre-service teacher education in France requires a three-year university diploma in the relevant subject, in this case in a scientific discipline or in mathematics. The teacher education then follows a two-year programme so that every teacher has a five-year university degree. This is the same for all teacher education programmes. The content of the training is however different for primary teacher education and secondary teacher education, only some of the courses are in common, for instance courses on the educational system.

Status of the Teaching Profession

It can be said that being a mathematics teachers has a certain prestige to it, as mathematics is seen as a key subject for those pupils wanting a prestigious career. As for science teachers, their status is not quite as elevated.

There is no lack in the supply of secondary science teachers but in primary schools most of the teachers have their degree in human sciences or French language/literature. The majority (60%) of young teachers (<30 years) at the secondary level are female.

Teacher Professional Development (in-service education)

Teacher professional development is compulsory for primary school teachers and voluntary for secondary school teachers. Each year a list of the possible training activities in a given region is published, and the teachers register for these activities. A typical activity is a two-day workshop. The number of TPD programmes is, however, very low compared to the number of teachers, and an essential prerequisite to support continuous learning in the teaching profession is having enough TPD programmes to offer.

Status of Teacher Professional Development

The French S-TEAM partners reported that it is necessary to improve the way France implements TPD, but they did not specify how this should be done.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

There is an inquiry and ICT oriented mathematics test in the Baccalauréat (examination taken at the end of upper secondary school), but this has not yet been made compulsory.

Inquiry in Teacher Education

The official curriculum proposes something similar to inquiry based science. Inquiry based mathematics is not represented in the teacher education programmes at the moment, but changes are currently under development. The French S-TEAM partners also report that the use of IBST in teacher education may vary according to the local teacher education programmes.

Germany

Education System

Germany consists of 16 federal states (*Länder*), which are in charge of their own education systems. Thus, Germany has 16 more or less different school systems. Whereas the structure of the individual systems was quite comparable up until the 1970s, it started to be more complex when the comprehensive school was added to the three already existing types of schools (Hauptschule, Realschule, Gymnasium) in some of the federal states. Reforms within the last 10 years have subsequently led to some diversity. Agreements between the federal states and the Federal Ministry of Education ensure that despite differing regulations, examinations and certificates are recognised between the federal states in order to allow people to move freely within the whole country.

Basic Structure of Schooling

Pre-school education in kindergarten is offered from age 3 to 6 and has to be paid by the parents. There are public as well as private institutions. Sometimes, the third year of kindergarten is organised as a pre-school year shifting activities from playing to learning.

Compulsory school lasts for nine years ranging from age 6 to 15. Primary education runs from grade 1 to 4 (in two federal states to grade 6). Core subjects are language, mathematics and – as an integrated subject – social and natural sciences (Sachunterricht). Lower secondary education comprises grades 4 to 9 or 10. Core subjects are mother tongue, a foreign language and mathematics. The sciences are obligatory, mostly taught as individual subjects (biology, physics and chemistry) but regarded as minor subjects.

After finishing primary school the pupils are distributed to different types of schools having different curricula, leading to different school leaving certificates and different career choices. The transition to the respective school type should depend on the performance of the pupils. In half of the federal states the decision follows the recommendation of the school, in the other half the parents decide.

On average, about 20% of German pupils join Hauptschule ranging from 0 to more than 30% in the different federal states. This proportion has been decreasing for more than 50 years. Science topics are mainly from biology and physics. On finishing Hauptschule after grade 9 (some federal states have an optional 10th grade) with sufficient marks, pupils get a leaving certificate that allows them to apply for vocational training in less prestigious professions.

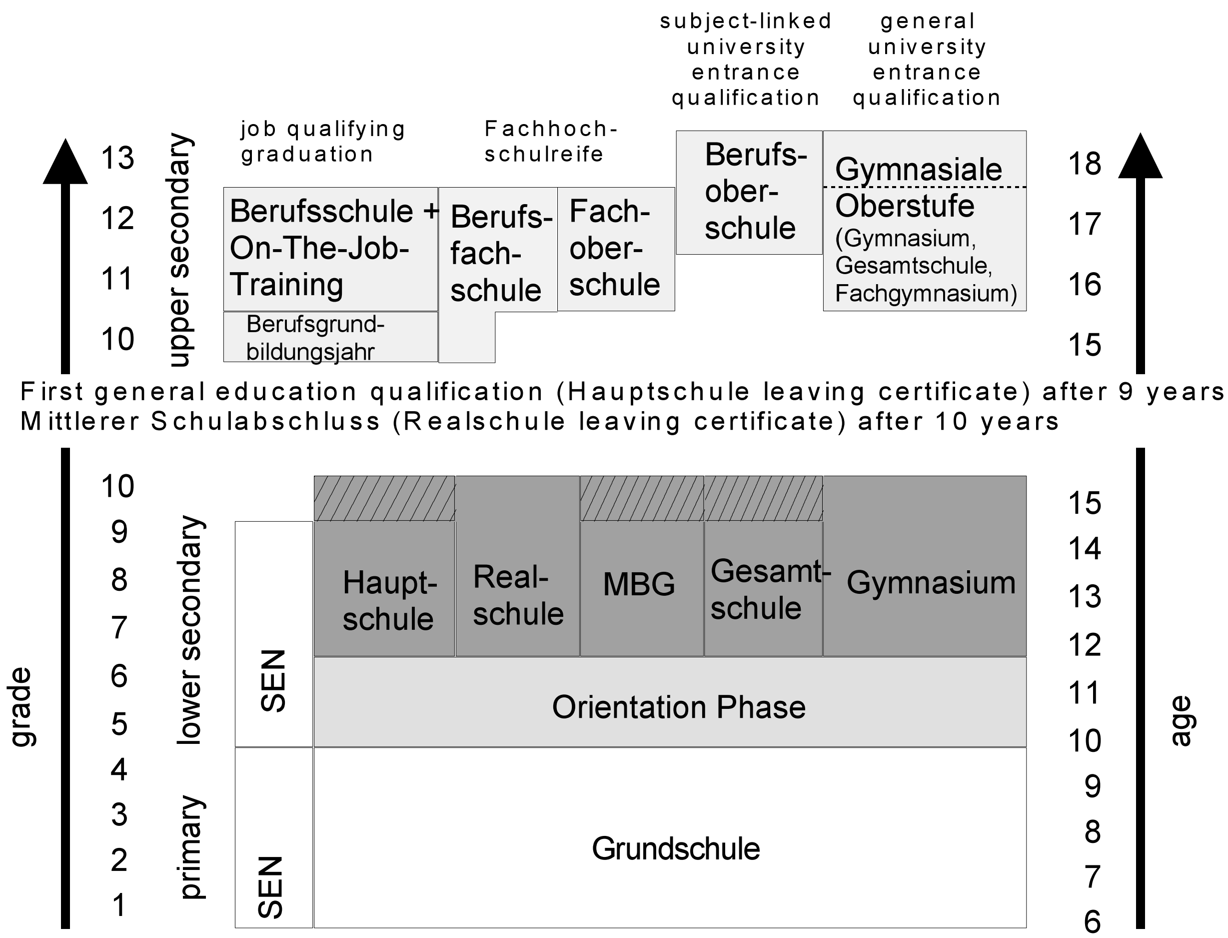
On average roughly 30% of the pupils go to Realschule. This proportion has been quite stable since the 1980s. Compared to Hauptschule more lesson time is devoted to science subjects. The leaving certificate after grade 10 allows for applying for more prestigious jobs.

The Gymnasium is the only secondary school type present in all 16 federal states. Around 35% of the pupils in Germany go to Gymnasium. During the last 50 years this proportion has more than doubled. Attending a Gymnasium is the most promising way to move on to higher education and academic careers. By now, all federal states offer the certificate of this school track (Abitur) after 12 years of schooling (formerly 13 years). It allows pupils to move to higher education and especially to universities. Science subjects are compulsory throughout the lower secondary level. At upper secondary level it is possible to choose between biology, chemistry and physics.

About 16% of the students enter secondary schools offering more than one of the above-mentioned certificates or having several tracks in one institution. In some of those, Abitur can be achieved after 13 years of schooling.

Theoretically, there exists the possibility to move between the different school tracks. Reality however, shows that transfers are mainly directed downwards towards less prestigious school types.

Fig.1 The German Educational System



Information about Quality

In the first PISA survey in 2000, German students performed within or even below the OECD average, which was far worse than expected and caused a lot of uproar and discussion at the public as well as at the policy level. In subsequent years, various actions were taken, e.g. a trend towards more centralised examinations.

For a long time, the development of examinations was the responsibility of individual teachers in most federal states. In recent years there has been a trend towards more centralised examinations. Additionally, the federal states agreed to implement and assess a system of national educational standards for mother language, foreign language, mathematics and the sciences. The first standards have been implemented since 2003 and assessments focus on three stages during schooling: grade 4 at the end of primary school, grade 9/10 towards the end of compulsory school. Standards for the upper secondary level are being developed.

In the PISA 2006 assessment of scientific literacy, students in Germany reached a mean competency value of 516 points, which was significantly above the OECD average and a significant improvement compared to previous PISA cycles. There is no statistically significant difference between boys and girls in science performance.

The Teacher Education System

Initial Teacher Education (pre-service education)

Universities and colleges are in charge of initial teacher education in Germany following guidelines of the individual federal state. Pre-service education is undergoing substantial changes at the moment due to the Bologna process. Study programmes differ between school types. The traditional system offers independent teacher studies which include pedagogical and subject studies in differing proportions depending on the type of school. The extent of pedagogical studies diminishes from primary school towards Gymnasium. After four years of studying students have to pass a state examination. The following second phase of teacher education (induction phase) takes place at schools and so-called ‘seminars’ for two years and concludes with a second state examination.

Many federal states have moved to the BA/MA system or are in a transition state. All new courses have to be accredited by one of 10 independent agencies to make sure that their structure and content “meets common and subject specific standards”. There is a tendency towards the 3+2 model. Some federal states offer a common BA, some a BA that aims at a subsequent MEd only. The two years of induction are retained.

Fig.2 Content of teacher studies (the example is from Hessen)

level or school type	**content**	**also qualifies for**
primary/Grundschule	pedagogy and social sciences, language, mathematics, fine arts, sports and one additional subject (including subject didactics)	grades 5 and 6 in all secondary schools in the subjects studied
Haupt-/Realschule	pedagogy and social sciences, two subjects	lower secondary level (grades 5-10) at Gymnasium
Gymnasium	two subjects plus pedagogy and social sciences	Haupt- and Realschule

Programme of educational studies at the University of Kiel (Gymnasium)

Semester	Topic	CP/ECTS
1	philosophy and education or sociology for prospective teachers	5
2	teaching and learning I	5
3	pedagogical practical	5
4	basic didactics	5
5	didactical practical	10
7/8	teaching and learning II	10
8	practical	5
8/9	psychology of teaching and learning	10

There are common complaints that pedagogical studies do not relate to subject studies for secondary teachers. Additionally, the induction phase is often experienced as a praxis shock. Sometimes prospective teachers are even told to forget everything they learned at university and adapt to reality at school.

Status of the teaching profession

The status of teachers in Germany is generally high. They earn good salaries (esp. teachers at Gymnasium) and are hired as public servants, which means that they have a secure post once they are employed in a school. These conditions are sometimes said to favour less able students joining the profession. On the other hand, there are studies indicating that teachers are highly motivated towards working with young people, hold high ideals and are very enthusiastic.

Teacher professional development (in-service education)

The federal states have institutes for school and teacher education at their ministries of education. Their tasks are to support and monitor the quality of schools in all respects. One task is offering TPD, which is mostly free of charge. Universities, associations and private institutions are providing TPD as well.

In general, TPD is mandatory in Germany. However, in many of the federal states the teachers decide on how and when they do something for it (for instance, read a book). In addition, even federal states which specify a set number of TPD courses do not impose sanctions on teachers who are unwilling to participate.

Status of Teacher Professional Development

The courses are mainly short (a few hours on afternoons up to one day) and focus on the update of subject knowledge, the implementation of new regulations or teaching methods. The offerings for science teachers are seen as neither sufficient nor adequate. Some of the federal states are running long-term courses, which are in part derived from the SINUS programme.

Besides SINUS there have been a few other large-scale TPD programmes in Germany, which were jointly financed by the Federal Ministry of Education and the federal states. Due to a change in the constitution such initiatives are no longer possible because the federal government lost its responsibility for education.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

Germany has no national curriculum. At least there are 16 (federal states) x 4 (school types) curricula. Some of them are quite traditional, i.e. they prescribe in great detail the content, experiments and the methods of science lessons at each grade level. Sometimes influenced by SINUS, but more by the national educational standards, curricula are currently changing towards a competency orientation. Since epistemological questions (how knowledge in science is developed), communication and assessment of scientific knowledge are three of the four competence areas, many aspects of inquiry-based teaching have entered these new curricula.

However, classroom reality has still to follow the changes in the curricula and there seems to be a lack of support for teachers to adopt and develop the required teaching style. Many teachers cite the need to cover overcrowded curricula as a barrier to introducing inquiry-based methods.

In Germany there are more than 200 pupil laboratories, mostly at universities but also at research institutions and major companies. They offer pupils from all ages – in groups or as a whole class – the possibility to visit an authentic environment and conduct experiments. In some of them, pupils are conducting real research.

Inquiry in Teacher Education

In initial teacher education seminars and practical trainings about experiments in schools are included. Inquiry may also be a topic of didactical courses. Yet, courses on inquiry teaching are supposedly rare.

Israel

Education System

Basic Structure of Schooling

From birth until the age of 6 children may attend pre-primary education (kindergarten). At the age of 6, children start their primary education, which lasts for 6 years. In primary school, science is one of the obligatory subjects with 2 to 4 hours of teaching hours per week.

From the age of 12, children start their secondary education, first in lower secondary or junior high school from grades 7-9 and then at upper secondary school or high school from grades 10-12. Science is compulsory in lower secondary, but becomes optional in upper secondary school. With regard to the junior high school curriculum, this is reported to be very crowded in Israel. As a consequence, there exists a difference between the formal and the practised curriculum.

The first table below shows the number of teaching hours in science for the different levels and the number of science teachers for each level. The second table shows the number of students that graduated in advanced science in 2008. There is some overlap between the groups in this second table as one student may choose to graduate both in biology and in chemistry.

Science studies

	Obligatory / optional	**No. of teaching hours per week**	**No. of teachers**[9]
Primary	Obligatory	2-4	2500 (science and technology)
Junior high school	Obligatory	3-4	4500 (science and technology)
High school	Optional	Advanced (5 units): 10^{th} grade - 3 h' 11^{th} and 12^{th} – 6 h'	Biology: 1800 Physics:1500 Chemistry:600

Number of students graduating in advanced science (5 units) in 2008[10]

Subject	**No. of graduates**	**%**
All graduates	83866	100
Physics	7807	9.31
Chemistry	7392	8.81
Biology	11050	13.18

[9] Science and technology education (2006). Report to the KNESSET committee of science and technology. www.knesset.gov.il/mmm (Hebrew).
[10] Ministry of Education, Matriculation data center, 13.9.09

Information about Quality

In the PISA 2006 science assessment, the achievement of the Israeli students (454 points) was well below the OECD average. Approximately one third of the students reached competency values that placed them at proficiency levels 1 or below. The amount of students at proficiency levels 5 and 6 is 5.2% compared to 9% on OECD average. There is no significant gender difference observed in Israel.

In general, the public attitude towards science and technology is very positive. Scientist, medical doctor and engineer rank highest amongst the professions parents want for their children. 96% of the population agree that it is very important to maintain a high level of science education in Israel.

The Teacher Education System

Initial Teacher Education (pre-service education)

There are four different teacher education programmes in Israel: Early childhood (ages 0-5); primary education (ages 6-11); secondary education (ages 12-18) and special education (ages 6-21). The threshold for acceptance to teacher education programmes was recently raised from 500 to 550 points at the psychometric exam (an average grade is about 530 points on a 200-800 scale).

The structure of the programmes of teacher training is outlined in *The Guidelines for Teacher Training* approved by the Council of Higher Education. Institutions with curricula for teacher training must complete compliance with these guidelines by the beginning of the 2010/2011 academic year. According to these guidelines, teachers should have a bachelor's degree in at least one major subject taught in school and 30-36 credits in teacher education (pedagogy, didactics).

Even though all teacher education programmes have to be in accordance with the same guidelines, there is no joint curriculum across all teacher-training programmes. The Israeli S-TEAM partner Technion provides an example of a bachelor's degree in Education in Technology and Science. At Technion this is a four-year programme leading to a bachelor's degree in education in technology, science or mathematics, including a high school teaching diploma. The programme would typically include courses required of all Technion students in basic science; departmentally required courses in the discipline of specialization, in other related disciplines and in cognitive and social psychology, educational foundations and general didactics; optional courses selected from a list prepared for each area of specialization; pedagogical studies specific to the area of specialization, including practice teaching; and a small number of courses freely selected by each student from the Technion catalogue.

Regarding the content of science and mathematics courses, this can vary between the different institutions. In general however, the education students are required to study the same courses as the science/mathematics students. According to the workshop participants, there are huge differences in the quality of teacher education between universities and colleges.

Status of the Teaching Profession

There is a lack of chemistry and physics teachers in Israel. In biology, there is no shortage at the moment but it is expected that there may be such a shortage in the future. If schools are unable to find teachers for a specialist subject they can close down the subject and teach the other science subjects instead.

Teacher Professional Development (in-service education)

In general, TPD is a very centralized system in Israel. All TPD programmes must be approved by the Ministry of Education. Activities for science and mathematics teachers are mainly run by the specialized National Teacher Centre (i.e. Biology at Hebrew University in Jerusalem, Physics at Weismann Institute). Generally, TPD is voluntary, single courses, usually based on individual teacher participation. Occasionally though, courses are organised for groups from the same school. Teachers are required to participate in special TPD, such as programmes aimed at the introduction of a new curriculum. The level of incorporation of IBST in teacher professional development varies greatly. Some programmes are aiming at content knowledge or curriculum innovations, while others are focusing on inquiry.

Status of Teacher Professional Development

Science and mathematics teachers who wish to develop professionally in Israel can usually find a satisfactory programme. There is a wide variety of programmes, as well as distance learning opportunities which makes TPD available for more teachers.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

In Israel, IBST is not limited to science classes but is an issue in all subjects. A process from “science for future scientists” towards “science for all” is already under way. A new subject called “Mutav” (can be translated as “Science for all”) was implemented and is in the process of including inquiry projects. IBST in Israel has been well established in high school advanced biology for more than 30 years. During the 1990’s IBST was partially introduced to junior high school science, as part of a reform in science education in Israel. High school chemistry adopted IBST gradually during the last decade. A great effort has been made by the Ministry of Education, aimed at adopting IBST across more subjects and levels during the past three years.

Table 1 (overleaf) illustrates the place of IBST in the curriculum

Table 1: IBST in science education: curriculum framework

Subject	Level	IBST in curriculum
Science	Primary school (grades 1-6)	Emphasis on inquiry skills, along with other skills such as information skills and problem-solving skills.
Science	Junior high school (grade 7-9)	Emphasis on inquiry skills, along with other skills such as information skills and problem-solving skills.
Biology	High school advanced courses (grade 10-12)	Emphasis on inquiry as core skills. Obligatory unit* – Inquiry project. Obligatory unit – inquiry lab experiments. Obligatory use of inquiry science skills in the matriculation exam
Chemistry		Emphasis on inquiry as core skills. A curriculum reform in 1999/2000 lead to less topics and more thinking skills in the curriculum Optional unit: inquiry lab experiments. About 60 % of the students are participating.
Physics		Inquiry is not mentioned, but learning skills in the lab unit include experiment skills (questions…)
Environmental education		Obligatory unit – Inquiry project

* One unit equals 90 teaching hours.

Teachers' views of IBST/E were described in the Ministry of Education's "Pedagogical Horizon" 2006-2009 report.[11] According to the teachers, the advantages of IBST/E were: students and teachers enjoyment of learning and teaching, and better understanding of the subject. The difficulties of IBST/E were: lack of understanding of the concept by teachers without inquiry experience, teachers having trouble with the need to change their role from the "master of knowledge" to the guide of a process, and increasing teachers' workload.

Inquiry in Teacher Education

Usually IBST is included as a basic approach to some of the science courses such as labs or science seminars. The introductory science courses are mainly content focused and based on frontal (direct) teaching. Regarding science education courses, there is usually no special course for IBST. Emphasis on IBST is however, present in biology and chemistry teaching methods courses. This year, a new course of IBST in biology teaching is being developed at the Technion.

[11] Report of education for thinking ("PEDAGOGICAL HORIZON"): Description, insights and recommendations (2009). Jerusalem: Ministry of education – The pedagogical secretary. (Hebrew)

The workshop participants feel that the amount of IBST in teacher education is not sufficient because teachers have usually never done research on their own. Teachers must have experienced IBST by themselves to be able to teach it to their students – generally, teachers themselves find IBST approaches very difficult.

Lithuania

Education System

Basic structure of schooling

According to the Eurydice national summary sheet on the education system in Lithuania, children attend compulsory education from the age of 7 to the age of 16. Compulsory education consists of primary education (ages 7-10/11) and basic education (ages 10/11-16).

After having finished basic education, pupils may start a two-year secondary education. This is however not compulsory.

The curricula for both compulsory and secondary education are defined at the national level.

The following link gives a chart picturing the educational system in Lithuania: http://www.baltic-education.eu/pdf/Lithuania_esystem.pdf.

Information about Quality

Students in Lithuania reached a mean competency value of 488 points in the PISA 2006 science assessment, which placed them below the OECD average. The value is comparable to Latvia but significantly lower than in Estonia (531 points). Approximately one fifth of the students were located at proficiency levels 1 and below (which is comparable to the OECD average) whereas the amount of high-performing students (at proficiency levels 5 and 6) was (at 4.9%) significantly smaller than the OECD-average (9%). In Lithuania, girls reached significantly higher competency values than boys.

In addition, national tests have shown a decrease in science performance over the last few years. About 40% of the students in grade 6 reported that they had never performed an experiment by themselves, almost 20% had never even seen the teacher perform an experiment. In general, there is little practical work and discussion in Lithuanian classrooms, and the instruction is very teacher-centred. The ministry wants science instruction to be more activity based.

Regarding students' subject choices, a lack of students in science and mathematics is observed.

The Teacher Education System

Initial Teacher Education (pre-service education)

In Lithuania, pre-primary, primary, lower secondary and upper secondary school teachers receive initial teacher education through non-university or university courses lasting respectively from three to four years at non-university studies and four years at university level. They have to complete a Professional Bachelor's degree or Bachelor's degree and acquire a professional qualification. In some cases Professional Bachelors or Bachelors may follow an additional one-year course to acquire a professional teacher's qualification (Eurydice 2009).

With regards to science and mathematics teacher education, there exist several programmes. The major one is presented by Vilnius Pedagogical University, but Vilnius State University and Kaunas Technological University offer science and mathematics teacher education as well. The latter offers a special programme called “Pedagogic” for engineers wanting to qualify for a teacher certificate. In general though, the teacher education programmes are more or less the same across universities.

Status of the Teaching Profession

In the opinion of the workshop participants, teachers in Lithuania are not motivated independent of the teachers’ age or education. The teacher profession is not attractive due to low salaries, the instability of the educational system in Lithuania and the fact that teaching is perceived as hard work. The thinking structure of Soviet times still remains in the system: Natural sciences are perceived as “hard” sciences in contrast to the “soft” social sciences. Since the school leaving examinations require the reproduction of factual knowledge, teachers feel that they do not have time for innovative methods. This reflects a general tendency in science education to teach only what we know – we should, however, put more emphasis on how this knowledge was achieved.

Teacher Professional Development (in-service education)

In general, the situation in Lithuania is problematic at the moment since some reorganisation is taking place. Formally teacher professional development (TPD) is voluntary in Lithuania. However, every five years teachers have to go through an accreditation process. This motivates them to develop their own professional competence. The Lithuanian Ministry of Science and Education is in charge of TPD, and they organize different types of TPD courses. There are also programmes for professional development funded by the EU.

Status of Teacher Professional Development

Lithuanian teachers evaluate the professional development courses positively. However, it is reported from the Lithuanian S-TEAM partners that teacher professional development should be more directed towards active teaching and learning methods such as IBST.

Lithuania plans to implement a small-scale project based on the SINUS approach. Two school networks consisting of 2-3 schools each should be established in Kaunas and Vilnius. The two networks will be connected through colleagues from the State Institutes. They are going to have 5-6 teachers at each participating school. After recruiting the schools (there already exist school networks in Lithuania that might be used), the idea is to bring together politicians from the Ministry of Education, school principals and people from the municipalities to agree on more freedom and support for teachers.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

An analysis of science education in Lithuania shows that 41 % of the students up to grade 6 have never done research or experiments by themselves, and 21 % have never even seen the teacher performing an experiment. Practical work, according to this analysis, is often performed by the teachers, whereas the students are only passive observers. There is not even much discussion in these courses. The Lithuanian Ministry of Education has, however, recognized the need for change, and expressed a wish for science education to be activity-based; to deal with real life problems and for students to be motivated to perform experiments on their own.

Inquiry in Teacher Education

IBST is getting more and more popular among Lithuanian science and mathematics teachers. As a teaching method it is included in the didactics curriculum in teacher training programmes. Topics as IBST furthermore are constantly developed and analyzed during teacher professional development courses.

Norway

The Education System

Basic Structure of Schooling

In Norway pupils attend 10 years of compulsory education, from the age of 6 to the age of 16. This includes both primary education (grades 1-7) and lower secondary education (grades 8-10). Among the mandatory subjects at these levels we find mathematics and natural science.

At the age of 16, after having finished compulsory education, pupils may start their upper secondary education, choosing the academic/general programme or the vocational programme. The former is a three-year programme qualifying students for acceptance to higher education. Pupils attending the vocational programme who would like to qualify for higher education may either attend a fourth year or change programmes after the second year, and follow supplementary studies the third year. Norway has a national curriculum for grades 1-13.

Mathematics is compulsory both the first (Vg1) and the second (Vg2) year of the general upper secondary education programme. According to the mandatory guidelines there are two mathematics subjects for Vg1 and Vg2; curriculum T and curriculum P. The former is more theoretically oriented, whereas the latter is more practically oriented. Natural science is compulsory only for the first year (Vg1). For the second and third year the natural science subjects are elective and go from being integrated subjects to being organized according to discipline (biology, chemistry, physics and recently earth science/geology).

For those pupils choosing a vocational upper secondary education, mathematics and natural sciences are obligatory in the first year. However, the curriculum is not the same, as these pupils have three fifths of the mathematical curriculum for Vg1P or Vg1T and only parts of the natural sciences curriculum for Vg1.

The main subject areas in mathematics and the natural sciences are listed below, as well as tables showing the number of teaching hours in the two subjects.

In the mathematics subject curriculum the following subject areas are listed according to level[12] (table 1).

[12] http://www.udir.no/Artikler/_Lareplaner/_english/Common-core-subjects-in-primary-and-secondary-education/

Table 1: Main subject areas in mathematics

Year	Main subject area				
1-4	Numbers	Geometry	Measuring	Statistics	
5-7	Numbers and algebra	Geometry	Measuring	Statistics and probability	
8-10	Numbers and algebra	Geometry	Measuring	Statistics, probability and combinatorics	Functions
Vg1T	Numbers and algebra	Geometry		Probability	Functions
Vg1P	Numbers and algebra	Geometry	Economics	Probability	Functions
Vg2T	Geometry		Combinatorics and probability	Culture and modelling	
Vg2P	Numbers and algebra in practice		Statistics	Modelling	

The Mathematics Subject Curriculum lists the number of teaching hours at the different levels as in table 2 (given in 60-minute units).

Table 2: Teaching hours mathematics

Primary school (year 1 to 7)	812 teaching hours
Lower secondary school (year 8 to 10)	313 teaching hours
Upper secondary education (academic or general education programme)	Vg 1: 140 teaching hours Vg2: 84 teaching hours
Upper secondary education (vocational education programme	Vg1: 84 teaching hours
Supplementary studies qualifying for higher education for vocational education programmes	140 teaching hours

In the Natural Science Subject Curriculum the following subject areas are listed[13] (table 3).

[13] http://www.udir.no/Artikler/_Lareplaner/_english/Common-core-subjects-in-primary-and-secondary-education/

Table 3: Main subject areas in the natural sciences

Year	**Main subject area**					
1-10	The budding researcher[14]	Diversity in nature	Body and health	The universe	Phenomena and substances/-elements	Technology and design
Vg1	The budding researcher	Sustainable development	Nutrition and health	Radiation and radio-activity	Energy for the future	Bio-technology

The curriculum states, as mentioned above, that "pupils in vocational education programmes shall have parts of the syllabus for Vg1. The main subject area *the budding researcher* is compulsory for all pupils".

The number of teaching hours in natural science, according to the curriculum are as follows in table 4 (given in 60-minute units):

Table 4: Teaching hours natural science

Primary education (year 1 to 7)	328 teaching hours
Lower secondary education	256 teaching hours
Upper secondary education Vg1 (programmes for general studies)	140 teaching hours
Upper secondary education Vg1 (vocational education programmes)	56 teaching hours
Supplementary studies qualifying for higher education for vocational education programmes	84 teaching hours

In 2008, 46% of pupils starting their upper secondary education chose the general study programme (Utdanningsdirektoratet 2009, 22).[15] However, this number increases at Vg3 (year 3), as many of the pupils attending a vocational study programme choose to change programmes after Vg2 (year 2) to follow supplementary studies to qualify for higher education. According to studies done by the Research Institute NIFU STEP, 15 % of pupils who started a vocational education programme in 2004 chose to take supplementary studies to qualify for higher education the third year (Utdanningsdirektoratet 2009, 79).

[14] The Budding Scientist may be characterized as the process of science. Ideas of IBST are found within this topic of the national curriculum for science at all grade levels (1-13).

[15] Utdanningsdirektoratet (2009): *Utdanningsspeilet 2008. Tall og analyse av grunnopplæringen i Norge*. Oslo: Utdanningsdirektoratet

Information about Quality

Norway is ranked below the OECD average in the international PISA survey. In this study Norwegian pupils have the lowest score among the Nordic countries in the subject 'natural sciences', with only six OECD-countries having a lower score than Norway. Regarding the sciences, the PISA results from 2006 show that only 6.1 % of Norwegian pupils perform at levels 5 or 6, whereas 9 % of pupils within the OECD countries seen as a whole perform at one of these levels. Rather large proportions (21.1 %) of Norwegian pupils perform at level 1 or below.

The Teacher Education System

Initial Teacher Education (pre-service education)

Until now teacher education for primary and lower secondary schools has been a four-year (class teacher) programme (240 ECTS points) with the subject mathematics (30 ECTS) and the didactics of reading, writing and mathematics (10 ECTS) as compulsory subjects. In the elective part, 60 ECTS points must be taken in a school subject (science may be chosen by students as an elective). The teacher education programme also includes 30 ECTS in educational science.

As a result of the unsatisfactory ranking of Norwegian pupils in international surveys such as PISA, the Norwegian Ministry of Education and Research has suggested various changes in the class teacher education in order to strengthen teacher's subject knowledge. These changes imply a restructuring of the class teacher education in two programmes according to level: one teacher education programme for those wishing to practice at grades 1 through 7 and another teacher education programme for those wanting to work in grades 5 through 10.

The suggested teacher education programme for grades 1-7 will include at least four school subjects, and the students are required to obtain 60 ECTS in at least one of these subjects. The students may choose to take up to 30 ECTS in subjects that are relevant to teaching (for instance special education), and lastly the programme will include 60 ECTS in educational science. The subjects Norwegian and mathematics are to be compulsory. Furthermore, as students graduate from this new teacher education programmes the Ministry of Education and Research suggests that all teachers hired for grades 1-7 are required to have at least 30 ECTS in both Norwegian and mathematics. This means that future teachers in grades 1-7 normally will have an education consisting of 30 ECTS in three different school subjects and 60 ECTS in a fourth school subject. After the third year, students may choose to start a 2-year Master's degree or they may choose subject studies for a fourth and final year.

(see fig.1 overleaf)

Fig. 1: Structure of the teacher education programme 1-7

<table>
<tr><td>Year 5</td><td colspan="2">Master 60 ECTS (optional)</td></tr>
<tr><td>Year 4</td><td colspan="2">Master 60 ECTS (optional)
or
Subject 4 / Subject 5: 60 ECTS
or
Subject 4: 30 ECTS + 30 ECTS in school relevant subjects
Practice</td></tr>
<tr><td>Year 3</td><td>PEL (pedagogy) 30 ECTS
Bachelor thesis

Practice</td><td>Subject 3/Subject 4/
Norwegian/Mathematics
30 ECTS
Practice</td></tr>
<tr><td>Year 2</td><td>PEL (pedagogy) 15 ECTS
Practice</td><td rowspan="2">Norwegian: 30 ECTS
Mathematics: 30 ECTS
subject 3: 30 ECTS

Practice</td></tr>
<tr><td>Year 1</td><td>PEL (pedagogy) 15 ECTS
Practice</td></tr>
</table>

The suggested teacher education programme for grades 5-10 includes three school subjects of 60 ECTS each and 60 ECTS in educational science. In this programme there are no compulsory subjects, but to be able to teach the subjects Norwegian/Sami, mathematics or English in lower secondary school, 60 ECTS are required. In addition, as students graduate from this programme, the Ministry of Education and Research suggests that all teachers hired for grades 8-10 should be required to have at least 30 ECTS in whichever other subjects they are hired to teach. After the third year students may choose to start a 2-year Master's degree or they may choose subject studies for a fourth and final year.

Fig.2: Structure of the teacher education programme 5-10

<table>
<tr><td>Year 5</td><td colspan="2">Master 60 ECTS (optional)</td></tr>
<tr><td>Year 4</td><td colspan="2">Master 60 ECTS (optional) or
subject 3: 60 ECTS or
subject 3: 30 ECTS + 30 ECTS in subjects relevant to school
Practice</td></tr>
<tr><td>Year 3</td><td>PEL (pedagogy): 30 ECTS
Bachelor thesis
Practice</td><td>Subject 2: 30 ECTS
Practice</td></tr>
<tr><td>Year 2</td><td>PEL (pedagogy): 15 ECTS
Practice</td><td rowspan="2">Subject 1: 60 ECTS
Subject 2: 30 ECTS
Practice</td></tr>
<tr><td>Year 1</td><td>PEL (pedagogy): 15 ECTS
Practice</td></tr>
</table>

Teachers in upper secondary school are required to have at least 60 credit points in each of the subjects they teach. There are three ways to qualify for teaching at this level. The first possibility is to study for a five-year subject Master's degree, followed by 60 ECTS in educational science. The second possibility is to start a two-year teacher education programme which focuses on educational science and school practice (PPU). To qualify for admission to this programme, students need to have at least 180 ECTS (the equivalent of a Bachelor's degree), of which 60 ECTS should be in one or two school subjects, in addition to having studied the subject didactics. PPU is offered both as a full-time and as a part-time study programme. The third possibility is a 5-year Master's degree where educational science and didactics are an integrated part of the programme (Lektorprogrammet) and studied simultaneously with subjects.

Status of the Teaching Profession

In Norway teachers are not seen as professionals the same way as for instance doctors and lawyers. This has an unfortunate effect on both how teachers see themselves and on their attitudes towards the need for professional development.

Teacher Professional Development (in-service education)

In Norway, the municipalities are responsible for teacher professional development at the primary and lower secondary level, whereas the counties are responsible for the professional development of teachers working in upper secondary school. The Ministry of Education and Research has in cooperation with the Norwegian Association of Local and Regional Authorities (KS) and the teachers' trade unions reached an agreement[16] about how teacher professional development should be carried out. This agreement states that the municipalities/counties are responsible for making an overview of the needs for professional development at each school in collaboration with the schools. Necessary measures are to be taken in accordance with the needs which teachers and schools feel should be met/prioritized.

There is no national control or overview of how many, or which type of TPD courses teachers are offered. This may therefore vary between different municipalities/counties. However, it may be noted that the TPD courses offered to teachers at primary and lower secondary school usually include a combination of subject and didactic/method.

Regarding professional development in IBST in science, the Norwegian Center for Science Education at the University of Oslo has organized TPD courses relevant to the subject area "the budding researcher".[17] The election of TPD courses is the responsibility of each municipality/county in collaboration with the schools. This means that there are no nationally or systematically organized TPD courses in inquiry to ensure that teachers' needs for professional development in inquiry are met. There is therefore reason to believe that such courses are not available for all teachers throughout Norway, as courses held by the Norwegian Center for Science Education primarily cater to the teachers in the Oslo-region. Considering that inquiry is very much a part of the curriculum in

[16] Kunnskapsdepartementet (2008): Kompetanse for kvalitet. Strategi for videreutdanning av lærere

[17] For more information on the budding researcher see part three on inquiry based science teaching.

the natural sciences through the "budding researcher", this situation is problematic. The courses that have been organized have not been compulsory, and there are great uncertainties whether teachers feel competent and confident enough to use IBST in their teaching.

Status of Teacher Professional Development

The Ministry of Education and Research has made a commitment to TPD through the agreement on TPD mentioned above. As of 2009 the Government has started to subsidize more TPD courses than before, primarily in the prioritized subjects Norwegian, English and mathematics, but also in the subjects chemistry and physics. The Government has granted 117 million NOK to TPD actions/measures in 2009, and is planning to increase this amount to 312 million NOK per year when the system of teacher professional development is in full capacity. This may be seen as a step in the right direction of prioritizing teacher professional development at the national level, but there is still great uncertainty whether this is carried out at the local level.

The University of Oslo has in cooperation with the Norwegian University of Science and Technology in Trondheim started a small scale SINUS[18] project in a small number of schools. This project aims at organizing teacher professional development courses for teachers, which focus on both subject knowledge and pedagogy in general and IBST in particular.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

Inquiry in Norwegian natural science teaching has been given a boost with the subject area "the budding researcher", introduced as a part of the curriculum by the Knowledge Promotion reform of 2006. This subject area deals with natural science methodologies for developing knowledge which involves the formulation of hypotheses, experimentation, systematic observation, openness, discussions, critical assessment, argumentation, grounds for conclusion and presentation.

"The budding researcher" is introduced in the first grade and accompanies the pupils all through primary; lower upper secondary and upper secondary school, even though the name changes after Vg1 to "the young researcher".

One of the challenges with "the budding researcher" is that teachers do not necessarily have the skills to use IBST in the classroom, as IBST demands not only methodological skills but also subject knowledge and confidence in one's own subject knowledge (Pedagogical Content Knowledge). The lack of subject knowledge in the natural sciences is therefore a common challenge and an obstacle for the use of IBST in the classroom. Thus, there seems to be a need for more professional development related to "the budding researcher".

The budding researcher is clearly a part of the intended curriculum, but it is difficult to estimate how much of this is actually being implemented in Norwegian schools.

[18] In accordance with the German SINUS-model for teacher professional development.

Inquiry in Teacher Education

Regarding inquiry in teacher education, there is no obligation to include this as a part of the syllabus/programme. Courses exist where IBST is included, but whether and where these are offered seems rather random. In the two new teacher education programmes mentioned above, IBST is intended to be a part of the syllabus, but this is still a work in progress.

The Norwegian education system

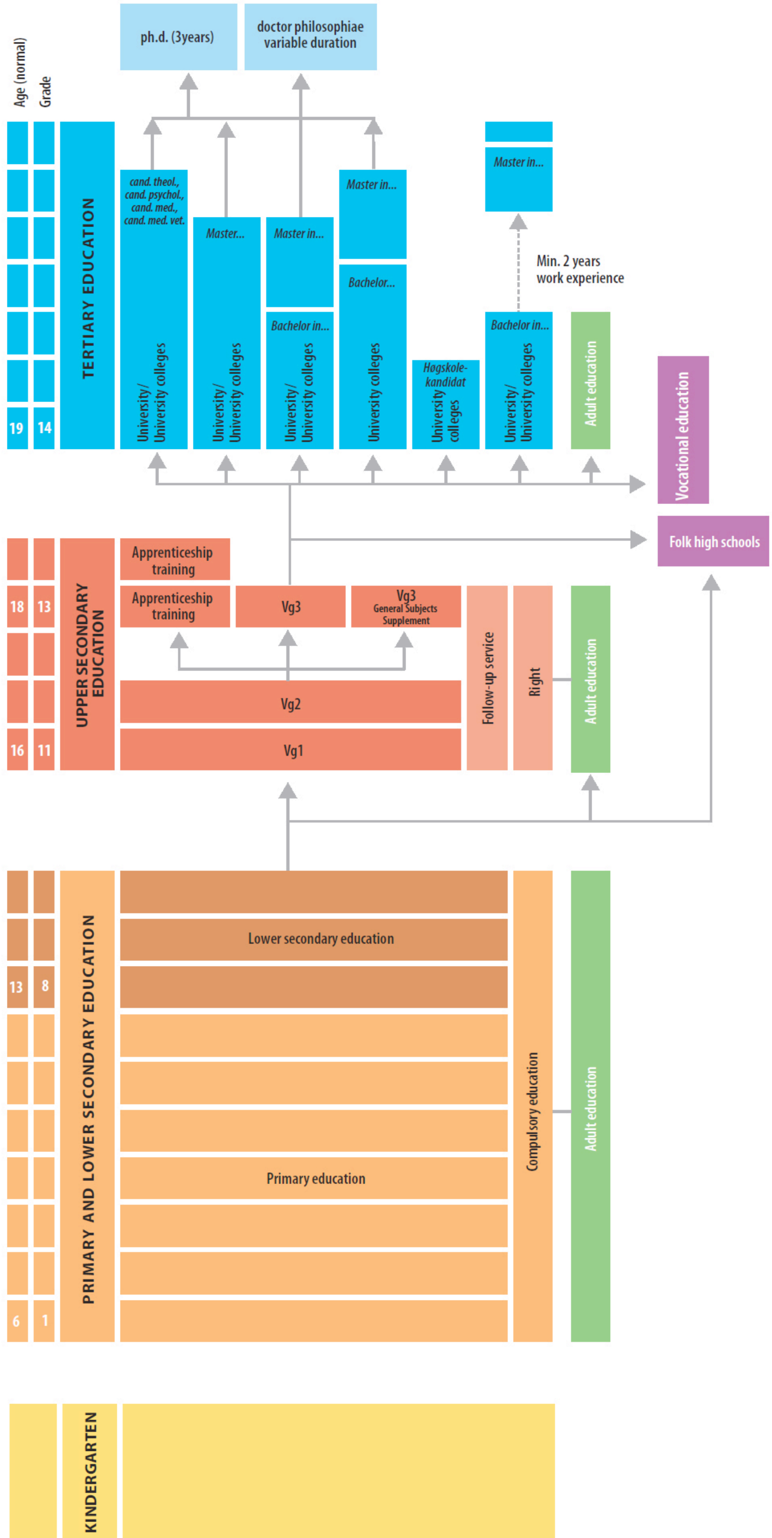


Fig1: see footnote[19]

[19] http://www.regjeringen.no/upload/KD/Vedlegg/Veiledninger%20og%20brosjyrer/Education_in_Norway_f-4133e.pdf

Scotland

Education System

Basic Structure of Schooling

Pupils in Scotland attend compulsory education from the age of 5 to the age of 16 (Eurydice, 2009). For the first seven years pupils attend primary school, and then at the age of 12 they start a four-year lower secondary education. In their first and second year of lower secondary education pupils do all subjects, and then at the end of the second year they choose which subjects they wish to carry on as certificates. Mathematics and English are compulsory, and the pupils have to choose the remaining subjects from blocks, such as social subjects, expressive arts, languages, science etc., to encourage a spread, unless a child has a real aptitude for an area such as science, and is therefore allowed to take additional subjects.

The pupils take Standard Grade, which is a certificate course for each of the chosen subjects (the Scottish equivalent to the English GCSEs). This takes two years (third and fourth year of lower secondary education).

At the age of 16 pupils usually start their upper secondary education, which lasts until the age of 18. This is, however, not compulsory. During these years the pupils do a set of one-year courses, and may leave after the first year, or stay to do more certificates the second and last year. These courses are called Intermediate 1 (easiest), Intermediate 2, Higher and Advanced Higher (for second year pupils who have achieved success at Higher in that subject). Highers are the Scottish equivalent to the English A-levels.

In August 2009 schools started to adopt a new curriculum, a Curriculum for Excellence (CfE).

The following link gives a chart picturing the Scottish educational system: http://www.dr-bongardt.de/uni/bongardt/archiv/projekte/schule_in_europa/staaten/scotland.htm.

Information about Quality

In the PISA 2006 assessment of scientific literacy students in Scotland reached a mean competency value of 515 score points. This value is comparable to the results of German students and is located well above the OECD average. The difference in performance between boys and girls is not significant. On average, there are fewer low performing students (at or below proficiency level 1) and more high performing students (at levels 5 and 6) in Scotland than the OECD average.

The Teacher Education System

Initial Teacher Education (pre-service education)

In Scotland, teachers at the primary level enter the profession through either a 4-year course leading to a Bachelors of Education (B.Ed) qualification or through a one-year Professional Graduate Diploma Education (PFDE Primary) course. Graduates undertaking the PGDE (Primary) route are required to satisfy the entry requirements to courses of Initial Teacher Education in Scotland. All degree qualifications are acceptable for entry to the PGDE (Primary) course (Eurydice 2009)

Most secondary teachers, after gaining a degree in the subject they wish to teach (e.g. chemistry, English, and physical Education etc) enter the teaching profession through undertaking a Professional Graduate Diploma in Education (PGDE) course. A few enter through the Bachelor of Education (B.Ed) degree route which is offered in a limited number of secondary subjects and a few through combined degrees which include subject study, study of education and school experience (Eurydice 2009).

Additionally, all those who wish to teach in publicly funded primary and secondary schools in Scotland are required to have undergone initial training and to hold a Teaching Qualification (TQ) in order to be registered as teachers with the General Teaching Council for Scotland (GTCS). Teachers who have achieved a Teaching Qualification (TQ) are provisionally registered with the GTCS. Through the Teacher Induction Scheme, all newly qualified teachers in Scotland can gain access to a teaching post for one year immediately following qualification. Full registration then follows a period of probation and assessment (which generally lasts for one year). To become fully GTCS registered, probationers have to meet the standards set out in the Standard for Full Registration (SFR) (Eurydice 2009).

Status of the Teaching Profession

Teachers' salaries have been comparatively good in recent years (for example, the starting salary tends to be higher than that for a beginning academic), but are likely to fall back again in the next round of spending cuts. Historically, the salary goes up and down relative to other careers.

Teachers' status is recovering, after years of deprofessionalisation by politicians. Generally, teachers are well respected by the public but can experience hostility from certain quarters – e.g. some business people and the socially deprived or disenfranchised.

An increasing trend is for teachers to be seen as part of a group of professions, which also comprises social (care) workers and healthcare staff. This refocuses their pedagogical role since the desired outcome of education is seen as a set of personal characteristics rather than a 'neutral' person to whom qualifications are attached. These characteristics are, to some extent, normative in that they are framed as contributing to social cohesion and to national economic success as well as to personal wellbeing and advancement.

Some science teachers are having difficulty in finding permanent posts, so this presumably indicates no lack of supply at present. However, very rural areas, e.g. far north of Scotland, have more difficulty recruiting, so there may be a shortage in these areas – surplus may be in the more populated, and popular areas.

Teacher Professional Development (in-service education)

1) 35 hours annual CPD

All teachers have to do 35 hours CPD a year. This is agreed at an Annual Review with the line manager. It is supposed to be geared to the development/improvement plans of the school/department and can consist of individual study, formal courses, research for course development, learning new skills (e.g. ICT, teaching methods), or anything else deemed appropriate. The CPD is recorded in the documentation for the Annual Review. Success of this TPD depends on the relationship between the line manager and the individual teachers, as well as the monitoring system/policy of the school management. Some schools/departments take it more seriously than others.

2) Chartered Teacher

Chartered Teacher is an alternative to seeking promotion and intended to encourage teachers to develop their knowledge of learning and teaching theories/ research and to develop their practice to make more impact in their schools. Once teachers have reached the maximum salary scale for unpromoted teachers (secondary and primary are the same), they can choose to begin to work towards Chartered Teacher status. Until recently, there has been a transition phase in which experienced teachers could claim this status by taking an introductory (self-evaluation) module at university, then producing a portfolio of work as evidence of advanced practice against the Standard for Charter Teacher. However, the way for most teachers is now to enrol for a Master's level programme at a University, achievement of which is matched against the Standard. Successful completion of the whole programme results in a substantial salary increase. However, completion of every two modules towards this final goal results in an incremental salary increase.

3) Scottish Qualification for Headship (SQH)

University courses matched against the Standard for Headship. This is becoming a requirement for those in management positions who wish to become Head Teachers.

4) In-service (INSET)

Within the school year, there are five days set aside as inservice (or INSET) days. The school has to account for how these are used to its local authority. Sometimes the local authority may specify, or provide inservice to do with its own policy initiatives. Otherwise, the school organises them itself in line with its own priorities (which, of course, may derive from national or local authority priorities). The time may be spent in meetings, carrying out development work (individually or in groups), or in training sessions delivered by other members of the school's staff or by visitors to the school.

IBST would only be involved in 1 and 2, if highlighted as a priority at national, local or school level. It may be part of the courses for 2 and 3, particularly for the Chartered Teacher.

Inquiry Based Science Teaching

Inquiry in the School Curriculum

According to the Scottish S-TEAM partners at the University of Strathclyde “the Curriculum for Excellence in Scotland for Science is, on the face of it, encouraging of investigative science lessons, the range of possible activities that could count as investigative, and in the diversity of the ways in which scientists work. However, to maintain this spirit, it was recognised that there was a need for assessment not to focus on rewarding the acquisition of atomised facts. This is rewarded by the current assessment system but investigative learning is not a pathway to success here and so is not favoured within it. Furthermore, there is a danger in driving curriculum change through examinations, as teachers will then focus on getting the pupils through – a problem also experienced in mathematics where in-service has been dedicated to finding the investigation that was easiest for the pupil to pass in formal assessments. However, as the exchanges between teacher educators in physics and mathematics suggested, even then there are opportunities for exploring questions raised by the pupils, but current curriculum and assessment restraints make this ‘risky’ in the eyes of many teachers.

The Scottish S-TEAM partners additionally report that “...both in science and mathematics, over prescribed curricula and assessments may only permit teachers to carry out investigations when they have unusual degrees of motivations to do so. It may even be naïve, say Hofstein and Lunetta (2003: 44) to think that teachers’ will ‘shift toward inquiry and the development of meaningful practical knowledge until such outcomes become more visible in the tests that increasingly drive what teachers […] think is important’. The question in that case may be, to what degree will the *Curriculum for Excellence* continue to be as supportive of investigations as it currently is, or will assessments come along that destroy that spirit”.

Inquiry in Teacher Education

The inclusion of IBST in programmes of teacher education will vary according to the range of expertise and ideologies of the lecturers developing ITE courses, as well as according to the range of exposure to inquiry-based methods experienced by student teachers in placement schools. The volume of IBST in the former may increase as a result of the ongoing implementation of a *Curriculum for Excellence* in Scottish schools, an initiative which places investigation and inquiry in the classroom on a more formal agenda, and to which ITE institutions will have to respond.

Spain

Education System

Basic Structure of Schooling

The compulsory education in Spain consists of primary and lower secondary education. Children attend primary education from the age of 6 to the age of 11, i.e. grades 1-6. The lower secondary education includes grade 7 through 10 (ages 12 – 15). After the 10th grade pupils can continue with upper secondary education or "Bachillerato" for two years. This is a non-compulsory education, but is required for those who wish to continue with higher education. The table below gives a summary of the Spanish educational system.

Table 1: The Spanish educational system

Age	Grade	Year	Stage	Character
		Doctoral programme 5th (and 6th) Master 1st-4th Grade		
17	12	2nd year "Bachillerato"	Upper Secondary (1)	Not Compulsory
16	11	1st year "Bachillerato"		
15	10	4th ESO	Lower Secondary (ESO) (2)	Compulsory
14	9	3rd ESO		
13	8	2nd ESO		
12	7	1st ESO		
6-11	1-6	1st – 6th Primary Education	Primary Education	

(1) Vocational training is an option to academic "bachilleratos". It starts at 16 for two years (intermediate grade vocational training), and may continue on higher grade vocational training.

(2) ESO: "Educación Secundaria Obligatoria" (Compulsory Secondary Education)

With regards to the curriculum, the Ministry of Education designs the guidelines for the national curriculum, and then the development for each programme and subject is agreed between the universities and the Departments of Education in each of the 17 autonomous regions in Spain.

Information about Quality

Students in Spain reached a mean competency value of 488 score points in the PISA 2006 assessment of scientific literacy which placed them significantly below the OECD average. One could observe, however, quite different results for the different provinces reaching from 474 points in

Andalucia to 520 points in La Rioja and Castile and Leon. The amount of students at or below proficiency level 1 is comparable to the OECD average whereas the amount of high performing students (at proficiency levels 5 and 6) is remarkably lower (4.9 % in Spain compared to 9 % on OECD average). There is no significant difference in the science performance of boys and girls in Spain.

The Teacher Education System

Initial Teacher Education (pre-service education)

The teacher education for teaching at the primary level is in the process of changing from a three-year degree to a four-year degree. This is a general teacher education programme, and the content is mainly structured around education/pedagogy. Of the 240 ECTS in the primary teacher education, 15 ECTS relate to science teaching and learning and 20 ECTS relate to mathematics teaching and learning.

The teacher education for teaching at the secondary level is now a one-year master's degree. Teachers at the secondary level are subject teachers, thus acceptance to the master's programme requires a four-year degree in the relevant subject. In the teacher education programme for the secondary level, the emphasis is both on education/pedagogy and subject (see table2 below):

Table 2: General subjects in the secondary teacher education at the University of Santiago de Compostela

Code	**Name**	**ECTS**
P3241101	(General) Didáctica, Currículo e Organización Escolar	4.50
P3241102	(General) A Función Titorial e a Orientación Académica	2.50
P3241103	(General) Educación e Línguas en Galicia	2.00
P3241104	(General) Desenvolvemento Psicolóxico e Aprendizaxe	3.50
P3241105	(General) Educación, Sociedade e Política Educativa	3.50

The secondary level teacher education consists of 60 ECTS; of which 16 belong to general educational subjects (as shown in the table above) and 26 ECTS correspond to specific matter courses as shown in the table 3 below. In addition the students are required to write a final essay corresponding to 6 ECTS and complete a practice period equivalent to 12 ECTS.

Table 3: Science education courses in the secondary teacher education at the University of Santiago de Compostela

Name	**ECTS**
Science and its methods of enquiry for Secondary Teachers	3
Design of Investigations in Science and Mathematics	3

Sciences for Secondary Teachers	5
Biology and Geology Education for Secondary	6
Physics and Chemistry Education for Secondary	6
Designing, planning and implementing teaching sequences in science in secondary	3

The faculties of education are responsible for organizing both the primary and the secondary teacher education programmes, not the disciplinary faculties.

Status of the Teaching Profession

The salary of Spanish teachers is of a medium range compared with other EU countries (lower than in Germany but higher for instance than in Italy). Teacher salaries are quite uniform across Spain.

Historically there is a problem in Spain about the perception of teaching as a profession with lower status compared to the "sciences". This is reflected in teachers defining themselves rather by their science background ("biologist", "physicist") than by their actual teaching profession. In the 1990s, secondary school was extended to the whole student population under 16 resulting in problems derived from coping with students without academic expectations. As surveys show, this has lead to considerable proportions of teachers (54.7%, according to Fundación Encuentro, 2003) who are unsatisfied with their work and are asking for more social acknowledgement. Secondary school teachers expect to teach their science subject and do not feel well prepared to manage conflicts or discipline problems.

There are no problems in the supply of science teachers, which is probably due to the relatively low number of good job opportunities for science graduates. Until the term 2008-2009, when the teacher certificate was available for all the graduates willing to enrol in it, the proportions of applicants for the examinations for getting a teaching position outnumbered positions by five or six times. With the new master course only a limited number of students are accepted in the programme.

Teacher Professional Development (in-service education)

These courses are not compulsory, but teachers need to have a number of credits each period of 6 years in order to get at promotion. The Departments of Education in each of the 17 autonomous regions are in charge of TPD.

Status of Teacher Professional Development

The participants in the Spanish S-TEAM workshop pointed to some areas of concern in TPD. There is a need for a shift in emphasis from stand-alone courses to a focus in schools and groups of teachers. There are difficulties in translating the courses' contents to the classroom.

Four main trends for promising innovations were identified during the national workshop: network models for TPD; students' inquiry projects; cooperation with scientists and exchange of innovative practices.

– **School-based / Network model**: Several Autonomous Communities are moving from individual TPD to a school-based or network TPD model (Andalusia, Aragon, Balearic Islands, Basque Country, Castilla-Leon, Catalunya, Navarre) or to a model based on teams of teachers (in rural areas where there is only one science teacher in each school, e.g. Castilla-Leon)

– **Promoting students' inquiry through projects**: Either as a compulsory school "subject" in post-secondary (Baccalaureate), an inquiry project accounting for 10% of the year's final marks (Catalunya, for the last 20 years); or an optional inquiry project (compulsory for schools to implement) in Asturias and Valencia. Support through teachers and also through awards, students' conferences, Science Fairs etc.

– **Cooperation with scientists and scientific research centres**: With the CSIC (High Council for Scientific Research, equivalent to the French CNRS) programme CSIC-school (Castilla-Leon, Madrid, Navarre); with Science Museums (Madrid, Valencia, Catalunya); with Universities and research laboratories (Aragon, Balearic Islands, Madrid, Ministry, Murcia); with individual scientists, Nobel laureates etc. (Galicia).

– **Exchange of good (innovative) practices** (among teachers): (Andalusia, Aragon, Catalunya, Ministry), through a combination of a data base or repository of good practices through a web-based platform (Navarre); teachers' conferences for exchange of good practices (Valencia); science conferences for teachers (Madrid, CSIC[20])

Inquiry Based Science Teaching

Inquiry in the School Curriculum

There are explicit references to IBST issues in the curriculum frameworks of both primary and secondary school. Regarding IBST dimensions such as problem based learning, argumentation, communication and other strategies for IBST (as defined for instance in the Mind the Gap project[21]), a reference search was made in the Secondary Spanish and Galician Decrees. Besides some references in the competencies and objectives sections, there are references to IBST (for instance, "strategies for problem-solving", "argumentation using scientific method", "critical thinking", "communication of science", and "media as a source of information about nature" and "STS perspective") in the content list for all secondary years. These are meant to be taught mainly in a subject area (content block) related to scientific work and practices.

[20] CSIC: http://www.csic.es/quien_somos.do

[21] http://www.uv.uio.no/english/research/projects/mindingthegap/about/index.html

Inquiry in Teacher Education

Whether Inquiry Based Science or Inquiry Based Mathematics is included in the teacher education programme varies between the different universities. In the case of the University of Santiago de Compostela (USC), inquiry is included as 2.5 ECTS in one of the science education courses in the 2nd year of the primary teacher education, and another 4 ECTS in the science education courses in the 3rd year. In the teacher education for secondary school, inquiry is included in the course “Design of Investigations in Science and Mathematics” (3 ECTS) and as 1.5 ECTS in each of the courses *Biology and Geology Education for Secondary* and *Physics and Chemistry Education for Secondary*.

Sweden

Education System

Basic Structure of Schooling

Compulsory education in Sweden consist of primary and lower secondary education, that is ages 6/7 – 15/16. The curriculum is determined at national level. Teachers and institutions are however free to determine teaching methods and select teaching material within the framework of the national curriculum and the general objectives for school activities determined by the municipalities. Mathematics is one of the subjects that occupy a prominent position in compulsory school. Additionally natural science is one of the core subjects.

At the age of 16 students can start their upper secondary education. The common core subjects at this level include both mathematics and natural sciences.

The following link gives a chart picturing the Swedish educational system http://www.sweden.gov.se/content/1/c6/07/92/85/f899a8ee.pdf.

Information about Quality

The results of Swedish 8th grade students in mathematics are slightly below the average in the latest TIMSS 2007, this is seen, however, as a significant problem. Swedish pupils are, on the other hand, quite good at reading.

PISA and national reports give the same picture. A high percentage of pupils fail every year (7-8 %). Some pupils get better grades than they should have, compared with the results of the national tests at the end of compulsory school, and the pupils are therefore likely to fail when they go to upper secondary school. Swedish pupils are on the whole not very interested in mathematics and science and they do not see the use of these subjects.

Almost all students in Sweden start upper secondary education but more than one third drop out (and the drop-out rate is increasing).

One goal of the current Swedish government is to reform the area of assessment and quality control in order to ensure education quality and to focus more on learning outcomes. To reach this goal, national tests should start in school year 3 in order to detect whether children are lagging behind as early as possible and allow for interventions. In 2009, national tests for biology, chemistry and physics were introduced. Moreover, the national school inspectorate is now an independent agency. There is supposed to be an education act to increase the power of the school inspectorate and more money shall be spent on monitoring school quality (resulting in reports for every subject). The quality controls of the school inspectorate started with mathematics in 20-30 schools.

The Teacher Education System

Initial Teacher Education (pre-service education)

Pre-service teacher education in Sweden always complies with the national framework,[22] but the programmes can still be organized differently according to different subjects, and different levels; primary education (ages 6 – 12); lower secondary education (ages 12 – 15) or upper secondary education (ages 15 – 18). Teaching at pre-school or the first year of compulsory school requires 210 ECTS. Teaching in the latter part of compulsory school and upper-secondary school requires 240-330 ECTS, and teaching in the vocational programmes at upper secondary school requires 180 ECTS.

The Swedish Teacher Education Programme consists of three parts. The first is the general field. This is compulsory for all students, regardless of what age and which subjects they wish to teach. This means that as much as 1, 5 years (90 ECTS) are common to all teacher students. The general field comprises areas of knowledge central to the teaching profession and interdisciplinary subject studies. Central knowledge is defined as teaching, special needs education and child and youth development.

The second part is the area of emphasis. It is designed to give the students opportunities to choose a profile in their studies. The students' possibilities of an individual choice are thus important. For teaching at upper-secondary school the students must have at least 90 ECTS in two areas of emphasis. If those areas are Swedish and social sciences, 120 ECTS in each subject are required.

The third part is specialization, which is a degree project equalling 30 ECTS.

The teacher education programme has a flexible design and provides, to a great extent, a free choice of subjects and courses. The programme results in either a Bachelor of Education or a Master of Education degree. Different faculties are responsible for different teacher education programmes.

The teacher education programmes include 20 weeks of placement at partner schools. The students get a partner school already at the beginning of their studies and are expected to be in regular contact with this school and the assigned supervisor throughout the whole programme.

Status of the Teaching Profession

The general belief of the government is that if you want to raise the quality of education you have to increase the competency of the teachers. The curriculum that teachers teach is often the textbook editors' interpretation of the curriculum.

Pre-school teachers especially are often not interested in mathematics and science. One reason might be that they did not study the subjects themselves. Current measures to change this concern the curriculum, the definition of clear goals, investments in teacher training and the establishment of a research school.

Teachers of social sciences often become teachers of natural science and mathematics without training in these subjects. 50 % of the teachers are not qualified for the subjects and level which they teach.

[22] The national framework referred to here is called "Högskoleforordningen".

The field of teacher education is not very attractive. The present teacher training has been criticised for its low quality. At the moment, discussions are taking place at the policy level how to change the situation but no agreement has yet been reached. One measure is to change the structure of teacher training. The present teacher training organisers should have to apply for permission to provide the new teacher training model that will start in the autumn of 2011. The rules and demands on teacher training will be tougher. The teachers must have the proper content subject education in the subject in which they are going to teach.

Moreover, science and mathematics teachers should also be aware of the importance of language skills. Teachers are reluctant to accept this. However, knowledge needs to be expressed to be useful.

Teacher Professional Development (in-service education)

The teacher professional development in Sweden consists mainly of voluntary courses, paid for by the schools. The courses are sometimes organized by the schools and at other times by the schools in collaboration with a university.

In the “lärarliftet” programme research schools for secondary and, more recently, pre-school teachers have been built up. In these research schools, teachers work 20% in their schools and do research in 80% of their time.

Status of Teacher Professional Development

Quite a lot of money is spent on teacher in-service training in pre-school and to make it possible for pre-school teachers to get a licentiate. It is important to raise the quality of teachers in general and to make teacher education attractive and of high quality. Good induction (e.g. the implementation of a mentor system for novice teachers to help them to learn “how to teach”) is of great importance as well as good in-service training. A lot of money has been spent on in-service training and this will continue until 2011. The responsibility for the in-service training is placed on the municipalities. In the future the Ministry wants to focus on the teachers (some 7000) that do not have the proper subject qualifications.

In the national workshop concerns were raised that the changes in the educational system might be based on a deficit model. Different approaches should be considered taking into account further development and the support needed. This requires common goals that have to be worked on locally.

The workshop participants emphasize the important role headmasters can play in the process. They should be included in the process of TPD and given responsibility to fulfil their role as pedagogical leaders.

Teachers' professional development
Global perspectives on teacher learning: Improving policy and practice. The UNESCO report (see (Schwille, Dembélé, & Schubert, 2007) notes that in contrast to one-shot workshops or top-down cascades training, effective professional development are characterized by
Programs conducted in school settings and linked to school-wide efforts;
Teachers participating as helpers to each other and as planners with administrators, of in-service activities;

Emphasis on self-instruction with differentiated training opportunities;
Teachers in active roles, choosing goals and activities for themselves;
Emphasis on demonstration, supervised trials and feed-back;
Training that is concrete and ongoing over time; and
Ongoing assistance and support available upon request
This view has been refined and elaborated (Villegas-Reimers, 2003) and two key dimensions are identified: core features and structural features. Core features include focus on content, active learning and coherence. Structural features include duration, form and participation. Schwille, Dembélé and Schubert (2007) mention the way in which to use teachers' own classrooms as laboratories for professional development, the public nature of teaching, the importance of teachers working together, and the "bifocal nature of lesson studies". Other issues are action research as a means for professional development, emphasis on understanding student thinking, cumulative impact through writing and dissemination of reports and balance between teacher initiative and outsider advice and guidance. Also the Swedish researcher Ference Marton has emphasized the content oriented nature of teaching/learning; it is not about methods– it is to be able to discern critical aspects for learning, and recommends Learning Studies for PD (Marton & Ling, 2007)
The MDU/S-TEAM view of Teachers Professional Development
"Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly." (Wenger, 2004). We find that our interest in developing teaching and teachers' interest for research informed strategies makes us a natural "community of practice" for teaching development. By inviting teacher teams and developing teaching activities around topics (energy for example), we intend to engage and explore the possibility to interact as a network and a community of practice. We argue that every teacher should have a supporting and observing researcher, who is willing to discuss and develop the teaching and evaluating results on a safe and interest-based level.
In the same way that participation and inquiry has become important in education in general, we think that this is also the situation for teacher education and teachers' professional development (PD). A way to include teachers as participators and owners of their PD, is to ask for best-practice experiences, and with this as starting-point together develop teaching further with input from research based ideas and results

Inquiry Based Science Teaching

Inquiry in the School Curriculum

As the Swedish Curriculum is goal oriented, there are no instructions for teachers about *how* to teach. However, most teachers are familiar with many different instructional approaches.

The Swedish school-system was influenced by problem based learning in the 1980s. The flexible learning, portfolio and storyline are educational concepts most teachers have come across. The website "Multimediabyrån [TheMultimedia Bureau]", supported by The Swedish National Agency for Education (www.skolverket.se), describes these instructional strategies, and provides material for enhanced variations of teaching and ICT skills. Probably most teaching in compulsory school still is "traditional", which is to say: the teacher is in control, and series of smaller teacher defined tasks are organized within separate subject disciplines. Learning takes place in the classroom, and the content is the most important aspect. Students' master knowledge through drill and practice, and content is not necessarily learned in context.

Most pedagogical influences in Sweden have been taken from US pedagogy. John Dewey's influence on the Swedish curriculum cannot be overestimated and his books are still used as sources for pedagogical discussions. In spite of the fact that "learning by doing" has been criticized since the 1970s, research finds that many inductive investigations without guidance still remain in schools; This was noticed and debated when Bergqvist, as a non- science pedagogue entered the optics lesson in a physics classroom and shared the pupils' confusion when they were supposed to discover for themselves the law of refraction, and to understand the teacher's analogies in this area (Bergqvist & Säljö, 1994). Recently Andrée (2007) has discussed inductive discovery still continuing in Swedish classrooms. In primary education learners' own planning of activities has gone far beyond what the older students do, in fact the independent planning of learning decreases rapidly with age! Few teachers go so far in using the inquiry process, that they become a facilitator or guide for the learner's own process of discovery and creating understanding of the world. Many teachers use parts of the new pedagogical "methods" and design a compromised learning environment or vary their teaching strategies. But, despite the freedom in the curriculum, many teachers follow text-book driven instructional methods. The pressure on time, and perhaps the lack of evaluation and appreciation, makes it easy to do as "always". ICT is perhaps the reason for teaching to change; assessments in the form of student powerpoint presentations are commonly used. We find that the Swedish curriculum empowers teachers to use IBST/L, but that educational development since the 1970s has involved many steps.

First the higher education problem-based learning "movement" increased interest in inquiry as such. *Secondly,* increased computer availability for teachers and students helped teachers to implement a variety of project based instructions into their classrooms. Many influences came from language learning and social sciences, and science education is seen as slow to adapt to new technology and to new educational paradigms. However, the entrance of education for sustainable development has given science education a "new chance".

Inquiry in Teacher Education

Most Swedish Teacher Education Programmes inform their students about teaching within the NTA-project (Science and Technology for All). This is integrated in one of the general courses within part one of teacher education, in this case the area of general educational science (but a new reform is coming in 2011).

NTA provides teachers with 14 units developed in the US, and another 4 units developed in Sweden. Each unit provides a teacher book, a pupil book and laboratory material for an entire class. Before using the "boxes", the teacher has to attend two general education meetings and two specific training sessions for every thematic area. The units are adapted versions of the Science and Technology for Children (STC) curriculum, developed by the National Science Resourses Center, NSRC, and Carolina Biological Supply Company, CBS. NTA is based on the Swedish national curriculum and syllabuses, but does not satisfy all the goals specified there.
The NTA programme started in 1997 as a project of the Royal Swedish Academy of Science (KVA), and the Royal Swedish Academy of Engineering Science (IVA) in cooperation with municipalities

throughout Sweden[23]. In April 2007 the participation had increased to 70 municipalities and 10 independent schools (a total of 66000 students and 4000 teachers).

[23] http://www.nta.kva.se/index.php?categoryid=39

Turkey

Education System

Basic Structure of Schooling

Children aged between 3 and 6 can attend pre-primary education, either in kindergartens, or for 5 and 6 year olds in nursery classes or practice classes.

The compulsory education equals the primary education and consists of the grades 1-8 (6-14 year olds). Primary education is free of charge. Compulsory core subjects at the primary level include mathematics, sciences and technology (Eurydice, 2009).

Pupils, having successfully finished their primary education, can start post-compulsory education, that is, the upper secondary and post-secondary level (ages 14-17). Pupils can then choose between general secondary education and vocational and technical secondary education. In the first year of secondary education, compulsory subjects include mathematics, biology, physics and chemistry. From the second year onwards, pupils in general high schools may choose to attend branches specialising in the natural sciences, literature, mathematics, social sciences, foreign languages, arts or physical education (Eurydice, 2009).

The following link gives a chart picturing the Turkish educational system: http://www.eie-surveyor.org/cd-complements/Bologna/Turkey.pdf.

Information about Quality

In the PISA 2006 assessment of scientific literacy, 15-year-old students in Turkey reached a competency value of 424 points and thus performed well below the OECD average of 500 points on the PISA scale (OECD, 2007; 2008). Of the 30 OECD countries only Mexico ranked below Turkey. The variance in the competency distribution in Turkey was quite small. Nearly half of the students were located below proficiency level 2 (OECD average 19.2%) which is defined as the achievement level at which students begin to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology. Furthermore, the amount of high achieving students (at proficiency levels 5 and 6) in Turkey is very small (0.9% compared to an OECD average of 9%). Turkey and Greece are the only two OECD countries in which girls significantly outperformed boys in science assessment.

The Teacher Education System

Initial teacher education (pre-service education)

Teachers for pre-primary and primary school hold a four-year bachelor's degree. This applies to both generalist teachers and specialist teachers (Eurydice, 2009). Generalist teachers or class teachers usually teach grades 1-5, whilst subject teachers work in grades 6-8. With regards to science education, class teachers get one-semester courses in chemistry, biology and physics, while subject teachers for primary schools get four-semester courses in chemistry, biology and physics as well as laboratory practice courses. Additionally the primary teacher education includes courses in science and technology education.

Secondary education teachers hold a five-year master's degree. At this level, all the teachers are subject teachers. Hence, the teachers at this level are much better educated in science and mathematics than teachers at the primary level.

Both the primary teacher programme and the secondary teacher programme include some practical training within one year of study.

The universities are responsible for pre-service teacher education in Turkey, but a national framework has been developed in this area and consequently all the universities offering teacher education programmes in Turkey will have the same courses and credit hours for the different levels. Access to university programmes depends on the score in the national entrance examination.

Status of the teaching profession

Teachers in Turkey are facing several challenges. First, only a small percentage of students graduating from teacher education programmes (especially in science fields) will get a position as a teacher (1-5%). In addition, teachers' salaries are comparatively low. Another challenge more specific to science instruction is that little support is provided to teachers implementing new curricula and new ideas in science education. Furthermore teachers struggle with large classes, a heavy work load with regard to numbers of teaching hours per week, administrative responsibilities and pressure on teachers, students and parents because of high stakes standard testing at almost every level of education. These factors are seen as hampering the efforts of change in the educational system. As a result, teacher students are often not very motivated because becoming a teacher was not their first choice as a study subject.

The workshop participants felt that teachers coming from the universities have profound scientific knowledge but they do not know how to teach it. Their studies have not prepared them to apply what they have learnt and to use their knowledge for good teaching.

The Turkish S-TEAM workshop showed that the majority of science teachers in Turkey are very young (less than 10 years of teaching experience), more than 50% of teachers do not communicate with their colleagues, more than 50% think that society does not appreciate them and does not value their work, 31% would change their job if they had the opportunity and 97% design their lessons based on the textbook.

Teacher professional development (in-service education)

The Department of In-Service Training under the Ministry of National Education is responsible for organizing training activities for teachers. Every year, an annual in-service training plan is prepared by the Department of In-service Training, in collaboration with other ministry departments. This plan includes: priorities and justification for the training; time, place, and date of the training period; training programme; the teaching staff who will give the training and the personnel who will receive the training. The stated purpose of in-service training is to help teachers and other ministry personnel to adapt to the new developments in science and technology, to increase their efficiency and to prepare them for higher level job positions. In-service teacher training in Turkey is highly subject-oriented. The following subjects are covered by in-service training: foreign language education; computer education; pedagogic formation education; education on preventing crime and violence in family, society, and educational environment; education for teachers' conformity to their environment and upper education programmes[24]. In other words, mathematics and science does not seem to be represented here. The nationwide training plan is mainly put into practice over two weeks during the summer holidays.

Regarding IBST in teacher professional development, it seems according to the Turkish S-TEAM partners that “the closest in-service training activity related to IBST may be those that aim at the introduction of the new Science and Technology Curriculum, since these new curricula are based on a philosophy that shares similar values to inquiry based teaching”. Further, teacher training programmes that address IBST have to some extent been applied with the support of Turkish Telecom Company[25].

Status of Teacher Professional Development

Information from the Turkish S-TEAM partners says that TPD is not successful in Turkey. This was also stated by top policy makers at the Turkish S-TEAM workshop. TPD programmes are reported to be too short to make an impact. There are no long-term training programmes. Moreover, most teachers do not value these programmes enough to learn from them. Thus, Turkey needs more effective TPD programmes, and it is said, especially for science and mathematics teachers. The workshop participants see a need to specify the qualifications which teachers should have, and to educate teachers based on these qualifications (there is already work going on with regard to this issue in Turkey).

Teachers' professional development in Turkey

An inspection system governed by the Ministry of National Education monitors the quality of education given in schools. Inspectors regularly visit classrooms (usually at the beginning and end of each school year and at any other time if needed) and give suggestions and ratings for each teacher and school, submitting their official report to their chiefs. There are five main categories of operation for inspectors: guidance and on-the-job training, inspection and evaluation, examination, investigation and research. Teachers are also provided in-service development opportunities at seven dedicated institutions nation-wide operated by the MNE. The ministry often cooperates with university faculty members in designing and running short term courses (one or two week) for teachers and inspectors. An immense teacher development effort is being implemented throughout the country for the renewed primary curricula and its approach to teaching and learning.

Inquiry Based Science Teaching

Inquiry in the school curriculum

It is reported from Turkey that IBST is included in the curriculum framework of science education to some extent. What this means in practice is not explicitly specified.

Inquiry in teacher education

The teacher education programmes in the science and mathematics fields include inquiry based science education, however, the extent and application varies.

[24] For more information: http://www.meb.gov.tr/

[25] http://www.vitaminogretmen.com/merak-ettikleriniz/omgep

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Section 3: Appendices

Appendix One: The SINUS Modules

(1) Further development of the task culture

Aims at a larger variety of tasks in mathematics and science instruction (e.g. tasks that allow for different ways of solving them) both in situations where a new concept or phenomenon is introduced and elaborated, as well as when skills are practised or knowledge is applied to new cases or situations

(2) Scientific inquiry and experiments

Focuses on more open forms of experiments that allow for active student participation, discourse among students about research questions, the planning and interpreting of experiments, and an understanding of the nature of science

(3) Learning from mistakes

Claims that mistakes are essential for learning, but should be avoided in assessment situations; students' conceptions and mistakes are viewed as opportunities for learning

(4) Securing basic knowledge – intelligent learning at different levels

Addresses the need for a common knowledge basis that all students are to achieve; takes into account the different pre-requisites for learning offering tasks that allow for solutions on different levels

(5) Cumulative learning – making students aware of their increasing competency

Aims at a higher coherence by linking the actual subject matter to the prior knowledge; also stresses the need for using and developing basic concepts in order to design cumulative teaching and learning sequences that make learning progress obvious for the students

(6) Making subject boundaries visible: working in an interdisciplinary way and a way that connects subjects

Aims at a better understanding of scientific phenomena by differentiating and linking the perspectives provided by the different scientific disciplines, mathematics, and other school subjects; allow for more complex and meaningful applications of science

(7) Promoting girls' and boys' achievement and interest

Focuses on gender differences with respect to interest and achievement; addresses possibilities for support, for example, by establishing differential courses or by embedding the content to be learned in contexts that are especially interesting for girls, but also for boys

(8) Developing tasks for student cooperation

Encourages students to verbalise what they think, to argue, and to deal with discrepant views and opinions, so that cooperative work will result in social learning as well as in cognitive gains

(9) Strengthening students' responsibility for their learning

Supports students' readiness and ability for self-regulated learning within the context of the particular subject; supporting strategies for the self-structuring and self-monitoring of learning are to be explored

(10) Assessment: surveying and providing feedback on competency increases

Takes into account that the type of assessment is of utmost significance for the success of instruction; aims at developing supportive feedback and assessment tasks that allow for the evaluation of students' progress beyond routine knowledge

(11) Quality assurance within and across schools

Aims at developing standards for science and mathematics instruction that are universally valid (and not only in the participating schools)

Appendix Two: Summary of WP6 Literature Reviews

Note: The literature reviews on which this section is based are not in themselves S-TEAM deliverables but have been produced as part of the Work Package 6 programme of case studies in aspects of professional development for inquiry. The summary provides additional background information and further references.

1) European University-Cyprus (CYCO): Supporting student inquiry in science

Inquiry-based Science Education

Teaching science through inquiry, especially "true scientific inquiry in the strictest sense" (Schwartz, Lederman, & Crawford, 2000, p. 7), provides the context for deepening understanding of scientific processes (NRC, 1996) and supports a more complex understanding of the Nature of Science (NOS) (Bianchini & Colburn, 2000). “Good science teaching and learning” has come to be increasingly associated with the term inquiry (Anderson, 2002) but challenges remain in defining inquiry and how this should look in the classroom. Descriptions in literature suggest either explicitly or implicitly, that the most important facet of scientific inquiry is empirical investigation (Russ, 2006).

Research recognises that deep conceptual understandings require the structuring of experiences to encourage curiosity, persistence and mediation (Lee and Songer, 2003; Bransford, Brown and Cocking, 2000; Vygotsky, 1978). Moreover, complex inquiry thinking requires the development of underlying science concepts and reasoning abilities such as building explanations from evidence or data (National Research Council, 2000). The development of complex thinking takes time (Bransford, Brown and Cocking, 2000) and ideally occurs systematically over multiple coordinated units and years. Through inquiry, students learn to carry out inquiry in the context of science content and develop epistemological understandings about the NOS, scientific knowledge and relevant inquiry abilities. CYCO take inquiry to mean the pursuit of causal, coherent explanations of natural phenomena (Hammer, 2004). Regardless of the form (experimental or theoretical), the instructional agenda is to help students learn to engage in that pursuit for themselves.

Teaching strategies for supporting student inquiry in Science

Nussbaum and Novick (1982) investigated a teaching strategy where students were made aware of their own prior conceptions and then engaged in “conceptual conflict” or “cognitive dissonance,” triggered by a “discrepant event”. Here, students express their ideas and interpretations as they try to understand the world and teachers use students’ statements to monitor understanding and progress. Teachers constantly encourage students to think more rigorously about familiar phenomena, to modify explanations in light of new information and to develop explanatory and problem-solving abilities (Smith et al., 1993).

Tzialli, et.al (2007), describe an exemplary teacher who “saw” learners as having the beginnings of abilities for scientific inquiry and acknowledged their need to refine those abilities. The authors highlight the need to develop better understandings of the process of teachers’ responding to students’ conversational contribution, and better understandings of the different types of “instructional/discourse moves” that can be used in different contents and contexts. Consequently, Tzialli et al (2007) feel that it is vital to provide as many details as possible (type and kind of repertoire of discourse moves, the context, the content) that influence a teacher’s moment-by-moment decisions. Thus, they focus on the process of deciding which discourse move to use, rather than only providing their descriptions.

Teachers' difficulties in promoting student inquiry

When inquiry is seen as the method for learning science "content", it is used as a teaching tool; when it is seem as part of the science teaching agenda, then teaching in science includes helping children to understand and use scientific inquiry effectively for learning about scientific phenomena, in addition to learning about the phenomena themselves (Louca & Zacharia, 2007). Furthermore there is no consensus regarding what productive inquiry entails, especially in early grades and it is not clear what teachers should be looking for and trying to promote. Controversies regarding children's developmental limitations and the implications of the current understanding for science education in contrast to the tangible and seemingly straightforward objectives of traditional content, explain why it is difficult to sustain instructional and programmatic attention to student inquiry, according to Hammer (1995). Moreover assessing student inquiry during class is challenging as it requires identification, interpretation and evaluation of students' scientific inquiry by the teacher before responding. In order to make progress in promoting student scientific inquiry, science education needs to develop a better understanding of nascent inquiry in classroom settings.

Scientific literacy involves knowledge of the processes that create the concepts and the organising framework that is science (National Research Council [NRC], 1996; American Association for the Advancement of Science [AAAS], 1993). Thus, if the goal of science teacher education is to prepare teachers to teach for scientific literacy, then instruction on the nature of science (NOS) should be an integral part of teacher education. A sound understanding of the characteristics of the NOS, the nature of the scientific knowledge and its construction has been a central component of scientific literacy for some years (AAAS, 1993; NRC, 1996).

Currently, there are three perspectives of NOS, where NOS is seen as developmental stages or beliefs, somewhat resembling cognitive development (King & Kitchener, 2004). Or the learner's epistemology is presented not as a unified whole, but deals separately with the different dimensions of the NOS, such as, structure, certainty and source of knowledge, (Hofer & Pintrich, 1997) where learners' views regarding each dimension are assumed to consist of semi-independent beliefs. In this second perspective, views about the NOS consist largely of comparatively stable, robust cognitive structures corresponding to articulate, declarative knowledge. These beliefs are taken to be the units of views about the NOS (Schommer-Aikins, 2004). Lastly, Hammer and colleagues (e.g., Hammer & Elby, 2002; Louca et al, 2004) suggest that the NOS are made up of resources, units of cognitive structure at a finer grain size than stages or beliefs. They understand people to have a range of cognitive resources for understanding the NOS and suggest that the difference between naïve and expert epistemologies lies not just in the content (views), but also in the form of the relevant cognitive elements.

2) University of South Bohemia (USB): Science-centred competitions to improve student motivation in science

Pupils in the Czech Republic consider science subjects as interesting and useful for life, but too difficult. Scientific and technical subjects are taught in a way which is considered as too graphical, unimaginative and too theoretical (see, e.g. Volf, 2005; Kekule, 2008; Svobodova, Sladek 2008). Students and educators agree that subject interest depends on the personality of the teacher and the quality of instruction.

Science competition – motivation for students and the tool for improvement and evaluation of education

Science and mathematical olympiads have gained considerable prestige at the national and international level. USB has been engaged in the Biology Olympiad for a long time. Therefore we use the BiO to demonstrate the importance of scientific competitions for improvement of interest and motivation in science.

What is the Czech Biology Olympiad (BiO)? (Cobut 2008).

The BiO is a competition with a long tradition and around 3000 students attend school rounds, about 350 attend regional competitions and the best go for the national competition. Students start at the age of 13 and finish at 19-20 years old. The International Biology Olympiad (IBO) is a competition for secondary school students and tests their skills in tackling biological problems and experiments. Interest in biology, inventiveness, creativity and perseverance are necessary. The Olympiad offers the opportunity to compare syllabuses and educational trends in biology in different countries. This is useful information for improving biology education on a national level. Contacts between the Ministry of Education, industry, teachers' associations, universities and schools, organising the BiO will lead to better understanding and communication about their respective activities in the field of biology (Cobut 2008; Farkac, Bozkova 2006).

There is no relevant research on students' motivation for the competitions and is covered in only a few publications e.g. Wilson (1981); Stazinsky (1988); Zoldosova, Held (2000); Seneklova (2008). These authors consider scientific competitions as an educational element, which supports motivation and scientific literacy. Skills and talent are developed through problem solving of tasks, experimentation, development of logical thinking and combinational or planning skills.

BiO offers at least two following possibilities for direct or indirect science teaching improvement: Participants of BiO provide data concerning motivation on which to base methods for the increase of pupils' motivation. Analysis of BiO tasks can bring new ideas for scientific inquiry and development of teachers´ repertoire of actions in relevant topics.

Intrinsic, interest driven and mastery-directed motivation, hypothesised for competition participants, is dealt with in Deci & Ryan (2002); Eastwell (2002); Midgley (2002); Elliot & Dweck (2005); Schunk, Pintrich &Meece (2008). The importance of self determined learning for development of interest is described by Deci and Ryan (2002) who suggest a functional model of interest genesis interest development takes place on two different levels of information processing: at the conscious-reflective level concerning decision about future learning goals and the emotional level which provides continuous and often non-conscious feedback about the quality and/or efficacy of the ongoing action. Here experiences play a crucial role for the fulfillment of the three basic needs

– competence, relatedness, autonomy. Competition tasks offer high levels of satisfaction of all three needs as they are within Vygotsky's "zone of proximal development of one's competence", the competition helps develop the sense of community of shared interest and the complexity of competition tasks offer broad space for student's autonomy.
Midgley (2002) describes the relation between students' achievement goals (the goal to develop ability - mastery vs. the goal to demonstrate ability or to avoid demonstration of lack of ability – performance goal); the learning context; and students' and teachers' patterns of cognition, affect, and behavior.
The relationship of competition and expectancy-value is discussed in Elliot & Dweck (2005). Competition encourages students to seek challenge. Those students who are mastery oriented, highly interested and participating in extra class activities, like olympiads, need further challenges for deveopment of their competence motivation. One of the most important sources of their motivation is the need to enhance their intellectual, interest-related skills.
Students' self-efficacy is related to adaptive academic behaviors, such as students' use of cognitiveand metacognitive strategies during online learning. In turn, by using adaptive learning strategies that result in "deeper and more elaborated processing of the information" (Schunk, Pintrich, & Meece, 2008), students are likely to experience greater academic success in the form of improved learning. These behaviors and the positive outcomes that result then feed back into the system, conveying to students that they are "capable of learning and performing well, which enhances their self-efficacy for further learning.

3) Aarhus University (AU): Improving teachers' capacities to motivate students

Framing the literature review

Our aim is to improve teachers' capacities to motivate students using key elements of contemporary motivational theory, in accordance with IBSE (cf. description in Rocard et al. 2007), which is seen as a central aspect of improving students' motivation in science teaching.

Danish students' motivation for school science

Recent reports (Osborne and Dillon 2008) claim that young peoples' interest is largely formed by the age of 14, but our Danish studies of physics (Krogh and Thomsen 2000b) and chemistry/biology (Andersen and Nielsen 2003; Andersen 2007) revealed that students going from lower secondary school to upper secondary school had very dynamic changes in their engagement in the different school sciences. New school settings, teachers with a different educational background, and new conceptualizations of subjects seem to influence students' engagement and interest in science.

Teaching strategies and style influence students' engagement with science.

We have been involved in most of the few studies concerning teaching strategies, students' engagement and how aspects of the school science subculture, teaching/learning strategies, and interaction in the classroom influence students' motivation, e.g. Krogh and Thomsen (2000a &b); Dolin et al. (2001); Krogh and Thomsen (2005); Krogh (2006); Andersen (2007) . Consequently we conclude that certain kinds of IBSE-oriented pedagogy or "orientations towards teaching" tend to improve students' motivation in school science.

- Students' subject-related Self-concepts (self-efficacy/sense of competence)
- Students' autonomy (allowing them to pursue personal/authentic learning goals and organize their own learning processes)
- Students' sense of relatedness to others in the classroom (peers, teachers).
- Value-orientations, as motivational constructs (e.g. situated goals based on values).

These social-psychological constructs serve as essential mediating devices that explain why IBSE-strategies tend to motivate.

Motivation in science classrooms - a multidimensional construct

We have observed a clear difference between studies performed by motivational psychologists and classroom intervention studies focusing on teachers' and students' motivational practice. The first are restricted to the exploration of a single theoretical motivational theory. In contrast, intervention studies are more practice related, and the complexity of active classrooms calls for a multidimensional approach. There is a growing realization (see Martin 2008) that narrow theoretical understanding has little to offer practical teaching and developmental issues. Pintrich (2003) has underscored the importance of considering, conceptualizing, and articulating a model of motivation from salient theorizing related to *self-efficacy, attributions, valuing, control, self-determination, goal orientation, need achievement,* and *self-worth*. The intervention studies mentioned above all share a common feature: their multidimensional and pragmatic approach to selecting and combining elements of a number of motivational theories. For the design of our teacher training modules and our teacher-training package, we will be using a similar approach.

Motivational theories and constructs of importance to our S-TEAM-project.

Guided by the research literature (Pintrich 2003; Martin 2008) and grounded in our experiences as teachers of secondary science education, we have decided to build our intervention around elements from a number of motivational theories. We list the selected theories, core components and constructs. (each theory is elaborated in AU full Lit review)
Self-efficacy: Bandura (1997).
Self Determination Theory: Deci and Ryan (Deci et al. 1991; Ryan and Deci 2000).
Attribution theory: see Pintrich and Schunk (2002)
B. Weiner has provided both rationale and important explication of the theory for use in educational settings (Weiner 1979).
Goal Orientations Ames (1992) notions of *Mastery/Performance*-orientations
Jagacinsky and Nicholls (1984). *Ego- and task-involvement*
Elliot (1997) *approach* and *avoidance* goals

Emphases for implementation of selected motivational theories in science education

Collaborative learning has been found to positively contribute to the self-efficacy of students in introductory science courses (Fencl and Scheel 2005), especially those requiring social interaction or creative and conceptual work.
Enactive mastery experience is the most influential source of efficacy information. Experiencing success is essential to boost confidence and the willingness to keep trying. Struggling learners must have assignments of moderate challenge, where they can succeed with moderate effort and strengthen their self-efficacy. The extent to which efficacy is built from enactive mastery experiences depends on Preexisting Self-knowledge Structures, Perceived Task Difficulty, Effort Expenditure, Selective Self-monitoring and Reconstruction of Enactive Experiences (see Bandura, chapt. 3 for more details) which all have potential for intervention. Verbal persuasion and feedback: in most classroom settings it seems more relevant to provide learners with formative and task-oriented feedback, which may convince them that they can manage the task (Margolis and McCabe 2006; Fencl and Scheel 2005). Physiological reaction: Struggling learners sometimes have a negative physiological reaction before, during and after engaging in a challenging task. Relaxation training and ways to challenge irrational thoughts might be helpful for some students (Margolis and McCabe 2006). Classroom investigations have shown that each of these instructional strategies can improve students effort and engagement, but they are mutually dependent and interact in a multiplicative manner (Ames 1992).

4) Helsinki University (HU): Professional development for increasing student motivation in science

Background

Though students claim that science is important most of them, especially girls, do not find science or related careers interesting (Osborne, Simon, & Collins, 2003). This dichotomy is the most critical factor that accounts for students' better understanding in science (Kim & Song, 2009). When inquiry activities are linked to everyday problems, constructions and manufacturing this enhances motivation.

Motivation

We base our analysis on Self Determination Theory (SDT) and theory of Interest. Ryan and Deci (2002), state a student's thinking has an important role in motivation either as self-determined/autonomous behaviour which arises freely from one's self or controlled behaviour as by interpersonal or intrapsychic force, like a curriculum or a task. The motivation styles in SDT are:

1) Intrinsic motivation based on the need to feel competent and self-determined.

2) extrinsically motivated behaviour performed for the sake of an expected outcome or reward.

SDT motivational features of a learning activity can be classified in five categories:

1. *autonomy-supporting activities/teacher*,
2. *support to students' feeling of competency*
3. *support to students' social relatedness,* through
4. *support to interest and enjoyment,* through
5. *science content* (new materials or new knowledge in science) and *context* (human being, occupations, technology or history).

Interest

Interest is seen as a content-specific motivational variable (Krapp, 2007), approached from two major points of view. *Personal interest* is topic specific, persists over time, develops slowly and tends to have long-lasting effects on a person's knowledge and values (Hidi, 1990). Pre-existing knowledge, personal experiences and emotions are the basis of personal interest (Schiefele, 1991). *Situational interest* is spontaneous, fleeting, and shared among individuals. It is an emotional state that is evoked by something in the immediate environment and it may have only a short-term effect on an individual's knowledge and values. Situational interest is aroused as a function of the interestingness of the topic or an event and is also changeable and partially under the control of teachers (Schraw & Lehman, 2001).

According to Hoffman (2002) an appropriate context where certain science content or topics are met or teaching and learning activity might have an influence on the quality of emotional experience, which is importance for the development of situational interest. Juuti, Lavonen, Uitto, Byman, and Meisalo (2004) surveyed Finnish 9th grade students' interests in physics in certain contexts. Girls were interested in topics referring to human being. Boys' experiences are more relevant to physics and technical topics whereas those of girls are more closely related to everyday life and health (Uitto, Juuti, Lavonen & Meisalo, 2006).

Inquiry for changing motivation and interest

Through the literature, it stands to reason that the inquiry activities in this module (text based inquiry, narrative as a personalized inquiry, inquiry in a school laboratory, and industry site visit) will provide students with balanced information and with motivation.

5) University of Leeds (UNIVLEEDS): Dialogic inquiry in science classrooms

Setting the scene: an increasing interest in classroom talk

Different studies of how meanings are developed through language in the science classroom have highlighted the importance of investigating classroom discourse and other rhetorical devices in science education (Lemke, 1990; Sutton, 1992; Halliday and Martin, 1993; Ogborn et al, 1996; Roychoudhury and Roth, 1996; Mortimer, 1998; Scott, 1998; Kress et al, 2001; Kelly and Brown, 2003; Mortimer and Scott, 2003). These studies signify a move towards research into understandings developed in the social context of the science classroom (Duit and Treagust, 1998). Moves are being made to engage students in the patterns of talk, or modes of 'argumentation', which are characteristic of science (see, for example, Driver, Newton and Osborne, 2000; Kelly et al, 2000; Duschl and Osborne, 2002). The notion of dialogic discourse seems to be a central part of all of these initiatives. Despite this widespread interest in dialogic discourse, the fact of the matter is that dialogic interactions are notably absent from science classrooms around the world (Alexander, 2001; Fischer et al, 2002; Wells, 1999).

Approaches to analysing and characterising classroom discourse

Systematic approaches

Systematic observation of classroom talk using a form of interaction analysis was initially developed to investigate the quantity and quality of teacher-student interactions (Amidon & Flanders, 1961; Amidon & Giammatteo, 1967; Anderson, 1939; Cogan, 1956; Flanders, 1967a, 1967b; Lewin, Lippitt, & White, 1939; Pankratz, 1967; Soar, 1965; Withall, 1949), typically involving some kind of 'tick-box' protocol against a pre-defined set of categories. A major criticism is its limitations in revealing the subtleties of the purposes/practices of classroom talk:

Discourse analysis approaches

Sinclair & Coulthard (1975) studied 'discourse analysis' from a sociolinguistic perspective, describing the moves in 'I-R-F' exchange structure, and with Mehan's I-R-E structure (1979) began the movement from 'systematic observations' towards 'insightful observation' directing attention to the structure of the discourse itself. Edwards & Mercer (1987) argued that these deal with the form of what is said rather than with what is said. Both IRE/F patterns have been used to criticise teaching practices which restrict students to responding to the teacher. Consequently, more exploratory patterns of talk were required, where students might make the initiation (Alexander, 2004; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Lemke, 1990), and to consider total patterns of talk in which the IRF/E exchange occurs rather than merely rejecting it (Wells, 1999). Today, the triadic coding of talk as I, R or F/E is difficult, if not impossible, to ignore in the analysis of any discipline of classroom talk.

Interpretative approaches

Douglas Barnes' (Barnes, 1971, 1973, 1976) seminal work explored the relationship between features of the talk and learning in relation to the social context and he is prominent in pioneering the tradition of transcribing lessons and using extracts as data. Edwards and Mercer (1987) argue that under teacher control, the process of education in 'pupil-centred' classes is one of cognitive socialization rather than of individual discovery.

A multi-level approach

Mortimer and Scott (2003) have proposed a multi-level framework, a product of an ongoing research of a number of years, (Mortimer, 1998; Scott, 1998; Mortimer and Scott, 2000), based on socio-cultural theory and developed from empirical analyses of classroom talk. The framework has been widely used (see for example: Aguiar Jr & Mortimer, 2005; Amos & Simon, 2007; Scott et al, 2007; Hennessy, Deaney & Ruthven, 2006; Mortimer & Scott, 2000; Southerland et al, 2005; Scott, Mortimer & Aguiar, 2006; Tachoua, 2005; Viiri, Saari & Sormunen, 2003), in probing how teachers guide meaning making interactions on the social plane of high school science classrooms by using different forms of discourse and patterns of interaction. Central to the framework is the concept of 'communicative approach' and provides a perspective on *how* the teacher works with students to develop ideas in the classroom.

Communicative approach

This approach focuses on whether or not the teacher interacts with students and whether their ideas are taken into account. Four fundamental classes of communicative approach are defined by characterising the talk along two dimensions, *dialogic-authoritative* and *interactive-non interactive*.

Patterns of interaction

This second aspect of Mortimer and Scott's multi-level analysis relates to patterns of interaction which Lemke (1990) refers to as triadic dialogue. Mortimer and Scott distinguish between *triadic* IRE patterns and *chains* of interaction generated when the third move prompts elaboration of the student's point of view and takes an **I-R-P-R-P-R-** form (where **P** stands for **P**rompt.

What do we mean by 'dialogic teaching'?

The term 'dialogic teaching' has significant variation in meaning, e.g. engaging in a dialogue; Wells' (1999) 'progressive discourse' where students refine and work on their ideas to generate a general understanding; Alexander's (2004) 'scaffolded dialogue' where dialogic teaching, lies between 'transmission' and 'discovery' approaches. Nystrand (1997), and Nystrand, Lawrence et al (2001), developed a scale, of classroom discourse as: Monologic: the main speaker, (the teacher), operates from a pre-determined 'script'' and Dialogic: the participants expand/modify others' contributions as one voice 'refracts' another'

Studies concur that monologic, traditional, dominative, authoritarian, teacher-centred, preclusive and direct approaches dominate teaching practice, while increasing evidence support the effectiveness, of more 'dialogic' approaches such as: *dialogic instruction* (Nystrand, 1997); *dialogic inquiry* (Wells, 1999); *dialogical pedagogy* (Skidmore, 2000); and *dialogic teaching* (Alexander, 2004).

Dialogic talk / Dialogic teaching distinction

Scott et al (2006) suggest that dialogic talk can be dominated verbally by the teacher, but yet be dialogic. Likewise, students can participate in answering the teacher's questions, and yet the talk can be authoritative thus breaking the bond between the dialogicity of the talk and verbal interactivity. The communicative approach places the authoritative and dialogic approaches together in one dimension, whereby shifting between communicative approaches is fundamental to teaching for meaningful learning, (Scott et al (2006). This means that in dialogic teaching, there is no preference of one type of interaction over the other because each one can have a certain function in a certain context and for a certain purpose.

6) Mälardalen University (MDU): Dialogic Inquiry

MDU focuses on episodes of dialogic inquiry where learners and teachers explore unplanned ideas, initiated by the developing dialogue in the class. Hurst (2002) describes "dialogue as a form of inquiry, but also a process". Dialogic discourse therefore gives rise to meaning-making, a dynamic that honours both the learners' own subjectivity and as it does the objectivity of the subject" (Hurst, 2002).

Education for sustainable energy

Climate change, decreasing oil resources and "security-conflicts" have resulted in a need for an increased level of competence in energy questions, primarily within the subject of physics. Education for sustainable energy is comprised of different aspects and a holistic way of working might be necessary (Hobson, 2006; SEET, 2008; Areskoug, 2006; Connecticut Energy Education, 2008). Students' understandings have been mapped in order to develop teaching for enhanced understanding (Andersson, 2001). Student explanations have a tendency to be marked by everyday language, and by non-scientific descriptions (Kesidou & Duit, 1993; Solomon, 1992; Wiser & Amin, 2001). It is especially difficult to learn scientific explanations useful for future society in areas where students already have a deeply rooted pre-understanding (Schumacher et al., 1993).
Recent science education research, has stressed the need to shift focus from students learning scientific content, towards schools promoting a culture of *scientific literacy* for all. This can be done by allowing the learners to become involved in science language and to use inquiry-based methods (Millar & Osborne, 1998), where students work with awareness in a process to define problems, critique experiments, see alternatives, plan investigations, suggest hypotheses, debate with peers and others, and formulate coherent and fact-based arguments (Blumenfeld et al., 1996; Driver, Newton, & Osborne, 2000).

Writing in Science.

There are two main reasons why writing should be an important part of teachers' instruction: Firstly, writing is an important learning strategy, and secondly, writing is part of the culture of each content subject. Writing is thus a powerful means to help the students develop their everyday, concrete, informal language use (*primary discourse* according to Bachtin 1986, 1997) and acquire the abstract, scientific language use of school (*secondary discourse* according to Bachtin 1986, 1997).
International research refers to *Writing Across the Curriculum* (WAC), which stresses writing-to-learn-strategies and *Writing in the Disciplines* (WID), which stresses the terminology of each subject, its linguistic style and requirements of the texts, specific to each subject. International (e.g. Berkenkotter & Huckin 1997, Clark Ivanic 1997, Schleppegrell 2004) as well as national research (e.g. af Geijertsam 2006) shows, however, that writing strategies are seldom used by teachers of content subjects and the development of the secondary discourse argumentative writing is vital. This kind of writing is regarded difficult and problematic, though (Andrews 1995, 2005).
Halliday and Martin (1993), show that the language used in natural sciences requires that the students receive competent guiding in text structure and the use of typical concepts. Wellington and Osborne (2001) survey teachers' and students' use of language for communication and learning as well as for the development of concepts and building of theories.

7) University of Jyväskyla (JyU): Dialogic Teaching

JyU investigates inquiry-based and dialogic science teaching and learning in relation to the pedagogy of global warming. According to Wells (1999), in order to reach a complex level of inquiry-based learning, inquiry should consist of three main phases:

- Launching, (students' pre-knowledge and interest areas are accessed),
- Inquiring (conducting, interpreting, and displaying results) and
- Reflecting (students evaluate and reflect on the process).

Complex inquiry tasks including authentic reasoning certainly cause dilemmas concerning the range of methods and content to be encompassed in science teaching. Inquiry-based learning has the potential to engage students to dialogic interaction, if they adopt appropriate discursive strategies like exploratory talk (Mercer & Littleton, 2007). Wells and Ball (2009) discuss whether inquiry orientation to curriculum indeed increased the amount dialogic interaction involving also the exploratory talk.

Although scientific inquiry seems to increase exploratory talk, it is still important to use a variety of communicative approaches in order to make learning meaningful (Scott & Amettler, 2007; Mortimer & Scott, 2003). It has been reported that Finnish pupils appreciate teachers leading discussions when working with difficult topics and problems (Juuti, Lavonen, Uitto, Byman, & Meisalo, 2009). Even though it is important to give students opportunities to share their knowledge, the role of the teacher as an orchestrator of the classroom discussions and guided inquiry should not be forgotten (Saari & Sormunen, 2007).

During the S-TEAM JYU project our students concentrate in developing teaching-learning sequences of global warming.

Global warming as a case of sustainable education development

Climate change as a result of the accelerated greenhouse effect, i.e. climate warming, is having huge social, environmental and economic consequences and so we need to research and implement both global and local solutions in order to adapt to climate change. How individuals understand and conceptualize complex climate warming plays a crucial role when evaluating their impact on climate. Climate change has become an issue for discussion in the science classroom which affects the abilities of future decision-makers to solve problems and to make appropriate decisions. School curricula and policy documents, now stress the importance of developing pupils' decision-making skills based on science. According to studies, traditional instruction has not achieved results which indicate pupils' understanding of climate change. There remains a need for more information about pupils' conceptual change during teaching

Conceptualization of the Greenhouse Effect and the Dialogic teaching

People's factual knowledge and conceptual understanding of climate warming and the greenhouse effect are incomplete and often misleading (Rickinsonin, 2001). Many people regard the greenhouse effect only as an environmental problem and not as the necessary phenomenon that regulates the Earth's climate. Researchers have found that student teachers know the basic facts about climate warming, but their knowledge is atomistic (Ratinen, 2008). It is not only students but also teachers who have misconceptions and misunderstandings about climate warming (Papadimitriou, 2004),

probably passed on to their pupils.
Primary pupils think that the environment deteriorates, plants and animals are infected by pollution, and the air becomes dirty, which prevents heat from re-radiating and therefore the climate is hotter (Koulaidis & Christidou, 1999). Jeffries et al., (2001) found that more students held misconceptions in their later study than 10 years earlier. Groves and Pugh (2002) found that students held on to their misconceptions even after instruction. According to Andersson and Wallin (2000), students cannot distinguish the greenhouse gases correctly and, for example, they believe CFCs are responsible for the climate warming because they destroy ozone, and create the ozone hole that allows UV rays to reach the earth.
Recently, students' views on global warming, their beliefs and willingness to decrease it have been an important research area. Boyes et al., (2008) indicates that altering beliefs about the usefulness of one's own action is not expected to produce noticeable changes in behaviour. Lester et al. (2006) point out that, pupils with adequate science knowledge tended to express more activism toward global warming.
Earlier studies identify seven scientific processes to which pupils' answers and analysis during dialogic class would help to discern different levels of understanding depicted by the concept categories. Moreover, three major entities, figurative, model and molecules (see Lin & Hu, 2003), can be used for the understanding of the greenhouse effect.

8) University of Copenhagen (UCPH): Cross-curricular & interdisciplinary approaches to science education

Aikenhead, Fensham, Orpwood & Roberts (2009) frame scientific literacy from the perspective of the two visions developed in Roberts (2007) as Vision I and Vision II. Vision I includes basic concepts in science, the nature of science and the ethics which influence the work of scientists while Vision II emphasizes the interrelationships of science and society and science and the humanities and the differences between science and technology. From an educator's perspective, they see seven types of school science. The relationship between science content and curriculum construction is divided into institutional discourse, programmatic discourse and classroom discourse, with implications for all and identify 'pitfalls' of using Vision II for curriculum design. Airey, Kelly, Linder & Martins (2009) contribute with the insight that basically Vision I is an 'inward view' of looking at science in a 'fundamental sense' while Vision II faces 'outward' in a derived sense. Both are important to curriculum design and teacher professional development as frames of reference in making curricular and teaching decisions.

Almqvist, Brickhouse, Lederman, Lederman, Ligozat, Östman, Sadler, T.D., Wickman, O. & Zeidler, D. L. (2009) discuss applications of scientific literacy to practice where conceptualization of scientific literacy falls short of the mark if moral reasoning, ethical considerations and character development are not a part of our understanding. Scientific literacy can provide an epistemological context for students' conceptual understanding of important scientific and social matters. In doing so, a more inclusive stance of Vision II of scientific literacy becomes necessary. Socioscientific reasoning advanced as a construct, can best provide a means of linking school science literacy to scientific literacy and help in addressing key 'core questions' related to scientific literacy.

Douglas A. Roberts (2007) offers Visions I and II for looking at scientific literacy. He clearly discusses the nuances and implications for teaching and learning. His conclusions, important for PD are that there will be differences in student outcomes, assessment frameworks, curriculum and teaching, ability of teachers to talk about science with each other depending on which of the two visions or combination are used. Additionally different 'discourse universes' are folded into the two visions and hence there are large societal implications that need to be considered in teacher professional development. Bulte, Erickson & Tiberghien (2009), bring the Roberts (2007) concept of Vision II to the personal level of both students and teachers stressing its impact the personal development of teachers and students.

Atlas of Science Literacy (2001). AAAS Project 2061 and the National Science Teachers Association a two-volume collection of conceptual strand maps show how students' understanding of the ideas and skills that lead to literacy in science, mathematics, and technology might develop. The detailed concept maps are road-maps for teacher PD that link concepts from both Vision I and II to teaching and learning competencies and goals..

9) Abo Akademi University (ABO): The use of open investigations and Vee-heuristics within science education

According to constructivism, knowledge cannot be transferred but must be constructed (Tobin & Tippin, 1993). Learners' existing knowledge is important for the construction of meaning. Knowledge is an individual and social construction, constructed through interaction with peers and teachers. Teachers represent the scientific community and must ensure that essential concepts are available when students need them to understand their own investigations. When students form the meaning of experiences they engage in thinking, feeling and acting (Novak, 1998). Meaningful learning occurs when learners relate new information to ideas they already possess. Students should be encouraged to articulate and share their ideas (Lunetta, Hofstein & Clough, 2007) in laboratory work where problems can challenge their thinking (Hacklin & Fairbrother, 1996).

When students work with open investigations in the laboratory they plan their work themselves (Lunetta, 1998; Garnett & al., 1995). In the problem-solving process, students may develop their logical argumentation and rational thought, which supports a sense of self confidence (Driver, 1985). The teacher as a coach, designs the task in a challenging way, appropriate to the students' current abilities (Roth, 1995) and supports the students. The Vee-heuristic was developed by Bob Gowin in order to help students and instructors clarify the nature and purpose of laboratory work in science (Novak & Gowin, 1984). In this study, students work with open investigations together with Vee-heuristics. When students plan their own investigations they gain a greater control of their work, a sense of ownership of their investigations, which can positively affect their interest. When, together with their peers, they manage to solve problems in the laboratory, their self-concept in chemistry may be influenced in a favourable way

10 Gazi University (GU): Interactive computer animations in IBST/E

State of science teaching in Turkey

Studies suggest that science education in Turkey had several inadequacies such as curriculum, teaching techniques and methods, equipment, teacher competencies (Kartal and Okur, 2001). Güver, (2004) emphasized that science education in schools is diminishing children's natural curiosity. Since science labs were regarded as unnecessary and used as regular classrooms, most equipment is either broken or not usable. Teachers accept that student centered education is not possible in crowded classrooms, demonstration activities are done for the sake of doing them and their relevance to real life is not understood by pupils. Science is taught by the blackboard and chalk technique, sometimes involving problem solving, having definitions written down, and infrequent question-answer episodes. In its current state science education is teacher centered, relies on memorizing facts and involves the teacher as the figure of authority.

Science and Technology education in Turkey

A feature of the new curriculum (2005) is that technology education is now being integrated into primary science education as 'Technology and Design'. Teaching – learning environments are now designed to allow both minds-on and hands-on learning experiences so that pupils can have positive science learning experiences, which result in a positive attitude towards learning science in later years. With the rise of the Science-Technology-Society (STS) movement in the field, related understandings, skills, and attitudes and values have all become integral components of almost all science and technology curricula. The new curriculum has four content strands while an additional three strands (Science – Technology – Society – Environment Outcomes, Science Process Skills Outcomes, and Attitudes and Values Outcomes) are interwoven into these. Embedding these outcomes indicates the intent of engaging pupils in student-centered activities while learning content. Learning by doing is seen to be a central pillar of the new curriculum, as well as alerting teachers to widespread and persistent misconceptions, which are often held by teachers themselves. Alternative formative assessment and measurement techniques rather than paper and pencil tests are preferred, from student portfolios and group activities to peer evaluation. Learning activities are enriched by inquiry, problem solving and cooperating with others which require that pupils should be actively engaged (Bağcı, 2003) in order to reach a conceptual understanding while teachers encourage them to question, formulate their own ideas and conclusions. The constructivist approach of the curriculum is inquiry learning based on the tenets of discovery learning, inquiry planning, gaining psychomotor skills, problem solving, and cooperative learning.

How students learn science

The constructivist approach stresses that learners come to the learning environments with pre-conceptions often not scientifically acceptable. Knowledge cannot be transferred but should be constructed in interaction with the social and physical environment. The teacher as a facilitator of learning designs activities and environments in which students can construct an understanding compatible with the scientifically acceptable one. It is critical to evaluate and make students aware of their initial conceptions about the phenomenon being examined. Thus formative diagnostic instruments play a vital role in examining these conceptions, understanding the learner and providing meaningful feedback in order to guide their learning processes.

11) Vilnius Pedagogical University (VPU): Inquiry based methods and integrated teaching in science.

Understanding of the inquiry-based method

Inquiry-based methods consist of two dimensions. As a learning method, it is based on research and experiments and from this we obtain a narrow understanding of inquiry-based method: problem teaching, teaching how to generalize, formulate conclusions and to apply them in new situations. The application of knowledge in new situations can broaden this understanding of inquiry-based method and take it closer to inner and inter disciplinary integrated teaching. It is necessary to shift pupils' knowledge from one subject into another in each interdisciplinary teaching situation (horizontal shift). This shift of knowledge provides new character, creates problem situations, and encourages pupils to acquire new information or envisage new aspects of the knowledge acquired. A similar psychological situation is created applying inner integration, where vertical shift is used (more intricate competences and skills are formed).

After independence in 1990, Lithuania started to change its educational system. Using the experience of foreign countries, a national school was formed where the teaching style change was sought moving from academic to basic literacy, from knowledge to skills, and from theory to practice, and thus interpretative educational system was created. Teaching methods were changed from lecture-type teaching to various active teaching methods (Dudaitė & Jolita 2006).

The analysis of national (Lithuanian) literary sources was carried out according to these principles:

- ◊ *Inquiry-based* method is a method based on research and experiments;
- ◊ *Inquiry-based* method is a method of problem-oriented teaching and learning;
- ◊ *Inquiry-based* method is a method of inner and interdisciplinary integration.

The use of inquiry-based method during science lessons in Lithuanian schools.

Inquiry-based method is regulated in Lithuanian General Programs for general schools (http://www.pedagogika.lt/index.php?-469374926) where integrated and exploratory teaching is emphasized, Interdisciplinary relationships is also a very important principle and is implemented in different levels of general education. An integrated course of natural sciences is taught at 5–6 grades, consisting of Biology, Ecology, Chemistry, Physics, Earth science, Health education, and Technology (some elements of Geography are integrated at the 5th grade, while it becomes a separate subject from the 6th grade). Biology, Chemistry and Physics become separate disciplines at 7–8 grades, but strong interdisciplinary relationships remain. These courses are not integrated at 9-10 grades. Inquiry-based method is used in after-school lessons as well.

Projects having exploratory elements are quite popular in Lithuania, at school, district or town, national and international levels. Project-based learning is used in science education quite often and is developing during informal education[26]. This method helps pupils to become active participants of

[26] *Nacionalinis 4 ir 8 klasės moksleivių pasiekimų tyrimas*. (2003). Lietuvos švietimo ir mokslo ministerija. Švietimo plėtotės centras. Nacionalinis egzaminų centras. (in Lithuanian) [*National research on 4th and 8th formers' achievement*]; see also Valentinavičienė (2005)

an education process and helps to improve inner and interdisciplinary integration.

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