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Socrates

IQST

Improving Quality of Science Teacher Training in European Cooperation – Constructivist Approach

Compendium

2007

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FOREWORD

Project IQST Improving Quality of Science Teacher Training in European Cooperation – constructivist approach is a project under the Socrates – Comenius 2.1 programme of the European Commission.

In all of the participating countries one can observe a lack of science teachers, mainly of physics and chemistry teachers, as well as a lack of students in this teacher training. There is no doubt that science teaching has a crucial role to play in shaping the future development of EU.

The aim of this project is to implement newer pedagogical theories into initial science teacher training. The constructivist perspective is becoming a dominant paradigm in the field of the science education. This approach in the initial science teacher training is not still too common at many European teacher training institutions. We want to design and produce new modules for science teacher training in the international cooperation between higher institutions of initial teacher training in five European countries. Modules produced will be used by lecturers with their students at science teacher training institutions. We also want to introduce new pedagogical methods based on constructivist approach in science teacher training.

This Compendium contains the description of initial science teacher training in cooperating countries, needs and competencies of constructivist science teacher and the description of the modules.

Project Team

The project participants are the initial teacher training institutions in five European countries:

Palacký University Olomouc (Czech Republic),

University of Cyprus (Cyprus),

Siauliai University (Lithuania),

University of Plovdiv "Paisii Hilendarski" (Bulgaria),

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CHAPTER 1

INITIAL SCIENCE TEACHER TRAINING

General Background

Prepared by: Danuše Nezvalová

An important task of science education is making science more relevant to students, more easily learned and remembered, and more reflective of the actual practice of science. Science education in EU has many proposals how to improve quality of science education. The science teacher training is very important part for the future quality of science education.

Students should be taught in ways that they recognize knowledge as a powerful means for solving problems and that it can be useful also in everyday life. Therefore learning and instruction should be anchored in meaningful situations and connected with important events (Brandsford et al., 1990).

Science teacher training has to provide new frameworks to pre-service teachers and to seriously consider new teaching practices. New perspectives on teaching tend to conflict with the pre-service teachers' previous and dearly held conceptions of teaching. Every pre-service teacher is itself an insider concerning the future profession due many years of experience as a student in school. Therefore, any implementation of new teaching strategies tends to face conflict. However, changing teaching practices at any point of a teacher career is a difficult and stressful process due to complex social and intellectual frameworks that both enable and constrain efforts to change. However, the pre-service training as an individual struggle period for an formation of an own professional identity as a particular kind of teacher might provide the most likely time period to achieve the higher quality of science education. In nearly all European countries teacher training is in the process of transition and most turbulent, but interesting times, with new challenges seem to be ahead.

Constructivist Teaching and Teacher Education: Theory and Practice

While a great deal has been written in recent years about constructivist learning theories and their applications to elementary and secondary school classrooms, much less has been said about these implications of these ideas and practices for teacher education. It is a reason why a group of science teacher educators from five European countries (BG, CY, CZ, LT and TK) focused on this topic.

Science Education Research has shown the existence of striking differences between the goals of curriculum developers and what teachers actually practice (Cronin-Jones 1991). Those differences have called attention to the influence teachers exert in the implementation of science curricula in high schools. The issue is a major one in a field such as for instance physics that foresees drastic curricular changes (some of which have already been implemented) on this level. On the other hand, there is a high percentage of students who fail in physics and students' negative attitudes towards science and science learning grow steadily (Yager and Penick 1985).

Those results have broken simplistic views about science teaching as an activity which demands just a sound scientific knowledge and some experience. In other words, those results have made clear that teacher training can not be reduced to just scientific courses, as it has been usually. A possible solution which has been tried in many countries is to complement the scientific courses with other courses about Education. Which are the results of this orientation?

As McDermott (1990) has shown, university physics courses generally do not provide the type of preparation that teachers should have:

- the lecture format of the classes stimulates passive learning; the prospective teachers are more accustomed to receiving than to imparting knowledge;
- the standard problems developed in the classroom lead to algorithmic, repetitive, solutions, and fail to stimulate the type of reasoning necessary to approach new situations such as unforeseen issues that students may raise;
- laboratory work calls for sophisticated material not available in secondary schools, and above all, it is restricted to mere verification, like cooking recipes, which gives a reductionist and distorted view of scientific activity.

On the other hand, courses on Education are totally separated from instruction in content, and teachers can not see the interest of those courses in the treatment of their specific teaching and learning problems. No one questions the need for teachers to have in-depth knowledge of what they are to teach. It may seem superfluous to state this point if we take into consideration that, in many countries, teacher training is virtually limited to science courses plus some pedagogical disciplines (Carvalho and Vianna, 1988).

Recent research in science education shows that teachers have ideas, attitudes, and behaviors related to science teaching based on a lengthy "environmental" training period - the period in which they themselves were students (Hewson and Hewson, 1988). The influence of this incidental training is enormous because it corresponds to reiterated experiences acquired in a non-reflexive manner as something natural, thus escaping criticism.

In fact, as Bell and Pearson (1992) have pointed out, it is not possible to change what teachers and students do in the classroom without transforming their epistemology, their conceptions about how knowledge is constructed, their views about science.

We have to refer here mainly to the constructivist approach, which is considered today as the most outstanding contribution to science education over the last decades (Gruender and Tobin 1991, Moutmer 1995), integrating many research findings. Educators need to understand, very particularly, that:

- Students can not be considered as 'tabula rasa', They have *preconceptions* or 'alternative frameworks' which play an essential role in their learning process (Viennot 1979, Driver 1986), obliging guiding science learning as a 'conceptual change' (Posner et al 1982) or, better, as a conceptual and epistemological change (Gil and Carrascosa 1990, Dusch and Gitones 1991);
- A meaningful learning demands that students *construct their knowledge*;
- To construct knowledge students need to deal with problematic situations which may interest them;
- The construction of scientific knowledge is a social product associated with the existence of many scientist teams; this suggests organizing students in small groups and facilitating the interactions between these groups (Wheatley 1991) and the scientific community, represented by the teacher, by texts, etc;
- The construction of scientific knowledge has axiological commitments: we cannot expect, for instance, that students will become involved in a research activity in an atmosphere of 'police control' (Briscoe 1991).

The most important thing is that all these contributions constitute related components of an integrated body of knowledge which is generating the emergence of a constructivist teaching/learning model, capable of displacing the usual transmission/reception one.

We have already referred to the ineffectiveness of simple transmission of knowledge, through manuals or courses, in the training of teachers. Such procedures have failed to prepare teachers for new, constructivist oriented, curricula (Briscoe 1991). For many, this constituted an unpleasant surprise: How is it possible that motivated teachers, who participated voluntarily in seminars and courses with the intent of mastering new methods and renewing their teaching, go on teaching as they have always done adapting the innovations to the traditional ways? Teachers themselves are frustrated when they have to affirm that things do not work better than formerly, despite the innovations. This ineffectiveness of the simple transmission means that other strategies of training are required. Investigations into the learning of science provide valuable suggestions of what these strategies might be.

Teachers, like students, have preconceptions. Just as pupils' learning of science is conceived of as conceptual, epistemological and attitudinal change, so should teachers' learning of didactics. Teachers' knowledge, like students', must build on the previous knowledge they have. There is a close parallel between how change occurs in conceptions of science and how it occurs in conceptions of teaching.

There should not, however, be a mechanical transfer of strategies used with pupils. Constructivist theory led to some teaching strategies and addressed conceptual change explicitly and directly. Driver and Oldham (1986) summarised such strategies as sequences of 1) identifying pupils' ideas; 2) questioning those ideas, using confronting examples to produce cognitive conflicts; 3) introducing concepts elaborated by scientists, that resolve the conflicts; and 4) using the new ideas in various contexts to promote their full assimilation. If a similar procedure were applied in teacher training, we would elicit beliefs about teaching and learning, then create cognitive conflicts to prepare the teachers for new conceptions, which they would have to be shown are effective in practice.

Such a procedure can quickly produce positive results, as it relies on common sense ideas that many accept uncritically as evidence. After the first impact, however, it becomes an "evil" strategy. What is the consequence of having teachers make explicit their ideas and then questioning their validity? It generates a reserve that inhibits the desired change. In the same way, this argument allowed us to appreciate that the strategy is inadequate for changing pupils' conceptions of science (Gil et al. 1991; Gil & Carrascosa 1985, 1990, 1994), although with pupils the resistance to systematic questioning of their conceptions is not so obvious.

There is another reason why such strategies can inhibit construction of knowledge. They focus on problems, in which prior knowledge and new ideas are brought together in a tentative way. In this process the initial conceptions might suffer change or even be questioned radically, but this is not the immediate objective - that remains the solution of the problem that has been posed.

This raises an issue concerning the cognitive conflicts: they will not mean an external questioning of the personal conceptions, nor the systematic recognition of the insufficiencies of one's own reasoning, with its consequent affective implications, but a confrontation of personal ideas, taken as hypotheses, with other hypotheses, as personal as preceding ones. We do not propose to eliminate the cognitive conflicts, but to prevent them from appearing as a confrontation between the personal wrong ideas and the scientific correct ones.

Besides, it is important to take into account that the study of preconceptions has aimed, so far, to detect what pupils, and, now, teachers too, answer in an immediate reply to certain questions; more important than that is what they should have answered if they would have time to reflect critically. Actually, if a collective work of certain depth is facilitated, teachers and pupils are able to question those conceptions uncritically assumed and to construct knowledge consistent with that accepted by the scientific community.

The foregoing considerations suggest that a more fruitful strategy for teacher change consists in involving teachers and prospective science teachers in research in their own classrooms into teaching and learning of science. In this, teachers might be major members of autonomous teams involving researchers and innovators in the teaching of science. Such a strategy would have the following characteristics:

- Be conceived in an intimate connection *with the teaching practice itself,* as treatment of the teaching/learning problems posed by such practice.
- Oriented to favour the *experiencing* of innovating proposals and explicit teaching reflection, questioning "spontaneous" teaching reasoning and be-

havior, that is, questioning the "natural" character of "what has always been done".

- Incorporate teachers to the investigation and innovation in science teaching.
- Involve them in the construction of the specific knowledge body of science teaching and incorporate them to the scientific community in this field.

Constructivist teacher education is defined as working with teachers in a constructivist way, helping them to re-examine and reflect about the tacit ideas they bring to their education for science teaching. Two quite different forms of constructivist teacher education are being advocated: to teach students how to teach in a particular constructivist manner and how to apply these approaches to the teaching of particular subject matters. The challenge for constructivist teacher educators is to develop an approach to teaching that does not contradict the content of the course – that is, constructivist teaching – but acknowledges differences in the nature of constructivist teaching depending on the subject matter that is being taught.

The philosophy of science is a special informant about the nature of constructivism. Much of scientific knowledge consists not merely on the phenomena of nature, but also on the constructs advanced by the scientific community to interpret and explain nature. Constructivism is a way of thinking about the events of teaching and learning.

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Structure of Science Teacher Education

The structure of the science teacher education programs has usually two parts:

1. Subject knowledge: academic studies in the license subjects;
2. Professional subjects: educational studies, professional studies, school practice.

Depending on whether the same institution is responsible for both academic training and the professional preparation of teachers, two basic models of program structure can be distinguished:

1. Two phases model of teacher training: There is a distinction between theory (what is taught at the University) and practice (what is taught by practitioners). The professional preparation is often provided by special institutes outside the university.
2. All programs contain both academic studies in one or more subjects and professional studies. Here the curriculum organisation comes in three types:
   - An integrated program, which means that academic and professional studies are to a large extent integrated.
   - A parallel or concurrent program, which means that academic and professional studies are taking place concurrently.
   - A consecutive program, which means that at first academic studies are completed and then followed by the professional studies.

Content

The program prepares candidates to structure and interpret the concepts, ideas and relationships in science that are needed to advance student learning in the area of constructivist teachers. Content refers to:

- Concepts and principles understood through science.
- Concepts and relationships unifying science domains.
- Processes of investigation in a science discipline.
- Applications of constructivism in science teaching.

Knowledge is a conceptual model through which the individual makes sense of the world (Sternberg, 1985). Shulman (1986) identifies three dimensions of professional knowledge important to the teacher: content, or subject matter knowledge; pedagogical content knowledge; and curricular knowledge. Content knowledge consists of the concepts and relationships constructed through professional investigations in the natural sciences, and the processes of scientific investigation.

Constructivism emerged from the realization that pre-existing knowledge influences the way new knowledge is added to the individual's conceptual model, modifying its subsequent meaning (Stahl, 1991). Educators increasingly understand that private knowledge - the true conceptual framework of the individual - may differ considerably from the public knowledge of science. Therefore the goals of formal education have shifted from the relatively straightforward process of transmitting information to the more complex task of facilitating development of a meaningful conceptual framework (Brophy, 1992).

Stalheim-Smith and Scharmann (1996) and Stoddart et al. (1993) found that the use of constructivist teaching methodologies and learning cycles--methods often emphasizing concrete learning--can improve the learning of science by candidates in science education. A second major problem in many courses taught traditionally is their emphasis on rapidly learning large amounts of unintegrated factual information. Major concepts are poorly delineated from less important concepts, and few concepts are learned in depth. This is in contrast with an approach in which fewer, well-selected integrating concepts are carefully linked to form a framework for further learning. A third problem lies in the division of knowledge, for convenience, into disciplines and fields. Such divisions may constrain the development of linkages among concepts across fields and so inhibit the development of an integrated cognitive model.

The content knowledge of the prospective science teacher is developed primarily in science courses taught by science faculty. Assigning the development of the skills and knowledge required to one or even several science methods courses is unlikely to produce the depth of understanding needed for effective teaching practice. All science teacher candidates should be provided with a carefully designed, balanced content curriculum leading to a demonstrated knowledge of the concepts and relationships they are preparing to teach.

To the greatest extent possible, science content should be taught in the context of investigation. Opportunities should be provided for all constructivist science teacher candidates to participate in a range of laboratory and field investigations, and to complete one or more projects in which they design and carry out open-ended, inquiry research and report the results.

In the constructivist science teacher preparation programs, content is integrated with pedagogy and includes considerable laboratory instruction, including inquiry. There is a clear justified rationale for selection of content based on a careful analysis the needs of practicing teachers. These programs integrate science instruction across fields and prepare candidates with a broad unified science background, in addition to specific preparation. In the best programs, science instruction includes deliberately planned linkages among related concepts in chemistry, physics and biology. Experiences with the analysis and interpretation of data are regularly provided in content courses, as are opportunities for engaging in conceptual development through open-ended inquiry and research in the context of science (rather than science education). The best programs develop a variety of science-related skills, engaging students in active science learning in a variety of contexts. Candidates from these programs have a demonstrably strong conceptual framework in science grounded in experience, are confident in conducting research and inquiry, and can collect and interpret data meaningfully.

Science teacher preparation is described very widely. It is necessary that new science teachers gain applicable knowledge and appreciation of each of the aspects of science teaching with competencies of constructivist science teacher. Without competency in and subscription to constructivist science teachers, new teachers will not successfully teach all students for understanding and application utilizing a broad vision of science.

We believe a constructivist model better reflects the challenges and consequences involved in science teaching.

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Case Study 1

INITIAL SCIENCE TEACHER TRAINING IN BULGARIA

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The structure of the educational system

The structure of the educational system in the Republic of Bulgaria is composed of the following levels: preschool education, school education (primary and secondary) and higher education. Figure 1 illustrates these levels; the numbers on the top of the figure represent the age of the pupils.

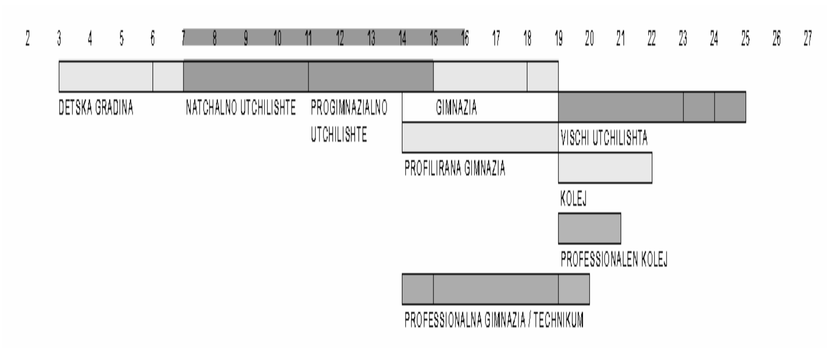

Figure 1. Scheme of the Educational system in Bulgaria

Preschool education [**DETSKA GRADINA**] includes children from 3 to 6/7 years of age. Kindergarden attendance is compulsory only at the age of 6 and the classes include preparation for reading skills.

Basic education in Bulgaria, which is for children from 7 to 15 years of age (1st form through 8th form) includes **primary school** stage [**NACHALNO UTCHILISHTE**] and a **pre-secondary** one [**PROGIMNAZIALNO UTCHILISHTE**]. The pupils in the primary school (1st form through 4th form are from 7 to 11 years old. Those in the pre-secondary stage (5th form through 8th form) are from 11 to 15 years old.

Secondary education [**GIMNAZIA**] might be divided into secondary general education (with different specializations in some schools, such as languages or art) and professional (vocational) schools. Secondary general education is provided at comprehensive schools for the children from 15 to 18/19 years of age. Its duration is from 3 to 4 years of study and includes the forms from 9 th through 11/12 th. The other type of schools is specialized (profiled) schools that require 4 or 5 years of study. Pupils may enter specialized schools only after completing 7 th or 8 th form (depending on the school they apply for) and if they pass successfully the entrance exams, that correspond to the profile of the respective school (Bulgarian grammar and literature, mathematics, humanities, etc.).

The university type of higher education [**VISCHI UTCHILISHTA**]is provided by universities and other higher educational institutions such as academies and institutes. It consists of the followings stages:

1. First stage – a course of study of at least 4 years. The student receives a Bachelor’s degree upon graduation.
2. Second stage – a requirement of Bachelor’s degree followed by 1 year course of study. The student receives a Master’s degree upon graduation.
3. Third stage – a course of study of 3 years for obtaining a Master's degree that meets the requirements of a Doctor's degree.

Colleges [**KOLEJ**] are included in the system of higher education and allow the acquisition of university education Bachelor's degree in some cities in the administrative range of the Universities.

Science teachers for lower and upper secondary schools

All teachers for primary and secondary schools in Bulgaria are required to have University education. At the moment 98% of the teachers in Bulgaria hold Univerity digree. Four universities in Bulgaria, situated in Sofia, Plovdiv, Blagoevgrad and Shumen, offer majors that prepare students for teachers. The Subject Core of the pedagogical courses and studies curricula is elaborated by the Ministry of Education and Science, hence it is similar in all Bulgarian universities. Only students who have successfully completed secondary school and who have passed entrance exams are eligible for university studies.

Organization of the science teacher training in the University of Plovdiv

At the Faculty of Education in The University of Plovdiv it is possible to obtain qualification for a teacher for the level of primary school (1st - 4th form). At the Faculty of Physics, Chemistry and Biology it is possible to obtain qualification for teacher for the primary and the secondary school level (5^{th} - $11^{th}/12^{th}$). Students who are specializing for Science teachers at the University of Plovdiv can choose from three majors, consisting from two subjects: Physics and Mathematics at the Faculty of Physics, Chemistry and Physics at the Faculty of Chemistry as well as Biology and Chemistry at the Faculty of Biology. The course of study for these two-subject majors is 4 years and corresponds to Bachelor's Degree. Students who graduate in these two-subject majors can teach physics, mathematics, chemistry and biology. The Master's degree in the university requires one and a half additional year of full-time studies.

The students from other majors at the above-mentioned faculties (at the Faculty of Physics they are Physics and Engineering Physics, at the Faculty of Chemistry - Chemistry and Computer Chemistry) can obtain pedagogical qualification by studying a pedagogical module simultaneously or after they finish their Bachelor's degree.

Study programs

An academic year at the University of Plovdiv consists of 30 working weeks divided into 2 semesters. The first semester starts in the fist week of October and ends in January (winter semester). Between the two semesters students have 1 month to prepare themselves for the exams. The second semester starts in the last week of February and ends the first week of June (summer semester). Similarly, students have 1 month to prepare themselves for the exams. According to Bologna process, in order to compare our curricula for Bachelor's and Master's level with similar curricula used in other EU countries, we present the curricula in ECTS-credit points (European Credit Transfer System) as well. The credit points (cp) at the Faculty of Physics for each semester are 30, therefore to receive a Bachelor's degree 240 cp are necessary. Now we present an overview of modules and subjects that must be studied at the Faculty of Physics and Faculty of Chemistry in order to obtain the qualification for teacher in physics and in mathematics and for a in chemistry and physics for High School level.

Modules and subjects

The BSc programme in Physics and Mathematics provides two basic modules – one in Physics and second in Mathematics and one in Pedagogic. Figure 2 shows the proportion of the subjects in these modules.

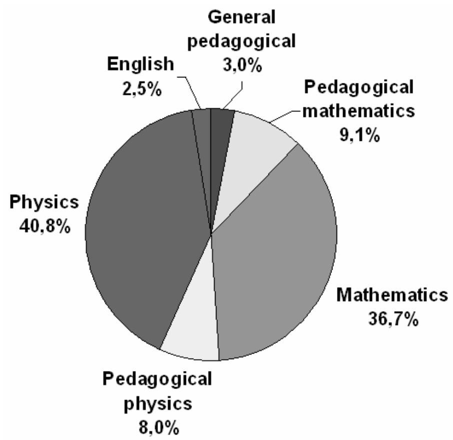

Figure 2. The relative part of the subjects. Major Physics and Mathematics

Table 1 and 2 represent the modules in the major Physics and Mathematics.

Table 1. Module of the subjects in Physics. Major Physics and Mathematics

N	Subjects*	term	L	S	E	Total hours	Cred	Cont-rol
1	Mechanics	I	3	2	3	120	8	Ex
2	Molecular Physics	I I	2	2	3	105	8	Ex
3	Electricity and Magnetism	I I I	3	2	3	120	9	Ex
4	Optics	IV	3	2	3	120	8	Ex
5	Mathematical methods of Physics 1	IV	2	1	0	45	4	Ex
6	Theoretical Mechanics	IV	2	1	0	45	4	Ex
7	Mathematical methods of Physics 2	V	2	1	0	45	4	Ex
8	Electrodynamics	V	2	1	0	45	4	Ex
9	General electronics and radio technique	V	3	0	3	90	6	Ex
10	Quantum mechanics	VI	2	1	0	45	4	Ex
11	Astronomy 1	VI	2	0	1	45	3	Ex
12	Atomic Physics	VI	3	1	2	90	6	Ex
13	Astronomy 2	VII	2	0	1	45	4	Ex
14	Statistic Physics and Thermodynamics	VII	2	1	0	45	4	Ex
15	Nuclear Physics	VII	2	1	2	75	6	Ex

16	Elect subject 1	IV	2	0	0	30	2	Ex
17	Elect subject 2	VIII	2	0	0	30	2	CEx
18	State Exam						10	SEx
19	Total					1155	98	

- L-lecture, S-seminar, E- exercise, all in hours per week, Cred-credit points, Ex –exam, CEx- current exam and SEx- State exam.

Table 2. Module of subjects in the Mathematics. Major Physics and Mathematics

N	Subjects	Term	L	S	E	Total	Cred.	Contr.
1	Linear Algebra and Analytical Geometry	I	4	4	0	120	8	Ex.
2	Mathematical Analyst 1	I	3	3	0	90	8	Ex.
3	Mathematical Analyst 2	I I	3	3	0	90	7	Ex
4	Algebra	I I	2	2	0	60	5	Ex.
5	Informatics 1	I I	2	0	2	60	5	Ex.
6	Differentially Equations	I I I	2	2	0	60	5	Ex.
7	Informatics 2	I I I	2	0	2	60	5	Cr.Ex.
8	Algebra with theory of number	I I I	2	2	0	60	5	Ex.
9	Complex Analyst	I V	2	2	0	60	5	Ex.
10	Probability Theory and Mathematical Statistics	I V	2	0	2	60	4	Ex.
11	Differential Geometry	V	2	2	0	60	4	Ex.
12	Numerical methods and Optimization	V	2	0	2	60	4	Ex.
13	Synthetic Geometry	VII	2	2	0	60	4	Ex.
14	Elected subject 1	III	2	0	0	30	2	Ex.
15	Elected subject 2	IV	2	0	0	30	2	Cr.Ex
16	Elected	VIII	2	0	0	30	2	Ex.
17	Elected subject 4	VIII	2	0	0	30	2	Ex.
18	State exam	VIII					10	St.Ex.
	Total					1020	88	

Table 1 and 2 and Figure 1 show that both modules are basically equivalent in working hours: for Physics 1 155 hours and for Mathematics 1 020 hours, as well as in credit points: for Physics 98 and for Mathematics 88. In both modules, the number of studied subjects is 17 and includes the main branches of

Physics and Mathematics. Figure 3 illustrates the proportion of Physics subjects in the major Physics and Mathematics.

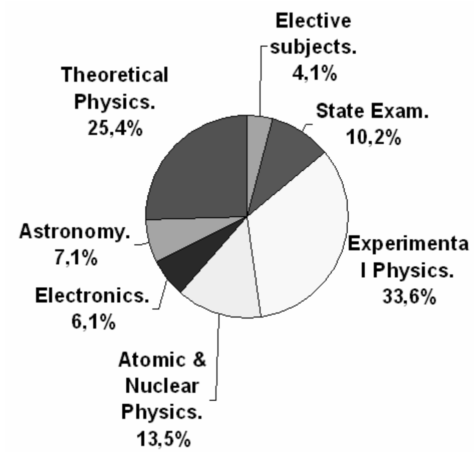

Figure 3. The relative part of the subjects in Physics. Major Physics and Mathematics

Table 3 shows the module of the pedagogical subjects in the major Physics and Mathematics.

Table 3. The Module of the Pedagogical subjects, major Physics and Mathematics

N	Subjects	Term	L	S	E	Total hours	Cr.	Con.
General Pedagogical								
1	Psychology	I	3	0	0	45	3	Ex
2	Pedagogy	I I I	3	1	0	60	4	Ex
Methodology of Physics								
3	Audio, visual and information teaching equipment	I I	0	0	1	15	1	CEx
4	Methodology of the teaching of Physics	V-VI	2+3	0	0	75	5	Ex

5	Observation in Physics	VII	0	0	2	30	2	CEx
6	Methodology and techniques of school experiments in Physics	VI	0	0	5	75	6	CEx
7	Current teaching practice in Physics	VII	0	0	3	45	3	CEx
8	Pre-graduate teaching practice in Physics	VIII	0	0	3	45	2	SEx
	Methodology of Mathematics							
9	Methodology of solution of mathe-matical task	V	2	2		60	4	CEx
10	Methodology of the teaching of Mathematics	V-VI	2+3	0	0	75	5	Ex
11	Observation in Mathematics	VI	0	0	2	30	2	
12	School mathematics 1	VII	2	2		60	3	CEx
13	School mathematics 2	VII	2	2		60	3	CEx
14	Current teaching practice in Mathematics	VII	0	0	3	45	3	CEx
15	Pre-graduate teaching practice in Mathematics	VIII	0	0	3	45	2	SEx
	Total					765	48	

*L-lecture, S-seminar, E- exercise, all in hours per week. Cr.-credit points, Con.-control, Ex.-exam, CEx.-curent exam, SEx-State exam.

In order to obtain qualification for teacher in Physics at the Faculty of Physics the students from other majors study a module similar to the those presented in Table 3 sub-modules of the General Pedagogic and Methodology of Physics.

The Master degree provides an additional module of 550 working hours corre-sponding to 60 credit points. This form of study is part-time. Figure 4 illustrates the proportion of the subjects in the course for Master degree.

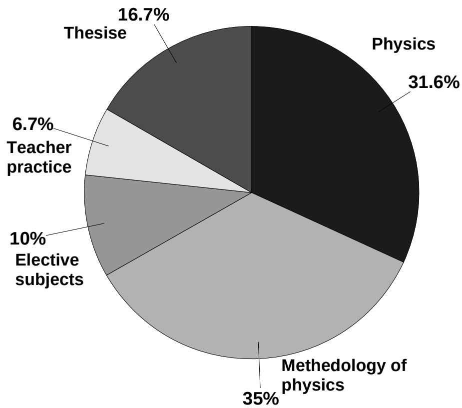

Figure 4. The relative part of subjects in the Master degree for teachers in Physics

The proportion of the subjects in the course of the Chemistry and Physics major is represented in Figure 5.

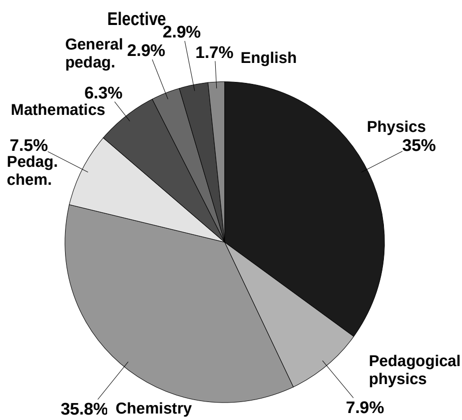

Figure 5. The relative part of subjects in the major Chemistry and Physics

Discussion

Tables 1, and 2 and Figures 2 and 3 shows, that teachers are provided with strong basic knowledge in there main subjects. The future teachers in Physics posses stable knowledge in Mathematics as well. In addition to the mathematical Module 2 students learn Mathematical methods of physics in two subjects - number 5 and 7 in Table 1.Figure 3 and Table 1 show that in addition to the Experimental Physics, the Atomic and Nuclear physics there are two separate courses and Theoretical physics is 25.5 % of the studies. Pedagogical subjects are substantial part of the study for science teacher. This can be observed in Table 3, and Figure 4. The pedagogical subjects for the students in specialization Physics and Mathematics is 20.1 % and for the students in specialization Chemistry and Physics 18.3 % of the credit points. Elective subjects give a possibility for students to choose a subject and prepare a thesis project. The teacher practice takes place in three semesters VI, VII and VIII and the last one is with the relevance of a State exam.

The science teacher training in Bulgaria for Bachelor's degree is a two-subject major with 3 000 working hours and as shown in Tables 1, 2 and 3 students take 34 exams, 16 current exams and 3 State exams. Such kind of intense study causes a substantial part of the students to pass with a minimal knowledge in more theoretical subject. The lectures (see Tables 1-3) are the main tool of the professors and the provided knowledge is mainly theoretical. This academic approach influences the teacher’s practice in schools. The lessons stress on theory rather than on practice; the only examples for the relevance of the theory are applications in the industry or in the human life. The lesson examines a particular phenomenon; however, it rarely discusses its relation with other phenomena or presents a generalization of the problem.

The advantages of the constructive approach are well estimated in the University of Plovdiv and we hope this project will stimulate the use of this approach in the primary school and the high school education. Our major goal is to improve the training of the science teacher and thus to make science more attractive for the modern pupils in schools.

Case Study 2

INITIAL SCIENCE TEACHER TRAINING IN CYPRUS

Prepared by: Nicos Valanides

Teacher's training in Cyprus

The educational system in Cyprus includes the Kindergarten, the elementary and the secondary schools as the three compulsory levels of education. The elementary education consists the levels/classes from one to six and the secondary school the levels/classes from seven to twelve. The Natural Sciences are one of the most important subjects in all levels of education, having common goals. Nevertheless, teachers' training for Kindergarten and elementary schools differs from the corresponding teachers' training in secondary schools.

The training of teachers who are intend for the Kindergarten and Elementary schools is general and considers methodology and philosophy of education, psychology modules and cognitive object (γνωστικό αντικείμενο). For a Bachelor's degree in elementary school teaching or kindergarten school teaching, a student must successfully complete at least 240 ECTS.

For the subject of Natural Sciences the kindergarten teachers have to complete two compulsory courses for a total of twelve ECTS, which are the following:

- *Science Concepts in the kindergarten school (EDU 175):* living organism, similarities and differences among them, their living conditions and their reactions to seasonal and everyday environmental changes. Human body, its structure and basic functions. Earth and planets in space and climate. States of matter forms of energy and their transformation. Emphasis on the methods and processes of science.
- *Natural Sciences in the kindergarten school (EDU 335):* the development of preschool-age children's mechanisms of understanding the physical environment and its changes and employing simple methods and processes of natural sciences. Design of teacher interventions which can sensitize preschool-age children to the interaction between man and the environment and develop their readiness and appropriate attitudes for learning natural sciences at the elementary level.

In addition, they have to successfully complete school experience, where they teach among others lessons of Natural Sciences.

The primary teachers, for the subject of Natural Sciences have to complete three compulsory courses giving them a total of eighteen ECTS. These are the following:

- *Natural Science in the elementary school. Environment and living organism (EDU 177):* living organism and environment. Basic function and interrelations of living organisms. Flow of mass and energy in the ecosystems. Technological culture and environment, environmental education and consciousness, environmental and ecological projects.
- *Natural Science in the elementary school. Physical and chemical phenomena and changes (EDU 276):* physical and chemical phenomena and changes. States of matter and their structure and properties. Changes of state of matter. Physical and chemical phenomena. Forces, forms of energy, transfer and transformations of energy. Heat, sound, light, magnetism and electricity, their sources, transfer and effects. Emphasis on methods and processes of science and experimental study phenomena.
- *The teaching of Natural Sciences (EDU 336):* the basic variables of the teaching-learning process which have special importance for teaching natural science at the elementary level based on research evidence. In-depth examination of elementary students' mechanism of understanding and their preconceptions about physical reality. Design and evaluation of teaching interventions in an attempt to promote students' cognitive, affective, and psychomotor development and to activate their innate capacities.

Additionally, they have to successfully complete school experience in the third and fourth year of their study. In the third year they sit under in public schools for a period of approximately three weeks. During this period they attend two Natural Sciences lessons and they teach one lesson. In the fourth year they get involved in school activities for one semester. The preparation is achieved after a three-week slot of lectures which take place before the entering in public schools. As far as the subject of Natural Sciences is concerned, the students have to attend the lessons from the class teacher for ten weeks. They also have to teach about ten periods under the guidance o their mentor (class teacher) and the supervision of an academic staff.

Students are required to complete four compulsory courses (twenty four ECTS) for their respective specialization during their fourth year studies. One alternative specialization relates to the teaching Natural Sciences and students have to attend the following courses:

- *Modern Trends in Science teaching at the primary school (EDU 476):* Cognitive demands of science curricula and students' cognitive capacity. Educational interventions and cognitive accelerations: research evidence. Misconceptions in science and the process of conceptual change. Children's science. Support for students' cognitive, psychomotor and affective development. Scientific and technological literacy at the primary school. The importance of experimental science teaching.
- *Computer Science application in the teaching of science in elementary school (EDU 477):* the course examines ways in which computer technology may support the teaching of science in elementary school. The purpose of the course is to make students aware of the computer as a simulation instrument and as a research medium.
- *Special Issues in Mathematics Education (EDU 471).*
- One additional course from the Department of Physics, or the department of chemistry, or the Biology department. This course relates to content knowledge from physics, chemistry, or biology, respectively.

The teaching of Natural Sciences in secondary school is divided into discrete subjects: Physics, Chemistry, and Biology. Any person holding a BA in physics, chemistry, and biology is considered as a prospective teacher of the respective subject (Physics, Chemistry, and Biology) provided that (s)he has completed a one-year pedagogical training from an Educational department (i.e., the Department of Education, University of Cyprus).

The structure of this pedagogical training is as follows:

1. Four compulsory courses (4x4=16 ECTS) that relate to educational theory, multicultural education and the educational system (4 ECTS), curriculum and instruction (4 ECTS) research and evaluation in education (4 ECTS), and educational psychology (4ECTS).
2. One compulsory course (enrichment) from their respective specialization (4 ECTS).

3. One elective course among a list of 10 several courses relating to the sociology, psychology, history of education etc., depending on their interests and/or needs.

4. Two compulsory courses (8 ECTS) in teaching methodology and related topics, such as action research, constructivistic approaches of teaching, and how to integrate ICT in their teaching. These two course focus exclusively on teaching physics, chemistry and biology at the secondary school.

5. Prospective secondary school teachers should also complete school experience. During that period, students participate in school activities and they undertake teaching in actual classrooms under the guidance of special personnel. They get a lot of feedback and have opportunities to be involved in action research and reflection on their teaching and how to become more effective teachers.

Case Study 3

INITIAL SCIENCE TEACHER TRAINING IN THE CZECH REPUBLIC

Prepared by: Danuše Nezvalová

Models of Training

Teacher training is predominantly at the higher educational level, the only exception being for pre-school education teachers.

Primary Teacher Training

The responsibility for initial training of teachers at the first stage of the basic school rests mainly with Faculty of Education Palacký University Olomouc. The study model for teachers is predominantly a one-stage concurrent programme (i.e. the academic and the professional parts run simultaneously) with elements of integration primarily between the theoretical and practical parts of the training. In addition to traditional methods (lectures, seminars), the "learning by doing" approach is also employed, as well as various theoretical methods, and experience learning through practical exercises, workshops etc. Practical training in schools is a significant element of the course. Teaching practice accounts for between 4 and 6 hours a week over the course of the whole study programme, or in blocks amounting to a total of 10 weeks within the programme. Graduates are qualified to teach all subjects.

The curriculum in concurrent courses of initial teacher training generally consists of five basic modules:

- subject module (the basics of all subjects taught at the first stage of the basic school (základní škola);
- pedagogical and psychological module (including practical training);
- university basics module (philosophy, history, rhetoric, ecology, computer technology etc.);
- didactic module (theory and practice of teaching individual subjects at the first stage of the basic school (základní škola);
- upgrading module.

Every student is obliged to choose one specialisation - music, visual arts or physical education. The studies usually consist of eight to ten terms, each of 15 weeks, and there are, on average, 20 hours of direct teaching each week. Emphasis is placed on the student's own attempts at teaching and their reflection on this practical experience.

Teachers at the compulsory primary level are qualified as generalists and would need further study at the faculty of education to teach at other than the primary level.

Secondary Teacher Training - General Subjects

Teachers at the second stage of the basic school (grade 6-9) are trained at Faculty of Education Palacký University Olomouc in four to five-year Master's studies, which are mostly concurrent.

Teachers of sciences at upper secondary schools can gain their qualification at Faculty of Science Palacký University Olomouc. The studies at this faculty can be both concurrent (older, but still runs till 2008) and consecutive (newly developed, runs from 2007), and are usually 5 years in duration.

The following components are always present: general education, education in a specific field (education in the field of future teaching), pedagogical education (psychological, pedagogical, didactic) and pedagogical practical training.

Teachers at upper secondary schools are qualified as subject specialists. The subject combination of specialists depends on their choice at the beginning of the study and can be selected from a list of combinations or from a list of individual subjects set by the faculty. Students can study science subjects and math to be qualified as 2 subjects specialist for upper secondary schools. Students can make choice in the following subjects at the Faculty of Science: biology, chemistry, physics, geography, computer science and mathematics.

Students study compulsory or elective subjects in their specific fields (biology, chemistry, physics, geography, computer science and mathematics), general education (english, philosophy of science), pedagogical education (psychological and pedagogical sciences, didactic) and pedagogical practical training. Practical training takes 6 weeks (in two periods, each of 3 weeks) and is realized at cooperating upper secondary school. Each course has certain number of credits. The course usually consists of ten terms, each of 15 weeks, and there are on average 20 hours of direct teaching each week.

Students are assessed through a system of partial and comprehensive exams, credits and classified credits. These can be in an oral, written or practical form or in the form of a seminar paper. After each term the students sit for examinations mostly in subjects taught during that term. (Some subjects are taught over several terms). In order to be allowed to sit for an exam, students must demonstrate that they have completed the relevant course work. Evaluation of the student teaching practice depends only on the report of teachers of school where teaching practice was completed. There are no criteria of the student performance.

Study achievements are assessed by a system of granting points or credits. Students have to get 180 credits to get bachelor degree and next 120 credits to earn master degree. The credit system is compatible with the ECTS as a necessary condition for entry to the European student mobility programme Socrates-Erasmus.

The frequency and methods of assessing the students' achievements differ according to different courses. In some cases a system of partial examinations taken after each semester is introduced, in other cases there is one comprehensive examination after each completed part of the studies - most often at the end of a certain module. Considerable emphasis is also placed on continuous assessment of the students' work, mostly in the form of tests of knowledge or independent work (on computers, graphic work, laboratory work or seminar work) or independent work.

The organisation of examinations is legally embedded in study and examination regulations, which are part of the internal regulations of a higher education institution (faculty) and are approved by the academic senate.

In general, examinations are taken in the course of an examination period at the end of each semester. Examiners are teachers of individual subjects. Relevant examiners declare the dates of individual examinations and the dates of all examinations are declared by the management of the institution (faculty). In justified cases it is possible to take an examination before the agreed official date. A failed exam may be retaken several times. Final examinations are taken in front of boards of examiners. In order to increase the level of objectivity, external examiners from other higher education institutions or scientific establishments are invited as to sit on the boards. Care is taken to authorise only the most qualified academic staff as examiners.

At the end of a three-year Bachelor's programme the student sits for a final state examination, a defence of Bachelor's thesis is usually part of it. The content is set by the faculties. It consists mostly of an oral examination in licensed subjects. Students continue in Master's programmes for next 2 years. In the end of studies the students sit for a state final examination, which consists of an exam in subject field(s), subject didactics and the defence of a thesis. The content is also set by the faculties. On passing the state final examination, he/she receives a certificate and a diploma, which acts as a qualification for the upper secondary schools and gives them the right to use the title Magistr (Mgr.).

Prospective teachers have to study two subjects. The natural science are separated from each other in the university studies and, as a rule with exceptions, in schools (biology, chemistry, physics).

Subject studies: In the natural sciences, one of the central problems concerning an appropriate design for the subject studies is described by the following question: What constitutes the basic subject knowledge a teacher has to master in order to be a good teacher? On the average, the answer stresses the significance of an extensive knowledge according to the traditional conception of the teacher preparation for the Gymnasium, that means the more extensive the teacher's subject knowledge the better his/her capability to teach. Therefore prospective secondary science teachers' study programs do not decisively differ from those designed for physicists, chemists, or biologists.

Science education: In each of their two subjects students have to take (only few) hours in subject education (physics/chemistry/biology didactics). These studies are structured along three main parts (modules) which can be described according to their specific functions within the whole study program:

(1) Introduction (overview).

(2) Basic skills which are necessary in order to prepare experiments and to give lessons.

(3) Teaching practice.

(4) In a last module in-depth studies which are to lead students to an elaboration of research based knowledge.

Case Study 4

INITIAL SCIENCE TEACHER TRAINING IN LITHUANIA

Prepared by: Vincentas Lamanauskas

General background

The description of a few key points defining a system of teacher training in Lithuania can be found rather purposeful.

- Professional teachers' qualification and competence is the pivot of the whole teacher training system.
- The candidates' sample /contingent/ of participation in the pedagogical curricula. Motivation for becoming a teacher and working at school constantly decreases. The pedagogical curricula usually choose the candidates with medium-based abilities. On the other hand, a demand for the teachers of sciences is fairly low.
- Education received by teachers /university or college education/. A new concept of the teacher training system basically answers the question.
- Material and intellectual resources of higher educational institutions. To train the teachers of sciences, not only intellectual but also large material resources are required (properly equipped research facilities, rooms of didactics, botanical gardens and zoos etc.).
- Elitistic and mass education.
- The ways of training mentors of teaching practice. A system of granting licences for teachers.
- Two models of teacher training: ***parallel*** /individual subject training + pedagogical training + practical activity/ and ***consistent*** /academic studies of a certain subject proceeding with realization of teacher training/. Primary and pre-primary school teacher training is received applying the parallel model whereas gymnasia teacher training uses the second model. The colleges also employ the parallel model.
- A right to work as a teacher /licence/ is granted when studies or successful pedagogical practice-traineeship in basic school (half a year under the

parallel model or one year under the consistent model) is over (Lamanauskas, Gedrovics, 2006).

Assessment Guidelines on the Present Situation of Teacher Training

The teachers of natural sciences are trained by Universities in Lithuania. Although the binary system of higher education including universities and colleges is prevailing in Lithuania, however, at the moment, the teachers from colleges are not involved in teacher training. Table 1 presents a list of institutions preparing the teachers of natural sciences.

Table 1. The major institutions training the teachers of natural sciences.

Name of the curriculum chosen	**Name of institution**	**Length of service (in years)**			**Qualification acquired**
		Full time	**University Extension**	**Part time**	
Biology	Vilnius Pedagogic University	4	4	5	BA in biology, teacher
Biology	Vilnius Pedagogic University	2	2	2	MA in biology, teacher
Biology	Vilnius Pedagogic University	2	2	2	MA in biology, teacher
Chemistry	Vilnius Pedagogic University	4	4	5	BA in chemistry, teacher
Chemistry	Vilnius Pedagogic University	2	2	2	MA in chemistry, teacher
Chemistry	Vilnius Pedagogic University	2	2	2	MA in chemistry, teacher
Physics	Šiauliai University	2	-	2	MA in physics, teacher
Physics	Kaunas University of Technology	1	-	1	teacher
Physics	Vilnius Pedagogic University	2	2	2	MA in physics, teacher

Physics and astrophysics	Vilnius Pedagogic University	2	2	2	MA in physics, teacher
Physics and physical education	Vilnius University	4	-	-	BA in physics, teacher
Physics and informatics	Šiauliai University	5	-	-	BA in physics, teacher
Physics and informatics	Šiauliai University	4,5	-	-	BA in physics, teacher
Physics and elements of other natural sciences	Šiauliai University	4	-	-	BA in physics, teacher
Physics and applied com-puter science	Vilnius Pedagogic University	4	4	5	BA in physics, teacher
Pedagogy of the subject studied	Šiauliai University	1			BA / a degree meeting requirements at University level
Educology and object of study	Šiauliai University	4	-	4	BA in Educology, teacher

Curricula of Studies

The teachers of natural sciences in Lithuania can choose between studying a bachelor's and a master's degree (can be either broadly-based or focused) curriculum.

The curricula of studies fall into three categories:

1. Basic studies;
2. MA studies;
3. Specified professional studies.

The curricula of studies can also be subdivided into two sections:

- Theoretical studies;
- Scientific research.

A module is the fundamental unit of planning studies. It is a subject studied or a part of it taught along the term. The module of studies can be either compulsory or optional and includes different forms of learning: lectures, laboratory experiments, practice, individual student's work, scientific research and planning.

A measurement unit of the scope of studying is a credit which on average makes 40 hours of effective and independent work in and outside the classroom and equates with one weak of studies. The curricula of studies are designed following the Rules of quality assessment for institutions of research and higher education approved by Order No 1326 of the Ministry of Science and Education of the Republic of Lithuania on October 10, 2000 and the regulations of the curricula of studies and modules of a higher school.

The scope of the bachelor's degree curriculum is 160 credits. The length of service of full-time studies makes 4 and university extension and part-time studies – 5 years.

The curriculum of studies schedules three groups of the subject studied.

- ***General education subjects at university level*** make no less than 15 % of the scope of the whole curriculum;
- ***Subjects discussing the fundamentals of studies*** make no less than 25% of the scope of the curriculum;
- ***Subjects dealing with special education*** take the rest of the scope of the curriculum but not less than 40%.

The scope of the term of full-time is 20 and of the 4th year of studies - 16 credits. Thesis takes 8 credits. The number of the subjects studied in the 1st and 2nd year cannot exceed 7, in the 3rd - 6 and in the 4th - 5 credits per term. From the beginning of term 4, the curriculum may enclose no more than 2 term papers/projects in each of the terms. The curriculum may also include practice. The examination session should accept no more than 5 exams (Type E). The bachelor studies ends in completing thesis and taking final exams.

The number of the modules of the subjects taught, the term papers and projects as well as the scope of the exams of the curricula of university extension and part-time studies agrees with that of the curricula followed by the full-time students except from the length of service, the number of credits and hours studied within the term.

The teachers having a bachelor's degree have a possibility of gaining a master's degree. The scope of the curricula of all forms of MA studies makes from 60 to 80 credits. The university extension and part-time studies may also last for 2 years and take 80 credits or 1,5 years and take 60 credits.

The scope of the term curriculum of full-time studies is 20 credits. The term may include no more than 4 theoretical modules, 1 module of research work and no more than 2 term papers/projects. The master's studies ends in completing thesis.

According to the number of exams, term papers, projects, modules and its scope, the curricula of university extension, part-time studies and remote education are equal to those of full-time studies except from the length of service, the number of credits and hours studied within the term.

The curricula of studies of the same field include a part of general subjects. A general part of a field curriculum is coordinated by the University board of studies and approved by the rector.

Planning Individual Studies

Every spring term, along the modules chosen, the students work out individual plans of studies for the forthcoming year. The questions of planning individual studies are discussed with the Dean Office and lecturers. The individual plans of studies can be adjusted within two first weeks of the term started. The final versions of individual plans and changes are approved by the Dean Office.

Types, Stages and Forms of Studies

The University offers two types of studies – continuing and incoherent. **Continuing** studies are aimed at all-round higher education confirmed by the obtained university degree and (or) professional qualification. **Incoherent** studies embrace only separate subjects or their cycles studied and focus on improving or changing one's professional qualification as well as on developing professional and general education. These studies also encompass supplementary (retraining) studies.

The stages of continuing studies are:

1. Bachelor's and professional studies;
2. Master's, and specified professional studies;
3. Postgraduate studies.

Bachelor's studies are continuing the first degree studies at university level. A student is awarded a bachelor's degree after studying is over. Professional qualification may also be obtained. The graduates are allowed to take up postgraduate or specified professional studies.

Complete studies concentrate on receiving master's degree and (or) professional qualification when first and second degree studies at university level are combined.

Specified professional studies are continuing the second degree studies for graduates from university devoted to the students seeking for professional qualification of a particular field. Studying helps with a better preparation for work that requires special practical abilities.

Master's studies are continuing the second degree studies for those improving individual professional and scientific qualification focused on scientific activity. The students are trained to be either scientists-researchers or teachers and directed to be involved in analytical applied activity.

Postgraduate studies are the third stage studies at university level concentrating on would-be scientists training. The applicant must have a master's degree or be a graduate from complete studies. When postgraduate studies are over and thesis is defended, a student is awarded a degree in Educology.

Examples Given

Pedagogy of the subject can be studied at the Department of Educology at Šiauliai University. The students are provided a possibility of obtaining a bachelor's degree in Educology. The curriculum mainly covers studying pedagogy and psychology and includes 4 week teaching practice in secondary school. Studying the curricula of pedagogy awards the graduates **professional qualifi-**

cation of teacher. The latter curriculum of studies is most frequently chosen by those having natural science education but not teacher qualifications.

A certain curricula of studies may specialize in natural sciences. For example, the curriculum *Specialization in Educology* by the Department of Educology at Šiauliai University is designed so that gained qualification will successfully allow teaching geography and integrated courses on sciences (e.g. *Nature and Human* in forms 5 and 6 and possibly in 7 and 8 if the course is included in the curricula of teaching). The curriculum points to training highly qualified and having professional competence teachers of sciences, geography and Educology. Within their studies, the students will be offered an opportunity of implementing natural science and environment protection education and ecology curricula at national level, gain a bachelor's degree in Educology and acquire high professional qualification of secondary school teacher of sciences and geography. The graduates dealing with these curricula will have better career prospects as curriculum implementation is supported by the educational establishments of Northern Lithuania, students' parents and naturalists and teachers of Educology at Šiauliai University. Having graduated the curriculum of studies *Educology (sciences and geography)*, a student is awarded a bachelor's degree in social sciences (Educology). ***The goal of the curriculum*** is *to train highly qualified and having professional qualification teachers of Educology, sciences and geography*.

The teachers of physics are trained by the Department of Physics at Vilnius University, by the Department of Physics and Technology at Vilnius Pedagogic University and by the Department of Sciences of Šiauliai University.

Bachelor's and professional studies

180 credits, full-time studies, 4 years

Qualification acquired: a bachelor's degree in physics and teacher's professional qualification

The main subjects of the curriculum. General educational subjects at university level: introduction into philosophy, culture of the mother tongue, law, foreign language, history of cultures and civilizations etc.

General subjects of studies: classical physics, differential equations, informatics, mathematical physics, mathematical analysis, linear algebra, probability theory, theory of atoms and molecules, astronomy, physics of waves, electrodynamics, experimental physics, history of physics, fundamentals of solid state physics, computer applications, biophysics, statistical physics etc.

Specific subjects: research methods of environment pollution, personalities and social pedagogy, education, research methods of biological objects, electronics, energetic and environment, methodology of teaching physics, historical and comparative pedagogy, computer applications in teaching physics, psychology, spectroscopy, applied nuclear physics, education elements and didactics, hygiene at school etc.

Vilnius Pedagogic University – *physics and applied computer science*

Bachelor's and professional studies

Full-time studies and university extension, 4 years

Qualification acquired: a bachelor's degree in physics and teacher's professional qualification

Šiauliai University – *physics and informatics*

Bachelor's and professional studies

180 credits, full-time studies, 4,5 years

Qualification acquired: a bachelor's degree in physics and professional qualification of teacher of physics and informatics.

The would-be teachers of physics and informatics study

general education subjects (focused on fundamentals broadening world outlook and understanding of the principles of sustainable development): fundamentals of philosophy, history of culture, psychology, education management, history of physics, culture of the mother tongue, terminology, foreign language;

subjects discussing the fundamentals of studies (focused to build up a professional image of the physical world and to develop abilities and skills required for studying subjects of special education and taking up studies at the second stage at university level): higher and discreet mathematics, differential equations, mathematical statistics and probability theory, computer systems, fundamentals of programming, mechanics, thermodynamics, electricity and magnetism, optics, astronomy, biophysics, solid state, nuclear and elementary particles and statistical physics, mathematical methods in physics etc.

special (professional) subjects (focused on accumulating knowledge and abilities allowing to successfully deal with the job that corresponds with education acquired): computer physics, laser physics, electronics, objective programming, database management, information teaching technologies, Educology, didactics of physics and informatics, hodegetics etc.

Practical studies take place at two stages. Teaching practice the purpose of which is practical student training to introduce the professions of teacher of physics and informatics and class tutor is accomplished twice. At first, practice takes place in forms from 7 to 10 of comprehensive school or may occur in certain forms of gymnasium (240 hours); the next step involves the students from forms 11 and 12 or certain forms of gymnasium (160 hours). In total, the length of service makes 400 hours.

The major qualities.

- In order to ensure the mobility of students, the curricula of physics teacher training of all universities are coherent.
- Qualified and experienced teachers are involved in the process of curriculum development.
- A substantial number of educational laboratories and equipment used.
- Quickly advanced computer technology and software are applied.
- A firm experimental basis of didactics of physics.
- Close collaboration with teachers of physics and physicists of other higher schools nationwide.

Weaknesses:

- Due to low prestige of teacher's profession, the latter is chosen by those having no success at school.
- To more precisely define the curricula, there is lack of regulations observing the curricula of teacher training.
- Scant attention devoted by the Government.

The majority of teachers of chemistry and biology are trained by Vilnius Pedagogic University. The structure of the curricula of these studies is similar comparing to those of other sciences.

It is supposed that in the future, the number of primary school teachers will decrease due to demographic problems, whereas the need for teachers of chemistry, biology and physics will rise (Dzemyda, Gudynas, Šaltenis, Tiešis, 2001).

In conclusion, we can maintain that:

- After restoring independence, the new teacher training curricula using experience of Western countries and considering national needs were developed.
- The teachers of natural sciences mainly have to meet new social, pedagogic and subjective requirements. They are treated not only as providers imparting knowledge and facts but also as those helping the learner with choosing the required information on an individual basis. The changes in society and the process of teaching show that higher schools must take into account these facts while training would-be teachers.
- The training curricula of teachers of natural sciences are designed on the basis of the regulations of the field of studies and standards of teacher training and are aimed at training teachers able to teach a few subjects of natural sciences.
- The curricula focused on preparing teachers able to teach natural sciences integrated into other subjects taught are designed.
- The curricula of natural sciences include education management, an introductory course on Educology, didactics and hodegetics that are involved into the process of competence development; however, it is not enough to gain general competence in pedagogical practice.
- The training curricula of teachers of natural sciences encounter a problem pointing to the recession of the parallel teacher training model. In this case, the prospects of professional studies that proceed receiving a bachelor's degree are confirmed by the new curricula of professional studies scheduling a general core section of the subjects developing pedagogical competence and didactical subjects of different fields of science that will be applied for the purposes of improving didactical competence of a certain subject.

- Lack of specific methodology, examples of good practice and recommendations for solving the problem of integrated education can be noticed in Lithuania.
- No detailed systemic recommendations and methodical and organizational tools of how to integrate modern Information Communication Technologies (ICT) into the processes of teaching/learning natural sciences are created.
- The teachers of natural sciences are not experienced enough in the field of general competence in modern ICT and suffer from shortage of methodical experience of how to effectively apply ICT in the educational process. The teachers should gain relevant experience in the seminars in methodology, training courses and accepted pedagogical practice at school using the latest Lithuanian versions of natural science training aids based on ICT.

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Case Study 5

INITIAL SCIENCE TEACHER TRAINING IN TURKEY

Prepared by: Osman Pekel

Information on the national education system (Turkey)

The basic structure of the Turkish National Education system consists of four main stages as pre-school education, primary education, secondary education and higher education.

Pre-school education encompasses training for those who have not as yet arrived at compulsory school age, and is optional for the children between the ages of 4-6.

Primary education is a compulsory 8 year program for all children (**grades 1-8**; ages 7-15). This is compulsory schooling for both boys and girls, in state operated schools where tuition is free.

The upper secondary education (Lycees) system includes "General High Schools" and "Vocational and Technical High Schools". Secondary education comprises a minimum of 3 years schooling in lycees and professional and technical schools (**grades 9-11**; ages 15-18).

The aim of lycees is to secure a level of general culture, develope an awareness of individual and community problems and be able to contribute to the economic, social and cultural growth of the country and to prepare the students for higher education.

Lycees encompass the Anatolian Lycees, Science Lycees, Teachers' Lycees of Fine Arts, Anatolian Teacher Training Lycees, Multi- programme Lycees, Evening Lycees and Private Lycees.

Since 1997 (following the new system which replaced the former system of five years of primary school, followed by three years of middle school/junior high school/lower secondary school education), secondary education follows eight years of primary education and covers general, vocational and technical high schools that provide three years of education and four in the case of technical high schools. General high schools do not prepare students for a specific profession but rather for higher education. The following institutions are considered to fall within general secondary education: high schools; high schools with intensive foreign language teaching; Anatolian high schools where a foreign language - English, French or German - is taught during the preparatory year and the teaching of certain subjects is provided in that language in upper grades; science high schools; teacher training high schools; Anatolian fine arts schools; multi-curricula high schools; evening high schools; and private high schools. In general high schools, the average number of weekly periods of teaching in each grade varies from a minimum of 33 to a maximum of 41. In their second year, students in high schools where the general programme is applied may choose to attend branches which specialize in the natural sciences, literature and mathematics, the social sciences, foreign languages, art or physical education. Vocational high schools provide three-year secondary education, train qualified people for various professions and also prepare students for higher education. Technical high schools offer a four-year programme. Subjects offered in the first year are the same as in the vocational high schools. Secondary education students obtain the Lise Diplomasi which is the prerequisite for entry to higher education. Admission to university is centralized and based on the Student Selection Examination (ÖSS). Those with good grades (minimum 120) are qualified for the four-year undergraduate programmes. Those who have grades between 105 and 119 can be admitted to the two-year higher education programmes.

Admissions to universities (higher education)

Name of secondary school credential required: Lycee Diploma

For entry to: all programmes

Entrance exams required: Since 1999, the entrance examination system has been essentially based on a one-stage examination, namely the ÖSS (The Student Selection Examination) which comprises two tests. One is to measure candidates' verbal ability and the other their quantitative abilities. ÖSS is usually taken in May throughout the country in a single session and at the same time in all centres. ÖSS consists of five parts: Natural Sciences, Mathematics, Turkish, Social Sciences and a foreign language. Admission is based on the composite scores which take into account the ÖSS scores and the high school grade point averages.

Higher education

Higher education is provided by 115 state universities and 26 foundations (private universities).

Higher education is defined as all post-secondary programs. The system consists of universities (state and foundation) and non-university institutions of higher education (police and military academies and colleges). Each university consists of faculties and four-year schools offering bachelor's level programs, the latter with a vocational emphasis, and two year vocational higher schools offering pre-bachelor's (associate's) level programs of a strictly vocational nature.

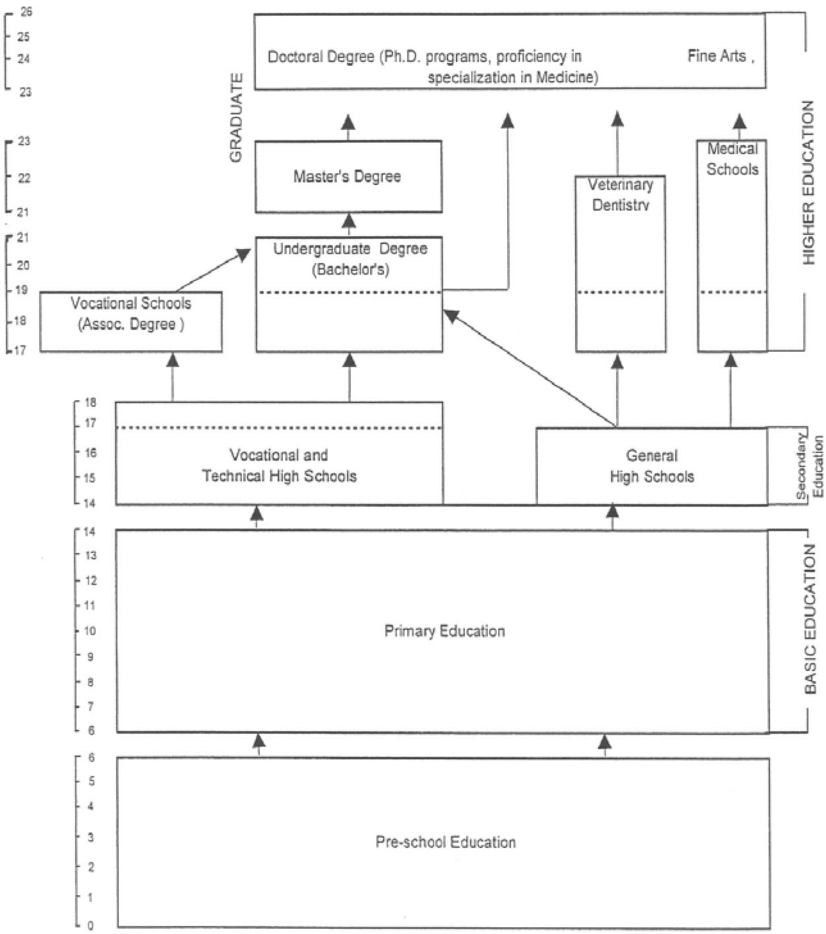
The Higher Education Law No. 2547 is the main law, which governs the higher education in Turkey. All universities (both state and foundation) are subject the same law and regulations/rules. All state and foundation universities are founded by Law.

Admission to higher education is based on a nation-wide Student Selection Examination (ÖSS). The examination is held once a year and is administered by the Student Selection and Placement Center (ÖSYM). Candidates gain access to institutions of higher education based on their composite scores consisting of the scores on the selection examination and their high school grade point averages.

Graduate-level programs consist of master's and doctoral programs, coordinated by graduate schools. Master's programs are specified as programs "with thesis" or "without thesis". Programs “without thesis" require completion of more graduate courses and a term project. The duration of these programs is a minimum of two years. In general, access to doctoral programs requires a master’s degree, unless the students’ performance at Bachelor’s degree is evaluated as exceptionally well. Doctoral programs have a duration of a minimum of four years which consists of completion of courses, passing a doctoral qualifying examination, and preparing and defending a doctoral dissertation. Medical specialization programs are equivalent to doctoral level programs and carried out within the faculties of medical schools with hospitals.

The Higher Education System is regulated by the Council of Higher Education (Yüksek Öğretim Kurulu-YÖK).

General Structure of the Turkish Education System



Bayburt Education Faculty

Turkey has a total of 115 universities. There are 61 state and 5 foundation (private) education faculties belonging to the universities. Bayburt Education Faculty is one of the two education faculty of the Ataturk University.

Compared to the past, the continuously changing role of teachers in teaching-learning process has become more important in the recent years. Traditionally, teacher is perceived as the unique source and the transmitter of knowledge. However, today teacher has become a guide who not only explains the subject matter but also facilitates the learning process.

In the context of the recent reform efforts in faculties of education in Turkey, **Department of Elementary Education** was established at Bayburt Education Faculty in 2002. The department currently runs two teacher education programs:

a. Primary School Teacher Education

b. Elementary Science Teacher Education (general science training for the grades 6-8; ages 13-15)

a. Primary School Teacher Education: Teachers graduated from Primary School Teacher Education department is responsible of teaching all subjects **for the grades 1-5; ages 7-12.**

b. Elementary Science Teacher Education Teachers graduated from Elementary Science Teacher Education department is responsible of teaching science (physics, chemistry and biology) **for the grades 6-8; ages 13-15.**

In addition to normal teacher education program Bayburt Education Faculty has **evening teacher training program** too. Evening education program starts at 17:00 am lasts 23:00 am, except Sundays.

Department of elementary science education

1. General Information on Undergraduate Program

The main purpose of the program is to educate science teachers with a good self-image, an outgoing personality, a sense of humour and an interest in helping their students to understand science in a meaningful way. The program also aims to develop teachers with a sound understanding of how children learn science; confident in using technology; capable in problem-solving; attentive to human rights, democracy, and ethics. The program emphasises critical thinking, personal reflection, and professional development of preservice science teachers.

Undergraduate Curriculum

2. Information identifying the qualification

2.1 Name of the Qualification: Fen Bilgisi Öğretmeni (Science Teacher), Lisans

2.2 Main Field(s) of Study for the Qualification: Fen Bilgisi Öğretmenliği (Science Teacher Training)

2.3 Name and Type of Awarding Institution: Ataturk University, State University Atatürk Üniversitesi, Devlet Üniversitesi

2.4 Name and Type of Institution Administering Studies: same as 2.3

2.5 Language(s) of Instruction/Examination: Turkish

3. Information on the level of the qualification

3.1 Level of Qualification: Bachelor's Degree

3.2 Official Length of Programme: 4 Years, 2 semesters per year, 14 weeks per semesters

3.3 Access Requirement(s):

High-School Diploma

Placement through a centralized national university placement examination

4. INFORMATION ON THE CONTENTS AND RESULTS GAINED

4.1 Mode of Study:
Full-time

4.2 Programme Requirements:
The Bachelor's Degree is awarded to students who have successfully completed all courses in the curriculum, and have obtained a cumulative grade point average of at least 2.00 on a 4.00 scale and have got no failing grades.

Objectives
The objectives of the department are to supply an overall and comprehensive outlook on physical, chemical, biological and educational issues, to understand science, its practical application in everyday life, learning and teaching, and develop skills in teaching science at elementary level.

4.3 Components, courses, modules or units studied and ındividual grades obtained

Course Code	Course Title	Course Category	Credits	Grade	ECTS
Semester 1					
101	PHYSICS I	REQUIRED COURSE	5		**5**
103	CHEMISTRY I	REQUIRED COURSE	5		**5**
105	MATHEMATICS I	REQUIRED COURSE	4		**4**
107	THE HISTORY OF ATATURK'S PRINCIPLES AND REVOLUTIONS I	REQUIRED COURSE	0		**3**
109	TURKISH-I:WRITING	REQUIRED COURSE	2		**5**
111	INTRODUCTION TO TEACHING PROFESSION	REQUIRED COURSE	3		**8**
			19		**30**
Semester 2					
102	PHYSICS II	REQUIRED COURSE	5		**5**
104	CHEMISTRY II	REQUIRED COURSE	5		**5**
106	MATHEMATICS II	REQUIRED COURSE	4		**4**
108	THE HISTORY OF ATATURK'S PRINCIPLES AND REVOLUTIONS II	REQUIRED COURSE	0		**3**
110	TURKISH-II:WRITING	REQUIRED COURSE	2		**5**

112	SCHOOL EXPERIENCE I	REQUIRED COURSE	3	**8**
			14	**30**
Semester 3				
201	BIOLOGY I	REQUIRED COURSE	5	**5**
203	CHEMISTRY III	REQUIRED COURSE	2	**4**
206	MATHEMATICS III	REQUIRED COURSE	4	**4**
207	COMPUTER	REQUIRED COURSE	3	**7**
209	DEVELOPMENT AND LEARNING	REQUIRED COURSE	3	**7**
YD-I	FOREIGN LANGUAGE I	REQUIRED COURSE	3	**3**
			20	**30**
Semester 4				
202	BIOLOGY II	REQUIRED COURSE	5	**5**
204	PHYSIC III	REQUIRED COURSE	2	**4**
206	CHEMISTRY IV	REQUIRED COURSE	2	**4**
208	MATHEMATICS IV	REQUIRED COURSE	4	**4**
210	PLANNING AND ASSESS-MENT TEACHING	REQUIRED COURSE	4	**8**
YD-I	FOREIGN LANGUAGE II	REQUIRED COURSE	3	**5**
			20	**30**
Semester 5				
301	PHYSIC IV	REQUIRED COURSE	2	**3**
303	BIOLOGY III	REQUIRED COURSE	2	**3**
306	LAB. APPLICATIONS IN SCIENCE I	REQUIRED COURSE	3	**4**
307	MATHEMATICS V	REQUIRED COURSE	3	**7**
309	INTRODUCTION TECH-NOLOGIES AND MATE-RIAL DEVELOPMENT	REQUIRED COURSE	3	**7**
SEÇ-I	ELECTIVE COURSE	ELECTIVE	3	**3**
SEÇ-2	ELECTIVE COURSE	ELECTIVE	3	**3**
			19	**30**

Semester 6				
302	BIOLOGY IV	REQUIRED COURSE	2	**6**
304	MATHEMATICS TEACH-ING	REQUIRED COURSE	3	**4**
306	LAB. APPLICATIONS IN SCIENCE II	REQUIRED COURSE	3	**4**
308	CLASS MANAGEMENT	REQUIRED COURSE	3	**6**
310	METHODS OF SCIENCE TECHING-I	REQUIRED COURSE	3	**4**
SEÇ-III	ELECTIVE COURSE	ELECTIVE	3	**3**
SEÇ-IV	ELECTIVE COURSE	ELECTIVE	3	**3**
			18	**30**
Semester 7				
401	SCIENCE, TECHNO-LOGY AND SOCIETY	REQUIRED COURSE	3	**5**
403	SPECIAL TOPICS IN SCI-ENCE EDUCATION -I	REQUIRED COURSE	3	**5**
406	INSTRUMENTAL ANALY-SIS LAB.	REQUIRED COURSE	2	**5**
407	CHEMISTRY LITERATURE	REQUIRED COURSE	3	**5**
409	BIOCHEMISTRY LAB.	REQUIRED COURSE	3	**5**
411	FOOD CHEMISTRY	ELECTIVE	3	**5**
			17	**30**
Semester 8				
402	INSTRUMENTAL ANALY-SIS II	REQUIRED COURSE	3	**6**
404	CHEMICAL AND SPEC-TROSCOPIC TECHNIQUES FOR MACROMOLECULES	ELECTIVE	3	**6**
406	INTRODUCTION TO QUANTUM CHEMISTRY	ELECTIVE	5	**12**
SEÇ-V	HISTORY OF CHEMISTRY	ELECTIVE	3	**6**
			14	**30**
TOTAL CREDITS	**141**	**240**		
CGPA	**3.61 out of 4.00**			

4.4 Grading scheme, grade translation and grade distribution guidance:

For each course taken, success of the student is given one of the following grades by the course teacher.

VERBAL	COURSE GRADE	COEFFICIENT
Very Good	AA	4.00
Very Good	BA	3.50
Good	BB	3.00
Good	CB	2.50
Pass	CC	2.00
Pass	DC	1.50
Pass	DD	1.00
Failed	F	0.00
Exemption	M	
Satisfactory Completion	G	_
not Attandance	D	_

The grade of (AA), (BA), (BB), (CB) and (CC) are given to students who are successful in credit courses. The grade of (DC) and (DD) are given to students who are conditionally successful in credit courses. The grade of (F) is given to the students who are not successful in credit courses.

4.5 Overall Classification of the Qualification:

Yüksek Onur Öğrencisi
EXAMINATION: For one semester (nearly 14 weeks) there are **two midterm exams** and a **final exam**. One of the midterm exam may be as homework(report), research, project, term paper.

EDUCATION of UPPER SECONDARY (HIGH SCHOOL) TEACHERS

Physics, Chemistry, Biology, Math Teachers for high schools (16-18 ages) have to get their branch lessons (eg. Botanic, zoology) during 7 semesters, and then they also have to get pedagogical lessons during 3 semesters. At the end of 10 semester=5 years they get **Master of science diploma**(with out MSc thesis). This is the only license or diploma for working as "teacher" on their branches. But in order to work for government schools they have to get enough mark from the **KPSS exams** which applied by government for teacher candidates.

SUMMARY

Prepared by: Danuše Nezvalová

To compare science teacher training in the five cooperating countries (BG, CY, CZ, LT, TK) is not so easy because of all existing cultural differences. To summarize approaches to the science teacher education three sets of variables are of importance:

Context variables, representing the influence on teacher training of the educational system, as its customer, and of the educational policies in the cooperating countries.

Institutional variables, representing the various aspects of the institutional constraints of the teacher training programs.

Curriculum variables, representing the various aspects of the content of the science teacher training program.

Context variables

In cooperating countries a little bit different educational systems exist that influence teacher education in the countries. Generally, all described systems have primary, lower and upper secondary levels. The systems differ from the length of the levels. Primary education takes 4 (BG, CY,LT) to -5 (CZ, TK) years. There is a different training for primary and secondary science teachers in all cooperating countries. Some of the cooperating institutions are more focused on the primary science teacher training (CY, LT, TK), others on lower secondary science teacher training (LT, TK) and the next on upper secondary science teacher training (CZ). In all these countries governmental control over the science teacher exist. In the context of science teacher training the various types of decision-making, however, become most evident in the extent of governmental influence on decisions with respect to:

(a) The control over the admission to teacher training.

(b) The control over the curriculum and the qualification.

In all these countries science teacher training is a part of higher education, a secondary general education diploma is the minimum entrance requirement. With the respect to the control over the curriculum and the qualification of science teachers, there are a little bit different models, but common for all co-operating countries is that government controls the curriculum through state examination and accreditation.

Institutional variables

These variables concern:

- The course length.
- The structure of the training program.

In primary teacher training the length differs between 3 (CY) to 4 (BG, LT, TK) and 5 (CZ) years. The teachers are trained mostly in schools of education (pedagogical faculties (BG, CY, CZ, TK) or pedagogical faculty and colleges (LT) which are part of universities. The course length of the science teacher training of lower and upper secondary school varies from 4 (CY, LT, TK) to 5 years (BG, CZ). All participating institutions implemented credit systems (ECTS).

The programs contain both academic studies and professional studies in all participating countries. The integrated program, which means that academic and professional studies are to a large extent integrated, is realized in primary science teacher training in all five countries. A parallel or concurrent program, which means that academic and professional studies take place concurrently, is most frequent for participating institutions in CY, LT and TK. A consecutive program, which means that at first academic studies are completed and then followed by the professional studies, was implemented in CZ and BG recently. For instance in CZ (Faculty of Science) prospective science teachers at upper secondary schools finish bachelor degree in academic subjects. Then students can continue with academic studies in two subjects and professional studies to earn master degree. The subject combination of specialists depends on their choice at the beginning of the study and can be selected from a list of combinations or from a list of individual subjects set by the faculty.

Content variables

In all cooperating countries the curricula for the science teacher training contain subject-knowledge (academic studies) and three components of professional preparation: educational theory, didactics of the subjects and school practice. In CY, LT and TK the professional preparation is more stressed while in BG and CZ subject-knowledge is more important. In educational theory such topics as child psychology, learning psychology, philosophy of education, history of education, general didactics, culture of mother tongue, educational management, foreign languages is possible to find. The curriculum is strongly focused on the ICT using in all participating institutions. The topic of constructivism is implemented only in the curriculum in CY. Didactics of the subjects are focused on the problems how to teach science at school (teaching methods, school curriculum, methodology, research in schools, communication in sciences, planning of lessons, choice and preparation of materials, techniques of presentation, methods of assessment, classroom management, labs in sciences). School practice is a series of structured learning situations in schools, designed for prospective science teachers, in which they are confronted with concrete teaching and classroom management activities on a systematic basis, supervised by a cooperating teachers in schools. There is different length (but 6 weeks at least) of teaching practice in cooperating institution in the project.

In the institutions participating in the IQST project the different approaches of science teacher education are possible to recognize. On the other side these institutions have nearly the same problems: lack of prospective science teacher and strong common interest how to improve the quality of science teacher training. One of the possible ways is to implement constructivist theory to science teacher training. In all participating institutions would be possible to realize main goals of the IQST Socrates Comenius project: to design and implement constructivism modules in science teacher training

CHAPTER 2

APPROACHES TO COMPETENCIES FOR CONSTRUCTIVIST SCIENCE TEACHER

General Background

Prepared by: Danuše Nezvalová

What does the term competency mean? The term competency was originally used in the context of vocational education, referring to the ability to perform a particular task. The building of competence means enabling individuals to mobilize, apply and integrate acquired knowledge in complex, diverse and unpredictable situations. Competency is defined as a capacity to efficiently in a number of given situations, a capacity based on knowledge, but not limited to it. Competency is interpreted as a roughly specialized system of abilities, proficiencies, or skills that are necessary or sufficient to reach a specific goals. Competency should be regarded as a general capability based on knowledge, experience, values, dispositions which a person has developed through engagement with educational practices. The competency is a set of teachers´ knowledge, skills, attitudes and values which are used in the educational practice. Constructivist teachers can construct and act on emancipatory conceptions of knowledge, yet the effects of these conceptions may be confined to their own classrooms. Teachers can experience a change in beliefs and practices after they have entered the workforce. If we engage pre-service teachers in process of emancipatory knowledge construction, we have an obligation to prepare them to toward the competencies necessary to allow them to incorporate these practices in their future classrooms.

Case study 1

APPROACH IN BULGARIA

Needs of Constructivist Science Teacher

Prepared by: Ani Epitropova

Science is major area of human mental and practical activity which generates knowledge. That knowledge are important to understand the world around and are basis of important technological applications. According to W. Harlen (2000 p.10) there are two significant aspects that set the way the teacher teach science – ***the nature of science*** *and* ***the view of learning.*** They determine and are implicit in all decisions that teacher makes.

If science and science activities are comprehend as being the application of principles and skills which first have to be learned, the aim of science education are convinced as begin mainly to teach these principles and skills. In this case the chiefly role of teaching science is then seen as being to demonstrate the skills and to corroborated principles. That view of science can be described as: having a determinate subject matter, having defined methods, being value-free, objective and tell ultimate truths.

If science is understand as developing understanding through testing ideas against evidence through using a wide range of methods of enquiry this will lead to varied ways of teaching science. Science will be accepted as human endeavour to understand and describe the physical world. The scientific knowledge will be seen as tentative, always possible to be changed if there are new evidence challenging them. Science will be accepted in social context and related to the values of the society. If this view is accepted from prospective teacher then the teaching will involve learners in process of developing understanding and in considering accepted scientific principles in this spirit.

The view of learning is the second main aspect crucial for teachers' action in class. This view is base on knowledge and understanding that prospective teachers acquire from the courses psychology, pedagogy and methodology of science. Their own experience as students and observing lessons in class during teaching practice also has strong impact on building their view of learning. The prospective teacher view of how students learn influence the opportunities they are ready to provide for learning through interaction with materials and between them. If learning is seen as mostly receiving and mastering information then teaching will be organized to provide respect and attention to the authority rather than children developing understanding for themselves. Constructivist approach to teaching and learning presuppose student active acquiring of knowledge trough building own meaning and be independent learners.

Summary

1. Prospective teacher need to develop and extend their understanding of what is science' as it is influence all decision that teacher make.
2. Teacher's view of how students learn affect the opportunities they provide for meaningful learning through interaction with variety of materials, resources of information and interaction between students. Prospective teacher need further building and developing of constructivist approach to learning and teaching is the one that ensure this opportunities.

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Competencies for Constructivist Science Teacher

Prepared by: Jeliazka Raikova

Competency is the combination of knowledge and skills that build awareness and the ability to a correct performance of certain activity. In this specific case of future science teachers' training, competency is the result of purposeful training and can be viewed as personal accomplishment, a prerequisite for their future work as science teachers.

Main competencies necessary for future science teachers can be classified according to different features. Due to the various character of teaching activities and the new role of the teacher according to the constructivist approach, by the end of the training students are expected to have the following competencies:

1. Regarding their scientific background:

Students should:

A. Have enough correct knowledge of science – facts, theories, methods, principles and laws but understand that science cannot be characterized as being either content or process alone;
B. Be able to use that knowledge in guiding pupils in their science learning;
C. Know the main research methods of science;
D. Have a sufficient amount of knowledge of cross subject character;
E. Know the history of the science;
F. Be aware of the contemporary fronts of the science and its impact on technology and society;
G. Have experimental skills – be able to formulate a hypothesis, choose the equipment, build an experimental site, identify a change, determine variables, describe the relationship among variables, find data, and arrange data in tables and graphs.

2. General intellectual:

Students should:

A. Know the general scientific methods of research;

B. Be able to collect information from various sources – books, Internet, etc.
C. Be able to present and share information in an accessible way;
D. Be able to find information on an issue and to evaluate its scientific value;
E. Encourage the dialog among the students;
F. Be able to listen and correct ;
G. Stimulate pupils thinking by asking open questions;
H. Be able to update their knowledge;
I. Have sufficient knowledge to use ICT;
J. Understand cause-and-effect relationship and use it to formulate a model.

3. Pedagogic (related to educational aspects of teaching)

A. Be able to control the class – impose discipline and motivate students to work;
B. Be able to determine clearly the objective of activity;
C. Be able to stimulate students' activities;
D. Be able to work with school documents – curricula, textbooks, etc.
E. Be able to asses student's achievement and use the results for future planning;
F. Organize and perform summative and formative assessment;
G. Be able to create a problem situation;
H. Manage students' individual and extra class work.

4. Particular didactic (related to particular science (or physics) teaching)

A. Be able to formulate the objectives of a specific lesson;
B. Plan the teaching of physics;
C. Create in students a necessity to acquire certain knowledge, i.e. motivate them regarding a specific scientific issue;
D. Know the structure of knowledge on physical phenomena, variables and constants, laws, tools and theories;
E. Have experimental skills to perform physical demonstrations;
F. Know and use the most popular methods and approaches for the management of students' activities related to the teaching of physics;

Case study 2

APPROACH IN CYPRUS

Competencies for constructivistic teaching

Prepared by: Nicos Valanides, Charoula Angeli and Stella Hadjiachilleos

Theoretical Framework

Research on student cognition has clearly demonstrated that students' prior conceptions create a framework for understanding and interpreting information gathered through experiences. Learning results from the interaction occurring between an individual's experiences and his or her current conceptions and ideas. The process of learning depends on the extent to which the individual's conceptions integrate with new information. This integration is characterized as assimilation or accommodation and is guided by the principle of equilibration whereby individuals seek a stable homeostasis between internal conceptions and information from the environment. The process of accommodation is, however, much more critical for the continuing conceptual development of the learners, because it requires a transformation of individual conceptions rather than integration of new information into the individual's existing frameworks.

The existence and persistence of students' alternative conceptions in science gave rise to different research efforts to identify conditions that encourage or drive accommodation (e.g., Posner, Strike, Hewson, & Gertzog,1982). Dissatisfaction with current conceptions acts as a catalyst for accommodation to occur provided that the new conception is intelligible, plausible, and fruitful. This approach tends to imply that learners behave like scientists, and that ontogenic change in an individual's learning is analogous to the nature of change in scientific paradigms, ignoring the differences and disagreements between philosophers, historians, and sociologists of science about the nature of this change. Thus, each time students encounter a discrepant event they search for new intelligible, plausible, and fruitful constructs in an attempt to balance the existing cognitive disequilibrium. Personal construction of knowledge occurs through the interaction between the individual's knowledge schemes and his or her experiences with the environment. The primary mechanism for cognitive growth is the learner's interactions with the physical environment, while the social interactions and language do not receive primary attention. Social interactions and talk with other people are, however, seen as aiding the process of accommodation by creating cognitive dissonance. This description focuses on the psychological process of equilibration and reflects the Piagetian perspective or the cognitive perspective in general.

Conversely, the Vygotskian perspective, or the socio-cultural perspective in general, considers the construction of knowledge as a social process, where social transactions and discourse are considered to be the basis for any subsequent learning. Representations of knowledge are viewed as patterned by social and cultural circumstances. This view "accentuates the social and cultural genesis and appropriation of knowledge" (Billett 1996, p. 264). Learning is viewed as the appropriation of socially derived forms of knowledge. Appropriation is not restricted to the internalization of externally derived stimuli. It consists of a transformational and reciprocal constructive process (Rogoff 1995) and results to a co-construction process of cognitive structures (Valsiner, 1994).

> The cognitive and socio-cultural constructivism seem disparate, but they offer some basis for considering "the mutuality between persons acting and the social and cultural circumstance in which they act" (Billett, 1996, p. 265), and for building bridges between them. Even though both perspectives deal with the construction of knowledge, the cognitive constructivist perspective emphasizes the internal processes of knowledge construction, whereas the socio-cultural perspective focuses on children's cognitive development as it occurs through social interaction and details the negotiated nature of the reciprocal transformation with social partners. Thus, language, in the socio-cultural perspective is considered essential in socially negotiating and constructing meaning. The widening interest in "situated learning" resides in the belief that learning is more closely linked to the circumstances of its acquisition, and that these circumstances influence the transfer of knowledge to other situations. This belief calls for a closer consideration of the contributions of socio-cultural constructivism in understanding the role of social transactions in shaping cognition and the complexities of the situated knowledge of the classroom.

Although the relationship between social circumstances and cognition remains opaque, our approach accepts the potential contribution of both perspectives to the construction of knowledge, and attempts to investigate how carefully designed classroom-based discourse supports students' conceptual growth. The attempt aims at providing students with the opportunity to be involved in experimentation and discussions or evidence-based argumentation for the purpose of examining how the knowledge construction process is shaped and validated by students' interactions amongst them, the teacher, and the physical environment.

The Cognitive Conflict Process Model (CCPM)

Piaget viewed learning as a process where an individual constructs his or her own meaning through cognitive processes. The main underlying assumption of constructivism is that individuals are actively involved right from birth in constructing personal meaning that is their own personal understanding from their experiences (Flavell & Piaget, 1963). Providing a problem-solving context for actively engaging students in the thoughtful application of knowledge is an important variable in increasing learning (McMahon, 1997). These viewpoints on learning, which are now called cognitive constructivism, paved the way for the emergence of the educational theory called social constructivism (McMahon, 1997). Vygotsky (1896 – 1934) became famous for his view on mediation as an integral part of human psychology (Vygotsky, 1978). Therefore, according to the Vygotskian perspective, learning is socially constructed, meaning that learners can, with help from adults or peers who are more advanced, master concepts and ideas that they cannot understand on their own. (Sternberg & Williams, 1998).

Therefore, meaning building and learning can be considered as "idiosyncratic events", involving unique learning and propositional frameworks of the learner, in addition to varying approaches to learning and varying emotional predispositions (Novak, 2002). Conceptual change is considered a complicated and dynamic process, which is affected by a variety of factors, beyond the cognitive ones, such as motivation, goals, and perceptions of the task (Dekkers & Thijs, 1998; Lee, Kwon, Park, Kim, Kwon, & Park, 2003). Posner, Strike, Hewson, & Gertzog (1982), suggested that, in order for accommodation to occur, the learner must experience *dissatisfaction with existing conceptions.* The dissatisfaction with existing conceptions has long been studied under several perspectives and using a variety of alternative terms, which were used to express similar meanings to cognitive conflict, such as, disequilibrium (Piaget, 1952), cognitive dissonance (Murray, Ames, & Botvin, 1977; Dekkers & Tijs, 1998), conceptual conflict (Johnson & Johnson, 1979), socio-cognitive conflict (Bearison, Magzamen, & Filardo, 1986). Based on an extended review of the literature, Lee, et al. (2003), developed their own definition of cognitive conflict:

> *Cognitive conflict is a perceptual state, where one notices the discrepancy between one's cognitive structure and environment (external information), or between the components of one's cognitive structure (i.e., one's beliefs, substructures and so on, which are in cognitive structure. (p. 586)*

In order to explain cognitive conflict and its effects on science learning, Lee, et al. (2003) developed the Cognitive Conflict Process Model (CCPM) that is presented in Figure 1. The CCPM is based on two assumptions. Firstly, the individuality of the learner and environmental factors affect the cognitive conflict process. Secondly, the components of the cognitive conflict strongly affect behavior. The model was developed to explain the cognitive conflict that occurs when a student is confronted with an anomalous situation that is incompatible with his or her existing conceptions in learning science (Lee, et al., 2003).

The CCPM (Lee et al., 2003) is comprised of three stages: The *preliminary stage* occurs before cognitive conflict, and represents the process during which the learner accepts a problem situation as anomalous to his existing conceptions. A problem situation is characterized as anomalous when the learner identifies it as incompatible with his/her previous conceptions, or when the learner realizes that his/ her existing conceptions are inadequate to provide explanatory frameworks for a phenomenon. The second stage is the *conflict stage*, during which the actual cognitive conflict occurs.

As presented in Figure 1, the CCPM (Lee et al., 2003) begins with the learner‘s initial conceptions, refered to as "belief in preconception." These beliefs refer to the explanatory structures of the learner that are constructed through his everyday experiences and prior to the examination of the concept in the school setting. Therefore, in order for cognitive conflict to occur, the learner must have some existing conceptions or explanatory frameworks regarding the phenomenon that will be examined. These preconceptions comprise, from students' perspectives, correct explanatory frameworks In case the learner does not have existing cognitive structures regarding a science concept, then there will be no need to refer to the CCPM (Lee et al., 2003).

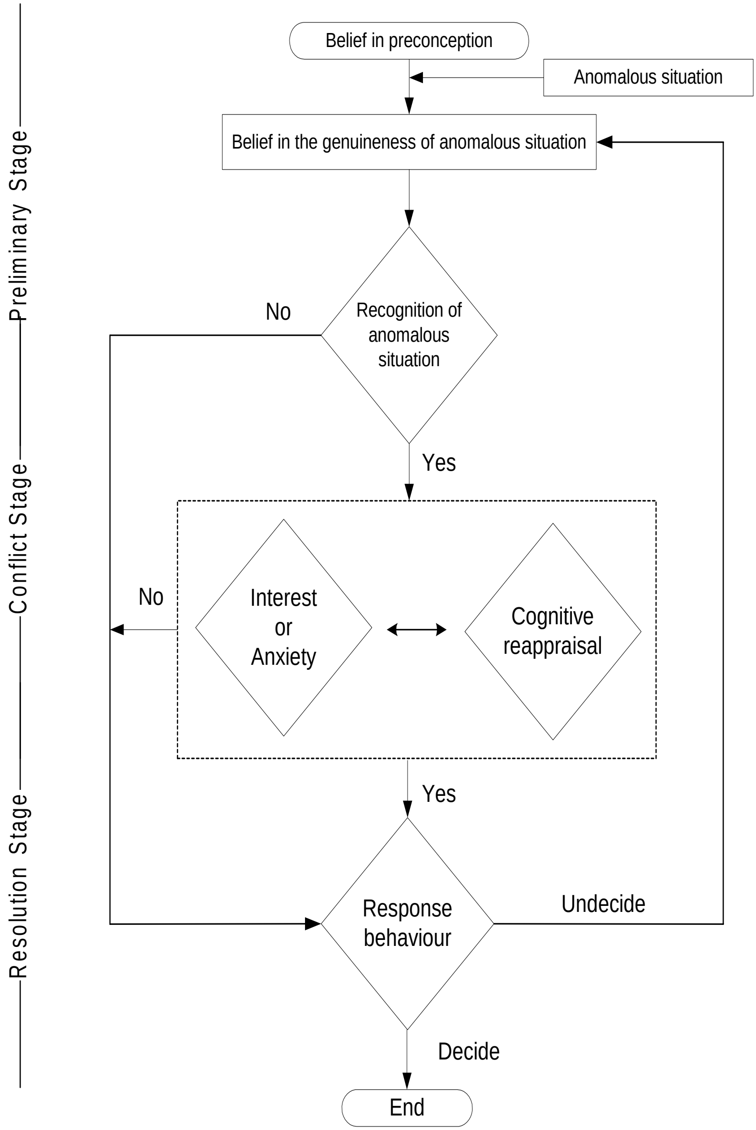

Figure 1: The Cognitive Conflict Process Model (Lee et al., 2003)

The real issue here is "How can learners' initial conceptions are identified?" Obviously, the learners should be asked and encouraged to externalize and clearly state these conceptions. The preliminary stage of the CCPM (Lee et al., 2003) is considered extremely important for several reasons. The learning environment or situation should be not only interesting and challenging to the learners, but it will also encourage the learners to express, in a psychologically safe environment, their genuine explanations of a phenomenon and commit themselves to these specific explanations. Subsequently, according to Figure 1, the teacher should provide the learner(s) with anomalous data (i.e., an experiment) challenging or even contradicting the learner(s)' initial conception, because the anomalous data reveal that the expressed conceptions are inadequate to provide any explanation to the problem. This situation is referred to as "anomalous situation." If the problem situation is recognized as anomalous or incompatible to the learner's existing conceptual frameworks, then the learner may eventually enter the conflict stage. Obviously, if the learner does not recognize the anomalous situation, then the learner will not be cognitively engaged in solving the problem and (s)he will not face any "cognitive disequilibrium" that could trigger his efforts to resolve it. Consequently, the learner remains unaffected, the situation does have any affective or cognitive implications on him/her, and does not produce any cognitive response. The arrows indicate that cognitive effort will be triggered only when the learner really accepts the genuineness of the anomalous situation, in which case (s)he will recognize the problem situation as anomalous and will enter the conflict stage.

As demonstrated in Figure 1, during the conflict stage, cognitive and affective factors come into play. More specifically, recognizing an anomalous situation, will either arouse the learner's interest and motivation or it will cause anxiety. Interest may trigger the learner's motivation to resolve the stage of cognitive disequilibrium and may have constructive effects concerning the cognitive reorganization of the learner's exist sting cognitive structures. As indicated in Figure 1, interest and motivation can encourage cognitive engagement and experimentation for resolving the cognitive disequilibrium leading to reappraisal of the learner's initial conceptions. On the other hand, anxiety is an emotion that may hinder the resolution of the cognitive conflict. In case anxiety is experienced, then the learner will either be discouraged, and eventually disengaged from the process of resolving the conflict, or will still proceed with cognitive reappraisal that may produce a non-appropriate response behavior due to the feelings of anxiety or fear of the situation.. Cognitive reappraisal that occurs under the pressure of anxiety is not likely to be as productive to the solution of the conflict as cognitive reappraisal resulting from students' motivation and interest. Evidently, Cognitive reappraisal, and conceptual change do not exclusively depend or are guided by "cold cognition" but depend as well on the emotions that are always present learner's engagement in any problem-solving situation, especially when the learner belongs in a social group, such as a classroom.

Lee, et al. (2003), elaborated on the catalytic role of the affective domain in the process of cognitive conflict.

> *Constructive cognitive conflict can be aroused when a student recognizes an anomaly clearly, experiences strong interest and/or appropriate anxiety, and reappraises the cognitive conflict situation deeply. However, if a student does not recognize the anomaly, ignores it, or experiences a negative feeling (such as frustration or feeling threatened) instead of interest, or if she does not like to be in a conflict state, the cognitive conflict in this situation might be a negligible experience or even a destructive one. (p. 590)*

According to the CCPM (Lee et al., 2003), the learner should be *consciously* engaged in the process of cognitive conflict and should be kept l aware of the differentiations between his/her initial and final conceptions. Having reappraised his/her ideas, the learner is subsequently able to resolve the problem or explain the discrepant phenomenon. If the learner is not able to reappraise his initial conceptions or is unaware of the differentiations between his initial and final conceptions, then (s)he remains undecided regarding the solution of the problem. Therefore, as indicated by the arrows in Figure 1, the learner re-examines the problem, and is subsequently re-engaged in the conflict stage.

During the resolution stage, a learner attempts to resolve cognitive conflict and adjust his existing explanatory frameworks concerning the phenomenon examined. According to Lee, et al. (2003), the resolution of the conflict will be expressed as an external response behavior. Response behaviors indicated by Lee, et al. (2003) include behaviors suggested by Chinn and Brewer (1998). Examples of these behaviors are ignoring, rejection, uncertainty, exclusion, abeyance, reinterpretation, peripheral theory change, and theory change.

The implementation of the CCPM requires some competencies for science teachers (Hadjiachilleos & Valanides, 2006). These competencies concern not only teaching practices implemented in the school setting, but also professional development of teachers and science education programs concerning pre-service education.

1. Science teachers must be aware of students’ main alternative conceptions that are discussed in the related literature.
2. Science teachers must also be competent in diagnosing their students‘ alternative conceptions, using mainly qualitative approaches and formative evaluation approaches.
3. Science teachers must be able to design and develop learning environments conducive to conceptual change taking into consideration their students‘ conceptions.
4. Therefore, science teachers must be able to invest on discrepant events that challenge students’ existing alternative conceptions.
5. Science teachers must be able to identify discrepant events that are interesting to and engaging for the students, and are well structured, so that students can be scaffolded to realize the discrepancy between their existing conceptions and the phenomenon.
6. Science teachers must be competent to structure problem situations that can provide scaffolding towards possible solutions.
7. Science teachers must be equipped with the required abilities for correctly recognizing whether their students experience cognitive conflict or not. Even if a problem situation is designed to engage students in the process of cognitive conflict, students often fail to engage in cognitive conflict either because they do not understand the discrepancy between the problem situation and their existing conceptions, or because they do not find the problem situation interesting or plausible.
8. Science teachers must have the flexibility to differentiate a problem situation according to students’ characteristics (e.g., cognitive ability, performance, gender, social and cultural background, etc) in order to enable more students to experience cognitive conflict.
9. Science teachers must be able to identify the groups of students for which the implementation of the cognitive conflict strategy is more or less effective (Zohar, & Aharon - Kravetsky, 2005) depending on students‘ characteristics.
10. Science teachers must be able to provide the necessary means for their students to resolve the discrepancies between the phenomena they observe and their existing conceptions. Therefore, they must be in a posi-

tion to actively support students in this process and provide cognitive and metacognitive scaffolding, without compromising students' flexibility towards finding multiple solutions for a problem situation.

11. Science teachers must be able to provide valuable feedback as to the kinds of reasoning implemented by students, and to help them develop their scientific reasoning skills.

12. Science teachers must be competent of identifying non-cognitive factors engaged in a cognitive conflict situation and to incorporate these factors productively in the learning process. Therefore, they must conceptualize students' learning as effort that extends beyond cold cognition, by incorporating the affective domain towards promoting productive learning outcomes.

13. Consequently, science teachers must be able to encourage positive emotions, such as, interest and feelings of psychological safety and competence, anong students when engaging them in the cognitive conflict process.

14. Accordingly, science teachers must be able to alleviate negative emotions, such as anxiety,. experienced by their students during a cognitive conflict situation.

15. Science teachers must be competent in undertaking roles as facilitators and supporters when students attempt to resolve their cognitive conflict situations.

16. Science teachers must be able to promote productive social interactions among their students in ways promoting collaboration and shared responsibilities for the knowledge construction process, so that groups of students become real learning communities.

17. Science teachers must be able of recognizing their students' conceptual change by identifying students' cognitive gains or conceptual advancement. initial and final conceptions and must provide opportunities for students to become aware of these differentiations.

18. Science teachers must be able to develop problem situations where students not only will become aware of their conceptual advancement but where they will also be challenged to implement their reappraised conceptions.

19. Science teachers must be able to provide opportunities for their students to become consciously aware of their involvement in each step of the problem-solving methodology, by incorporating continuous ongoing reflection concerning the process and outcomes of doing science through inquiry.

20. Science teachers must be competent of evaluating their own and their students' conceptions based on criteria compatible with the tentative nature of science.

This list of competencies for science teachers is not exhaustive but constitute useful guidelines that should be taken into consideration for both pre- and in-service training of science teachers. More specifically, professional development for science teachers should be a continuous process extending from pre-service education to the end of their professional career. Professional development programs should also provide incentives and opportunities for science teachers to be involved in a variety of professional activities, regarding not only the understanding of abstract science concepts, but also rich learning activities for improving science teachers' Pedagogical Content Knowledge (PCK) and action research skills for evaluating their own classroom teaching (Valanides, 2002; Valanides & Angeli, 2002; Valanides & Angeli, 2005; Valanides, Nicolaidou, & Eilks, 2003; Papastephanou, Valanides, & Angeli, 2005; Zion et al., 2004). Needless to mention that there is also an urgent need to encourage the integration of ICT in teaching and learning and promote the development of ICT-related PCK (Angeli & Valanides, 2005; Valanides, 2003; Valanides & Angeli, 2006; Valanides & Angeli, 2006). Regarding this issue of preparing science teachers to teach in technology-rich classrooms, in-service and pre-service training should emphasize ICT-related PCK as the form of knowledge science teachers need to become competent to teach science with ICT tools appropriate for science learning in ways that signify the added value of technology for science (Valanides & Angeli, in press; Angeli, Valanides, & Bonk, 2003; Angeli & Valanides, 2004; Angeli & Valanides, 2005). Moreover, pre- and in-service science education programs must make science teachers aware of and able to use a variety of methodological approaches in order to promote more effective learning outcomes. For example, science teachers must be able to promote learning essential science content through the perspectives and methods of inquiry (Zion et al., 2004). Therefore, they must be competent of actively investigating a phenomenon, interpreting results, and extrapolating those findings towards conclusions, which are compatible with current accepted scientific understandings. Additionally, professional development programs should encourage, support, and sustain teachers as they implement effective science programs incorporating cognitive conflict, since the cognitive conflict approach seems to promote effective science learning for certain groups of students (Hadjiachilleos, 2007).

Additionally, pre- and in- service science education programs should provide opportunities to enable educators understand the interconnectedness between multiple domains of the subject matter or between science and other cognitive domains (e.g., mathematics) and to enable educators to incorporate this interconnectedness in their science teaching. The problem situations implemented by science teachers should be developmentally appropriate, interesting, and relevant to students' lives, emphasize student understanding through inquiry, and be connected with other school subjects.

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Case study 3

APPROACH IN THE CZECH REPUBLIC

Prepared by: Danuše Nezvalová

Introduction

A great deal has been written in recent years about constructivist learning theories and their applications to secondary science classroom. Much less has been said about the implications of these ideas and practices for teacher education. Constructivist teacher education is defined as working with prospective teachers in a constructivist way, helping them to re-examine and reflect about the tacit ideas they bring to their education for teaching. Constructivism can be a lens through which we can understand the process of learning to teach.

One cannot think of constructivist teaching, however, as a monolithic, agreed-upon concept. Constructivism is a learning or meaning-making theory. It suggests that individuals create their own new understandings, based upon the interaction of what they already know and believe, and the phenomena or ideas with which they come in contact. Constructivism is a descriptive theory of learning (this is a way people learn or develop); it is not a prescriptive theory of learning (this is a way people should learn). Teacher educators are attempting to develop a constructivist teacher education programme.

Two quiet different forms of constructivist teacher education are being advocated today. One form attempts to teach students how to teach in a particular constructivist manner (for example, Black and Ammon, 1992). Often these approaches apply to the teaching of particular subject matters (Mosenthal and Ball, 1992; Schifter and Simon, 1992). Another form of constructivist teacher education involves working with prospective science teachers to help them to understand their own tacit understandings, how these have develop, and the effects of these understandings on their actions; and to introduce new conceptions and premises as potential alternatives to those held by students (Harrington, 1995; Richardson, 1992,1994). The first form often involves considerable direct instruction in theory and practice. The second attempts to model a manner of involving students in investigations of premises and perspectives that it is thought may be used by the preservice teachers when they begin to teach.

Both forms of constructivist teacher education could present problems. When the teacher educator directly instructs teacher science education students in constructivist theory and has in mind a particular approach to teaching, he or she models an approach to teaching that is contrary to the one that is hoped the students will employ when they are teaching. On the other hand, the second form – the investigation of beliefs and presentation of alternative conceptions of teaching – models and approach to constructivist teaching that may not be appropriate for the teaching of science subject matters.

The challenge for constructivist teacher educators is to develop an approach to teaching that does not contradict the content of the course – that is, constructivist teaching – but acknowledges differences in the nature of constructivist teaching depending on the science content that is being taught. If we engage preservice teachers in process of knowledge construction, we have an obligation to prepare them to work toward the changes necessary to allow them to incorporate these practices in their future classrooms.

In science teacher education knowledge construction is crucial; teacher educators must be able to teach in a manner that models the attitudes and behaviours that they would like their preservice teachers to manifest in future classrooms. Pedagogical approaches derived from constructivism should begin with the content that:

- Foregrounds cognitive development based on merging academic and everyday concepts;
- Defines knowledge as partial and positional;
- Stress critical analysis and reflection.

Needs of Constructivist Science Teacher

Prepared by: Danuše Nezvalová

In this part we develop our ideas in the context of the needs of science teacher education. This invites the philosophy of science as a special informant about the nature of constructivism. We understand a central tenet of constructivism to be what philosophers of science have argued for decades – that facts and processes of observation are theory laden and, therefore, cannot be taken as self-evident in the classroom. Much of scientific knowledge consists not merely of the phenomena of nature, but also of constructs advanced by the scientific community to interpret and explain nature. A constructivist perspective on meaning-making is useful if it develops in individuals a disposition for inquiring into problems.

Science teacher education students need opportunities for testing, discussing, and comparing various perspectives and approaching to teaching. Science teachers become more responsible for their pedagogical choices. Students continually construct meaning of classroom events based on their prior understandings and experiences. It follows that a constructivist science teacher will have a disposition for attempting to see science classroom phenomena from students´ perspectives in the instructional programme. The disposition and ability to see from students´ points of view is fundamental to sorting out what is right about their thinking as well as what is inconsistent or incoherent about it. To see a phenomenon from a student's point of view requires reconstruction on the part of teacher. The phenomenon in question must be seen in a new light. A critical aspect of science teaching is a teacher's ability to see how such perceptions arise from student's perspectives. We appreciate the difficulty of imparting constructivist orientation to science teacher education students. They often appear to us as discovery learning teachers, with hand constructivist-on activities related to the science idea.

Constructivist talk seems to evoke in some teacher education students a distorted image, or a truncated version, of constructivist teaching. In some representations by students, constructivism sounds like a recipe, a procedure of teaching. In many cases the constructivism looks like discovery learning, when children put forward their science ideas at discoveries, and the cross-checking and testing of those ideas with other references (peers, teacher's scientific knowledge) is omitted.

Science teachers need to concern themselves with the manner in which hear or read constructivism but also the ways in which they represent it to themselves as researchers. Constructivism is a way of thinking about the events of teaching and learning.

Summary

1. Initial knowledge is fragmentary and unstable. Candidates often denote concepts in ways that suggest they think about them in functional or operational terms. Science teacher students need to integrate new professional learning with their knowledge.
2. Structural knowledge increases over the course of science pre-service teacher education, and continues to increase with teaching experience.
3. Knowledge growth is uneven and idiosyncratic. The variation and turbulence in knowledge growth is displayed by beginning teachers.
4. Cognitive structure of student is correlated with the ability to reflect deeply about teaching. Reflection should be a part of science teacher training.
5. Teaching practice is an important part of science teacher training. Student teaching provides such an environment as university classes cannot do.
6. Some science teacher students have misconceptions about science teaching and learning. Students have the needs to directly challenge these misconceptions. Understanding of candidate's prior knowledge is a key to improving science teacher education. Prior knowledge is central to constructivism.
7. Students need better tools in the courses (concept mapping, journaling, biography, research, cooperative work, experimenting, hands-on activities, questioning, discussion, learning by doing, …).
8. Students need to encourage reflection on previously held views of science teaching and learning.
9. Students need to promote an understanding of a constructivist perspective on learning and its implication for teaching.

10. Students need to understand the prospects and problems of implementing a constructivist-based approaches for promoting changes in science teaching and learning.

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Competencies of Constructivist Science Teacher

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Introduction

Teachers of science at all grade levels must demonstrate competencies consistent with the achievement of the vision of high quality of science teacher. They should not only demonstrate that they have the necessary knowledge and planning skills to achieve these goals, but also that they are successful in engaging their students in studies of such topics as the relationship of science and technology, nature of science, inquiry in science and science-related issues. Competencies are intended as the foundation for a performance assessment system, through which teacher candidates must satisfactorily demonstrate their knowledge and abilities in the science teacher preparation program. This competencies address the knowledge, skills and dispositions that are deemed important for teachers constructivist courses in the field of science.

Competency 1: Understanding of Science Content

Teachers of science understand and can articulate the knowledge and practices of contemporary science. They can interrelate and interpret important concepts, ideas, and applications in their fields of licensure; and can conduct scientific investigations. To show that they are prepared in content, teachers of science must demonstrate that they:

a. Understand and can successfully convey to students the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields.

b. Understand and can successfully convey to students the unifying concepts of science.

c. Understand and can successfully convey to students important personal and technological applications of science in their fields of licensure.

d. Understand research and can successfully design, conduct, report and evaluate investigations in science.

e. Understand and can successfully use mathematics to process and report data, and solve problems, in their field(s) of licensure.

Knowledge within the content discipline is required as the basis for conducting instruction through inquiry and engaging students in effective inquiry.

Competency 2: Nature of Science

Teachers of science engage students effectively in studies of the history, philosophy, and practice of science. They enable students to distinguish science from non-science, understand the evolution and practice of science as a human endeavor, and critically analyze assertions made in the name of science. To show they are prepared to teach the nature of science, teachers of science must demonstrate that they:

a. Understand the historical and cultural development of science and the evolution of knowledge in their discipline.

b. Understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.

c. Engage students successfully in studies of the nature of science including, when possible, the critical analysis of false or doubtful assertions made in the name of science.

Students should engage in active investigation and analysis of the conventions of science as reflected in papers and reports in science, across fields, in order to understand similarities and differences in methods and interpretations in science, and to identify strengths and weaknesses of findings.

Competency 3: Inquiry

Teachers of science engage students both in studies of various methods of scientific inquiry and in active learning through scientific inquiry. They encourage students, individually and collaboratively, to observe, ask questions, design inquiries, and collect and interpret data in order to develop concepts and relationships from empirical experiences. To show that they are prepared to teach through inquiry, teachers of science must demonstrate that they:

a. Understand the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.

b. Engage students successfully in developmentally appropriate inquiries that require them to develop concepts and relationships from their observations, data, and inferences in a scientific manner.

In science education, inquiry may take a number of forms: discovery learning, in which the teacher sets up the problem and processes but allows the students to make sense of the outcomes on their own, perhaps with assistance in the form of leading questions; guided inquiry, in which the teacher poses the problem and may assist the students in designing the inquiry and making sense of the outcome; and open inquiry, in which the teacher merely provides the context for solving problems that students then identify and solve bridge.

These approaches lie on a continuum without boundaries between them. What is common to all of them is that they require students to solve a genuine (to them) problem by observing and collecting data and constructing inferences from data. More advanced forms of inquiry require students to ask questions that can be addressed by research, design experiments, and evaluate conclusions. Teachers who use inquiry effectively tend to be more indirect, asking more open-ended questions, leading rather than directing, and stimulating more student-to-student discussion. Students who learn through inquiry gain a deeper understanding of the resulting concepts than when the same concepts are presented through lecture or readings. This has led to the principle that less is more: teach less, learn more is typical for constructivist science teacher.

Competency 4: General Skills of Teaching

Teachers of science create a community of constructivist learners who construct meaning from their science experiences and possess a disposition for further exploration and learning. They use, and can justify, a variety of classroom arrangements, groupings, actions, strategies, and methodologies. To show that they are prepared to create a community of constructivist learners, teachers of science must demonstrate that they:

a. Vary their teaching actions, strategies, and methods to promote the development of multiple student skills and levels of understanding.

b. Successfully promote the learning of science by students with different abilities, needs, interests, and backgrounds.

c. Successfully organize and engage students in collaborative learning using different student group learning strategies.

d. Successfully use technological tools, including but not limited to computer technology, to access resources, collect and process data, and facilitate the learning of science.

e. Understand and build effectively upon the prior beliefs, knowledge, experiences, and interests of students.

f. Create and maintain a psychologically and socially safe and supportive learning environment.

Science related instruction should be presented in many ways including, but not limited to, cooperative learning, concept mapping, diagramming, model building, role playing, game-playing, simulating, studying cases, questioning, discussing, solving problems, inquiring, field trips, projects, electronic media, written reporting of investigative techniques and data, and reading.

In general, learning a particular concept should involve multiple interactions with various features of the concept. In turn, concepts must be integrated into a coherent network of concepts from which one can make cogent decisions. Teachers must provide learning opportunities requiring multiple interactions with a concept in different contexts.

Candidates should know how to use appropriate technology including, but not limited to, computers and computer peripherals, both to enhance learning and to relate the use of technology to science. The ability of students to use technological tools is becoming increasingly important for collecting and processing data; and for presenting and disseminating the results. In addition to using technology in the science classroom, teachers should also ensure that students understand the role technology plays in professional science.

Teachers of science should be able to determine and use presently held student knowledge to frame and develop new concepts to be learned. Much of what we know about how people learn has been encapsulated in the epistemology of constructivism. Learners are actively involved in the knowledge construction process by using their existing knowledge to make sense of new experiences. Pre-existing knowledge influences the way new knowledge is added to the individual's conceptual model, modifying its subsequent meaning. To be effective, teachers must learn how to listen and to probe for various conceptualizations, and then use this knowledge to frame the way the concepts to be learned are taught. Pretesting and preconceptions surveys are excellent ways for candidates to determine the prior conceptual knowledge of their students. Candidates should also be able to show how they used prior conceptions and variations in the knowledge of their students to plan instruction in relation to the target concept.

Competency 5: Curriculum

Teachers of science design, plan and implement an active, coherent, and effective curriculum. They begin with the end in mind and effectively incorporate contemporary practices and resources into their planning and teaching. To show that they are prepared to plan and implement an effective science curriculum, teachers of science must demonstrate that they:

a. Understand the curricular recommendations of the National Science Education Curriculum, and can identify, access, and/or create resources and activities for science education that are consistent with the National Curriculum.

b. Plan and implement internally consistent units of study that address the needs and abilities of students.

Curriculum identifies three major dimensions: the intended curriculum (goals and plans), the implemented curriculum (practices, activities, and institutional arrangements) and the attained curriculum (what students actually achieve through their educational experiences).

Well prepared science teachers can plan, implement and evaluate a high quality science curriculum that includes long-term expectations, learning goals and objectives, plans, activities, materials, and assessments. Candidates should know how to effectively use various resources such as news media, libraries, resource centers and the Internet.

Competency 6: Assessment

Teachers of science construct and use effective assessment strategies to determine the backgrounds and achievements of learners and facilitate their intellectual, social, and personal development. They assess students fairly and equitably, and require that students engage in ongoing self-assessment. To show that they are prepared to use assessment effectively, teachers of science must demonstrate that they:

a. Use multiple assessment tools and strategies to achieve important goals for instruction that are aligned with methods of instruction and the needs of students.

b. Use the results of multiple assessments to guide and modify instruction, the classroom environment, or the assessment process.

c. Use the results of assessments as vehicles for students to analyze their own learning, engaging students in reflective self-analysis of their own work.

Constructivist science teachers must feel confident in using authentic assessment it to measure achievement of science. Assessment is not a punitive action; rather it should be a process of learning by teacher and student. Good assessment strategies help students learn about their strengths and weaknesses. Poor assessments result only in a sense of failure or incompetence for sincere students. Reflective teachers help their students identify and celebrate their achievements.

Central to the process of assessment is the concept of alignment: the consistency between goals, actions and assessments. New teachers must learn how to design instruction and assessments that are consistent with multiple goals, not just those aimed at content acquisition. In a climate of positive assessment, learners and their teachers look for evidence to document growth. Diagnostic, formative and summative assessment strategies are woven throughout instruction as a natural part of the classroom activities. Portfolios are often used to collect evidence of growth and change.

Multiple assessment methods including videotapes, demonstrations, practicum observations, discussions, reports, simulations, exhibitions and many other outcomes are useful alternatives to the traditional written test. Peer assessment in cooperative learning groups is especially useful for demonstrating skills using laboratory equipment, and for evaluating process skills such as the creation and interpretation of graphs. Computer-based testing can help students diagnose their own abilities while placing fewer demands on teacher time.

Authentic assessment has also become an important part of science education. It is assessment that mirrors and measures students' performances in 'real-life' tasks and situations. It is also important that teachers be able to involve students in self-analysis. Too often assessment is something done to students. It takes little effort for candidates to include items that require student reflection on tests, projects, or activities they have completed. Conferencing with students using data from their assessments may also be a way of involving students in self assessment as long as the students themselves are doing the assessing.

Competency 7: Safety and Welfare

Teachers of science organize safe and effective learning environments that promote the success of students and the welfare of all living things. They require and promote knowledge and respect for safety, and oversee the welfare of all living things used in the classroom or found in the field. To show that they are prepared, teachers of science must demonstrate that they:

a. Understand the legal and ethical responsibilities of science teachers for the welfare of their students, the proper treatment of animals, and the maintenance and disposal of materials.

b. Know and practice safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials used in science instruction.

c. Know and follow emergency procedures, maintain safety equipment, and ensure safety procedures appropriate for the activities and the abilities of students.

d. Treat all living organisms used in the classroom or found in the field in a safe, humane, and ethical manner and respect legal restrictions on their collection, keeping, and use.

Safety and liability are especially of concern to science teachers, given the variety of environments in which they may teach and the materials they may use. Candidates must know how to check and use safety equipment properly and the hazards of improperly shielded equipment, and must be able to avoid risks from fire hazards and biological contaminants. It is also important that candidates actually behave in a safe manner, model ethical and safe behavior, and ensure that students behave safely at all times. They must give proper safety instruction and causations, and must label materials and equipment in such a way as to maintain safety.

Competency 8: Professional Growth

Teachers of science strive continuously to grow and change, personally and professionally, to meet the constructivist needs of their students, school, community, and profession. They have a desire and disposition for growth and betterment. To show their disposition for growth, teachers of science must demonstrate that they:

a. Engage actively and continuously in opportunities for professional learning and leadership that reach beyond minimum job requirements.

b. Reflect constantly upon their teaching and identify ways and means through which they may grow professionally.

c. Use information from students, supervisors, colleagues and others to improve their teaching and facilitate their professional growth.

d. Interact effectively with colleagues, parents, and students; mentor new colleagues; and foster positive relationships with the community.

Teaching becomes a profession when teachers practice with a common knowledge base and apply their knowledge to effective practice Professional teachers must be capable of profound reflection on practice, competent to enter into dialogue of the practice they know and the theory or literature they read; and able to observe, document, and analyze their own practice and experience, and take that analysis into their practice.

Case study 4

APPROACH IN LITHUANIA

Assessment of the Needs for Studies

Prepared by: Vincentas Lamanauskas and Margarita Vilkonienė

The assessment of the needs for studies was based on gained experience of training the teachers of natural sciences in Lithuania. The curricula of preparing the teachers of natural and exact sciences are implemented only through the studies at university level. Four Lithuanian universities train the above mentioned teachers. The assessment of the training curricula of natural science teachers disclosed the major drawbacks which allowed defining the needs for teacher training studies.

1. The qualitative curricula of studies corresponding to the students' needs. The training curricula of natural science teachers include the tendencies displaying alienation from a parallel model of teacher training. Two rather independent but not equivalent parts can be distinguished in the above mentioned curricula:

Part 1 (130 – 134 credits per 4 years of studies) focuses on scientific issues (biology, chemistry. physics) and on gaining a bachelor's degree which is defined by the structure of general university studies;

Part 2 (16 – 30 credits) is directly concentrates on acquiring teacher's qualification defined by the structure of the subjects of a specific (professional) part.

Obviously, the pedagogical qualification of would-be teachers is devoted scant attention. The development of professional pedagogical competence covers such general subjects as education management, introduction into Educology, didactics, hodegetics and subjects discussing methodologies (Nature Study didactics, Biology didactics, Chemistry didactics etc.). However, the curricula do not clearly disclose the situation, for example, it is unclear how didactics integrate, arguments or meets with chemistry (biology, physics) didactics.

A few curricula are only partly oriented towards development of didactical competence of natural sciences i.e. only narrow methodical aspects are emphasized, for example completing school tasks, Olympiad assignments etc.

In conclusion, in order to gain general competence of pedagogical activity, teaching/learning general subjects are not enough. Following the parallel model, teacher training must be legally defined and an optimal qualitative curriculum for integration of the content of a subject and pedagogical activity must be created.

2. The optimization of the natural science teachers' training model. It should be discussed whether an officially and universally applied coherent model '4 years + 1 year' should be more promising in the process of training the teachers of natural sciences. The future of professional studies following the acquisition of a bachelor's degree is confirmed by the possibility of preparing the new curricula of professional studies which may include a general thematic unit of the subjects that concentrate on developing pedagogical competence as well as didactical matters of particular directions in science that focus on increasing didactical competence in a certain subject. Clear methodologies of how to arrange self-expressed students' learning are required. The quantity of practice, experiments, seminars etc. in the curricula of studies should relatively grow. A burning need is development of students' abilities to operate information and be computer literate.

3. The system of methodological support for designers of the curricula of studies. While designing the curricula of studies at University level, no methodology is provided and no methodological support is received. That is why the process of planning the curricula of studies at University level is rather liberal and not defined by standardized competencies. On the one hand, it offers possibilities of making the curricula more flexible considering educational competencies; however, on the other hand due to lack of common methodology, too wide diversity appears in developing them.

4. Dissemination of good experience. To solve the problem of integrated training of natural science teachers in Lithuania, there is shortage of specified methodologies, the examples of good experience and recommendations.

5. The model of optimal integration of information communication technologies (ICT) into natural sciences. Applying ICT in the teaching/learning process is one of the methods of constructive self/education. Nevertheless, no detailed systemic, methodical recommendations on how to integrate modern ICT in the teaching/learning process are produced. There is a severe lack of constructive software. Therefore, the teachers of natural sciences feel shortage of general competence in the field of modern ICT as well as have no methodical experience of how to efficiently apply ICT in the process of natural science education. Similar experience should be gained during training activities such as seminars etc., within specific pedagogical practice at school using modern training aids based on ICT and certainly along the process of studying. Consequently, appropriate training curricula and those at university level are required.

The list of initial science teachers competencies in the context of constructivism

Prepared by: Vincentas Lamanauskas and Margarita Vilkonienė

Unit of Competence	Competencies	Content of Competencies	Comments
1. General competencies in Educology	1.1. Competen ce in critical thinking	1.1.1. Knows classical and modern concepts of natural science education, perceives its major differences, qualities and drawbacks.	1.1.1. on the basis of modern natural science concepts positively evaluates learners' research work and their ability to apply scientific research methods in the educational process; does not overestimate the importance of science (is not a radical 'positivist') and encourages learners' discussions, interpretations and creativity;
		1.1.2. Knows the natural science situation at national, European and worldwide level.	1.1.2. is interested in the newest information and modern methodologies as well as in the latest results of research on natural science education and on the issues of science education. The obtained information is used for stimulating the process of natural science education.
	1.2. Organizational competence	1.2.1. Ability to successfully combine classical and modern concepts of natural science education in practice and to predict the most efficient means of educational impact.	1.2.1. Orientation to modern natural science education tendencies helps with stimulating practical learners' activities (observation, experimentation), applying scientific cognitive methods in the teaching process, planning and implementing research projects and indicates how to assess the researched data and make comments on findings and presentations of the carried out investigations. The teacher simultaneously understands that interaction between the learners including speaking, interpretation, discussion etc. and questioning help with acquiring abilities and

			knowledge of natural science education. Therefore, they are not afraid of Socratic teaching technology and work together with their students to find the true answers to the raised questions;
		1.2.2. Ability to organize the teaching/learning process through communication and collaboration.	1.2.2. perceives that exactly the social interaction leads to the process of constructing knowledge. Although the interpretation of an appropriate event can carry an individual character, however, in most of the cases, the structure or understanding of a specific natural science phenomenon/object should have common features. Thus, the students are offered favourable conditions of reciprocity and active collaboration;
		1.2.3. Ability to accept alterations.	1.2.3. understands that s/he cannot be only a knowledge or experience 'provider' and depending on a situation, acts as a teacher-assistant, teacher-adviser, teacher-moderator, teacher-partner and teacher-scientific tutor.
	1.3. Competence in solving problems	1.3.1.Ability to quickly and efficiently solve the problems of the quality of students' natural science education and the questions of natural science education as a subject; ability to establish the qualitative changes in natural science education	1.3.1. Planning the educational process (daily activities), appropriate coping with teaching/learning purposes and tasks and regular evaluation of learners' achievements, progress and the whole educational/training process help with examining specific issues of natural science education. Moreover, scheduled activities are aimed at foreseeing the problems encountered along the process beforehand and focus on finding optimal solutions. On the basis of the evaluated data, the teacher improves the process of natural science education and thus makes impact on the teaching/learning results.
	1.4. Creative and innovative competence	1.4.1. Ability to create original ideas; faculty of initiative; resourcefulness	1.4.1. It is relevant trying to engage the students in natural sciences, stimulating activities focused on projects and scientific research, dealing with specific issues of natural science education.

	1.5. Communication competence	1.5.1. Ability to cooperate and work in team;	1.5.1. Able to collaborate through gaining and sharing good experience and achievements in the field of natural science education. Frequent collaboration in methodical groups at school and the city when good experience is known at national and international level. Thus, the majority of teachers of natural sciences are offered possibilities of developing their skills. This is teacher's expression of the ability to work in concentrated and remote teams of science teachers.
		1.5.2. Ability to apply skills; ability to adopt experience of other people;	1.5.2. Social interaction leads not only to the process of knowledge construction but also to the transformation of skills (adaptation). Depending on changes in the tendencies of natural science education, circulation of other teachers' good experience and constant innovations in the technical teaching/learning environment, a constructive teacher finds the ability to change personal skills extremely relevant. S/he is not only a teacher but also a learner who communicates and collaborates with other people around him/her.
		1.5.3. Ability to think flexibly;	1.5.3. Ability to think flexibly becomes important to participating in and organizing natural science, environment protection and creative project-based activity;
		1.5.4. Ability to discover natural science education achievements; 1.5.5. Ability to defend one's point of view with self-respect	1.5.4; 1.5.5. The majority of research carried out in the field of natural science education illustrates that society's interest in natural sciences is very low; the larger part of the youth does not see any links with the above mentioned sciences; it is supposed that in the nearest future, society will feel lack of natural science teachers. Therefore, the abilities to reveal the achievements in the fields of natural science and science education become a burning issue. This is the way to attract society's attention to the mentioned sciences. The dissemination of individual good experience, the publication of personal ideas and attitudes are very important to the teachers of natural sciences as the ability to defend one's point of view with self-respect is a highly important matter.

2. Efficient competencies	2.1. ICT competence	2.1.1. Ability to use ICT;	2.1.1. The teacher is computer literate which is important to making the educational process more diverse;
		2.1.2. Ability to use ICT for the purposes of natural science education;	2.1.2. When applying ICT in the educational process and optimally using the Internet, the teacher raises the possibilities of teaching/learning and promotes educational alterations. The ability to use and apply ICT in the educational process helps the teacher with becoming an expert in the field of natural science education.
	2.2. Knowledge and information management competence	2.2.1. Ability to self-sufficiently raise professional qualification;	2.2.1. Strives for continual perfection, participates in teacher training events, is engaged in the latest methodical and scientific information on the issues of natural science education, adequately evaluates and optimally applies it in practical activities;
		2.2.2. Mastering a concept system that falls into the 'natural science education' category;	2.2.2. For example, environment study, natural history, sensual perception of nature...;
		2.2.3. Comprehension of scientific knowledge;	2.2.3. about nature, the interaction between nature and society, nature and technologies, nature as a unique phenomenal system;
		2.2.4. Understanding, comprehension and management of the most important natural science theories, laws and consistent patterns in different situations.	2.2.4. for example, the cell theory, the law of conservation of energy, symmetry, polarity, periodicity etc.;
	2.3. Competence in establishing value-based attitudes	2.3.1. The awareness of nature as a value;	2.3.1. respect for life concept;

<table>
<tr><td></td><td></td><td>2.3.2. Ability to reveal the potential of natural science education of different educational subjects in secondary school</td><td>2.3.2. to foster learners' love and respect for nature, the need to protect environment; to make students interested in the environment protection lookouts, to foster their cognitive and value-based relations with the outward natural environment; to teach students properly behave and act in nature, to disclose the negative patterns of unacceptable behaviour in nature.</td></tr>
<tr><td></td><td>2.4. Competence in conducting research</td><td>2.4.1. Ability to plan and supervise the students along the research on natural science;</td><td>2.4.1. Predicts the required material resources and research instruments, chooses suitable research tools, helps with recording and processing the researched data etc.</td></tr>
<tr><td></td><td>2.5. Competen ce in making content</td><td colspan="2">2.5.1. The secondary school students' knowledge and comprehension of matter, the goals and tasks of natural science education. The knowledge of general curricula and didactic attitudes of natural science education standards;

2.5.2. the secondary school students' knowledge of contemporary natural science tendencies, mastering natural science education forms, methods and patterns;

2.5.3. the ability to schedule and manipulate the process of natural science education in secondary school.</td></tr>
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Case study 5

APPROACH IN TURKEY

Prepared by: Osman Pekel

Competencies of Constructivist Science Teacher

Competency 1: Understanding Nature and Context of Science:

- The science teacher knows the values, beliefs and assumptions inherent to the creation of scientific knowledge within the scientific community, and compares science with other ways of knowing.
- Analyze local, regional, national, or global problems or challenges in which scientific design can be or has been used to design a solution.
- Evaluate the scientific design process used to develop and implement solutions to problems or challenges.
- Evaluate consequences, constraints, and applications of solutions to a problem or challenge.
- Analyze how scientific knowledge and technological advances discovered and developed by individuals and communities in all cultures of the world contribute to changes in societies.
- Analyze how the scientific enterprise and technological advances influence and are influenced by human activity
- Analyze the effects human activities have on Earth's capacity to sustain biological diversity.

Competency 2: Inquiry:

- Understand how to plan and conduct scientific investigations.
- Synthesize a revised scientific explanation using evidence, data, and inferential logic.

- Apply understanding of how to report complex scientific investigations and explanations of objects, events, systems, and processes, and how to evaluate scientific reports.
- Analyze why curiosity, honesty, cooperation, openness, and skepticism are important to scientific explanations and investigations.
- Analyze scientific theories for logic, consistency, historical and current evidence, limitations, and capacity to be investigated and modified.
- Evaluate inconsistent or unexpected results from scientific investigations using scientific explanations.
- Analyze scientific investigations for validity of method and reliability of results.
- Understand how scientific knowledge evolves.

Competency 3: General Skills of Teaching:

- Able to use science teaching actions, strategies, and methodologies.
- Able to establish interactions with students, including questioning techniques, that promote learning and achievement.
- Able to effectively organize classroom, laboratory, and field experiences in different student groupings.
- Able to use advanced technology to extend and enhance learning.
- Able to use prior conceptions and student interests to promote new learning.
- Able to design investigations for science.
- Able to analyze and present data.
- Able to prepare laboratory reports.
- Able to operate science laboratory equipment.
- Able to prepare materials used in the science laboratory.

- Able to establish and enforce lab safety (including storage and disposal of hazardous waste) in the science laboratory.
- Monitor students' understanding of content through a variety of assessment strategies; provide feedback to students to assist learning.
- Being able to use advanced technology to extend and enhance learning.
- Design, conduct, and evaluate laboratory activities that target the development of science concepts, using techniques.
- Being able to use prior conceptions and student interests to promote new learning.
- Preparation of laboratory reports
- Operation of equipment
- Preparation of materials
- Lab safety (including storage and disposal of hazardous waste)

Competency 4: Curriculum: The science teacher develops and applies a coherent, focused science curriculum that is consistent with the need, abilities, and interests of students. Curriculum refers to:

- Able to develop and apply an extended framework of goals, plans, materials, and resources for instruction.
- Able to develop and apply science principles, both in and out of school.
- Able to plan instruction which promotes problem analysis, critical thinking, creativity, leadership development and decision-making based upon subject matter, organization and integration of content and the relationship of content to education, career and life goals; student learning and motivation, with emphasis on individual differences; the community; and current education standards and practices.

Competency 5: Assessment:

- Knowing the measurement and evaluation of student learning in a variety of assessments.

- Identifying outcomes to be measured.
- Being able to measure and evaluate student learning in a variety of dimensions.
- Being able to use outcome data to guide and change instruction.
- Monitoring and assessing students' understanding of content through a variety of means, providing feedback to students to assist learning and adjusting instructional strategies.

Competency 6: Professional Practice: Science teachers have a knowledge base that prepares them for professional practice. Professional practice refers to:

- Knowledge of science.
- Knowledge of standards of ethical behavior consistent with the interests of students and the community.
- Participate the activities of the professional community to include colleagues, organizations, to improve student learning.
- Reflect on professional practices and continuous efforts to ensure the highest quality of science instruction.
- Willingly work with students and new colleagues as they enter the profession.
- Communicate effectively with parents/guardians, business and industry, and other agencies, and the community at large to support learning by all students.

CHAPTER 3

COMPETENCIES OF SCIENCE TEACHERS: COMPARATIVE ASSESSMENT

Prepared by: Vincentas Lamanauskas and Margarita Vilkonienė

Recently, competencies have become a priority area of discussions. Acquiring appropriate competencies in higher school is a guarantee of successful pedagogical work. Therefore, accurate defining of competencies as well as their content and structure is very important. It should be taken into consideration that the majority of competencies gained during studies at university level will be developed in comprehensive schools i.e. achieving competencies is not a finalized process as it lasts long - the whole time of active pedagogical activities. For example, such teachers' strengths as the ability to individualize educational content, the ability to teach how to learn and communicate with other people, the ability to purposefully apply the learning strategy and different methods in the teaching/learning process for collaboration purposes, the ability to apply varying methods evaluating students' achievements and progress in the educational process etc. are absolutely crucial points.

It is clear that conveying knowledge, broadening students' world outlook and establishing a positive relationship with an immediate environment (natural and social) are outstanding qualities. Different international research (SAS, ROSE, TIMSS, etc.) shows that motivation and increased interest in sciences play a fundamental role. The teachers of sciences interdependently coordinate their activities, maintain a close interdisciplinary-integrated relationship and look for new more efficient educational methods and activities. Thus, they can achieve highly positive results (in terms of students' knowledge level and value-based maturity).

Experience gained during the process of training foreign teachers of sciences is very relevant. Within the framework of the carried out IQST project the experts from the project-partner countries prepared the lists of competencies.

First, it should be noticed that the experts from different countries singled out a number of different competencies of science teachers. The majority of competencies necessary for teachers were mentioned by the respondents from Turkey and Bulgaria. Considering the meaning, some of the presented competencies are very close, for example *organizing educational process* (Lithuania), *practical pedagogical activity* (The Czech Republic), *general pedagogical* *abilities* (Turkey), *general pedagogical competence* (Bulgaria). Some of those are very exceptional, for example solving problems and critical thinking (Lithuania), safety and welfare (The Czech Republic), general intellect (Bulgaria), modelling the process of cognitive conflict (Cyprus) (Table 1).

Table 1. Competencies of science teachers singled out by the experts.

Country	Competencies *									
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Lithuania	Critical thinking	Organizing educational process	Problem solving	Creativity and innovativeness	Communication	Use of ICT	Information and knowledge management	Value-based attitudes	Researching	Content of the taught subject
The Czech Republic	Perceiving the core of science	Perceiving science development	Researching	Practical pedagogical activity	Content of the taught subject	Evaluation	Safety and welfare	Professional improvement	-	-
Turkey	Perceiving the core of nature and science	Professional activity	Researching	General pedagogical abilities	Content of the taught subject	Evaluation	-	-	-	-
Bulgaria	Perceiving the core of science	General intellect	General pedagogical	Didactics of the taught subject	-	-	-	-	-	-
Cyprus	Modelling the process of cognitive conflict	-	-	-	-	-	-	-	-	-

* further in the article, competencies are expressed by the symbols representing the singled out original competence indicated by the experts of every country. The meaning of a symbol can be established using Table 1: a letter is a symbol of a country and a figure shows competence itself, for example B2 is *Competence of general intellect* learned by the experts from Bulgaria.

The content of competencies revealed that the experts from different countries highlighted the same elements of competencies using various methods of combining them into certain units. The content of individual competencies includes components that in terms of semantics reach the notional framework of other competencies. For example, Lithuanian experts established that the teachers of sciences should demonstrate *information and knowledge management* – (L7) (Table 1). The component of the competence *able to self-sufficiently increase professional qualification* semantically agrees with the content of competence *professional improvement* (C8) singled out by the experts from the Czech Republic. Another component of the same competence *perceives knowledge of science* conforms to the content of competence *perceives the core of science* – (C1; T1; B1) named by the Czech, Turkish and Bulgarian experts. It is worth mentioning the competence *modelling the process of cognitive conflict* specified by the colleagues from Cyprus. The content of the latter competence consists of 20 integrated parts embracing the aspects of *pedagogical activity, evaluation, problem solving, ensuring safety and creativity*. Therefore, a thorough assessment of competence content disclosed that the experts from different countries identified the following competencies required for science teachers-constructivists:

- perceiving the core of science;
- perceiving science development (historical aspect);
- content of the taught subject;
- critical thinking;
- evaluation;
- problem solving;
- researching;
- practical pedagogical activity;
- modelling the process of cognitive conflict;
- creativity and innovativeness;
- communication;
- professional improvement;
- information and knowledge management;
- safety and welfare;
- value-based attitudes.

As it was mentioned before, depending on the meaning, the individual components of the content of some competencies agree with a few competencies.

Thus, the integrated elements of different competencies cover the majority of the above introduced competencies (Table 2).

Table 2. Proportion of the integrated elements of competence content to the singled out competencies

Integrated elements of competencies	**Competencies**				
Perceiving the core of science	L7		T1; T2	B2; B3	
Perceiving science development (historical aspect)	L7	C2		B1	
Content of the subject taught	L10	C5	T5	B4	CY1
Critical thinking	L1			B1; B2	
Evaluation	L3	C6	T2; T6	B2; B3	CY1
Problem solving	L3				CY1
Researching	L9	C3	T3	B1; B2; B4	
Practical pedagogical activity	L2; L6	C4	T4	B2; B4	CY1
Modelling the process of cognitive conflict					CY1
Creativity and innovativeness	L4		T6	B3	CY1
Communication	L5	C8	T2	B2	
Professional improvement	L5; L7	C8	T2; T6	B2	
Information and knowledge management	L7	C8	T2	B1; B2; B4	
Value-based attitudes	L8				
Safety and welfare		C7			CY 1

Science teacher's competence to be a teacher should be confirmed by his/her gained knowledge, developed abilities and formed value-based orientation. These are the main points to be considered discussing competencies necessary for teachers of sciences. An assessment of the competence list demonstrates that the experts from different countries emphasize the following competencies focusing on knowledge:

- content of the taught subject;
- perceiving science development;
- perceiving the core of science;
- modelling the process of cognitive conflict;

The following competencies are focused on ability development:

- professional improvement;
- evaluation;
- solving problems;
- critical thinking;
- researching;
- modelling the process of cognitive conflict.

Very few students' value-based competencies have been singled out:

- value-based competence;
- safety and welfare.

A more thorough assessment reveals that the integrated elements of competence content make different groups of competencies concentrating on knowledge, abilities and value-based attitudes (Table 3). Practical abilities (22 positions) rather than knowledge (16 positions) are devoted more attention. Only 3 positions on value-based attitudes show scant attention to the latter aspect of competencies.

Table 3. Competence distribution considering knowledge, abilities and value-based attitudes

Content of competencies		
Knowledge	**Abilities**	**Value-based attitudes**
L7; L9; L10; C2; C3; C5; C8; T1; T2; T3; T5; B1; B2; B3; B4; CY1	L1; L2; L3; L4; L5; L6; L7; L9; C3; C4; C6; C8; T2; T3; T4; T6; B1; B2; B3; B4; CY1	L8; C7; CY1

The table illustrates that due to the variety of separate content elements the same competence frequently focuses on knowledge as well as on practical abilities, for example *information and knowledge management* (L7), *professional and practical activity* (T2), *researching* (T3).

All indicated competencies focus either on the taught subject or on practical pedagogical activity (Table 4):

Table 4. Competence distribution considering the taught subject and pedagogical activity

Competencies in a taught subject	Competencies of practical pedagogical activity
L6; L7; L8; L9; L10; C1; C2; C3; C5; C7; T1; T3; T5; B1; B4; CY1	L1; L2; L3; L4; L5; C4; C6; C8; T2; T4; T6; B2; B3; CY1

The table shows that almost there is a balance between the competencies concentrating on the taught subject and those focusing on practical pedagogical activity. The former competencies are slightly predominating (positions 16 to 14).

Along the undertaken assessment, a comparison of competence subdivision into the taught subject and pedagogical activity sections focusing on knowledge, abilities and attitudes has been made (Table 5).

Table 5. Competence subdivision into the sections focusing on knowledge, abilities and attitudes

	Taught subjects	Pedagogical activities
Knowledge	➢ content of a taught subject; ➢ perceiving science development; ➢ perceiving the core of science; ➢ modelling the process of cognitive conflict (separate elements)	
Focus on knowledge and abilities	➢ information and knowledge management; ➢ researching; ➢ perceiving the core of science; ➢ didactics of the taught subject; ➢ applying ICT.	➢ professional and practical activity; ➢ professional improvement; ➢ general intellect; ➢ general pedagogical.
Abilities		➢ critical thinking; ➢ organizing educational process; ➢ problem solving;

		➢ creativity and innovativeness; ➢ communication; ➢ practical pedagogical activity; ➢ evaluation; ➢ professional improvement; ➢ modelling the process of cognitive conflict (separate elements)
Attitudes	➢ value-based attitudes; ➢ safety and welfare (separate elements)	➢ safety and welfare (separate elements)

Table 5 clearly discloses that competencies in the taught subjects are aimed at knowledge whereas those in pedagogical practical activity are fixed for abilities. An assessment of competence content disclosed that some competencies focused on knowledge as well as on abilities (highlighted in the table).

A summary of the findings of the carried out research reveals the possibility of modeling a list of competencies of an ideal science teacher organizing the educational process on the basis of the principles of constructivistic teaching/learning. Such a programme could help the teachers intended to follow the above introduced educational principles with self-evaluation of personal abilities and achievements and prefigure the fields to be improved in the future (Table 6).

Table 6. The list of the competencies of science teacher organizing the educational process through the constructivistic approach.

Sections of competencies	**Competencies**	**Content of competencies**
1. Competencies in the taught subject	**1. Information and knowledge management**	➢ knows the basic facts of science evolution; ➢ knows the history of science knowledge development of the taught subject; ➢ knows and identifies the most important science theories, laws and

		regularities maintained in different situations; perceives the value of scientific information; ➢ able to understand and process scientific information; ➢ knows preconditions necessary for creating scientific knowledge; ➢ able to efficiently apply the gained knowledge training the young generation; ➢ understands and is able to provide the possibilities of applying a scientific knowledge in every day practice for the students; ➢ analyzes and perceives the public alterations encouraged by the rise of a scientific knowledge, technological progress and personal and community development in different cultures worldwide; ➢ able to compare science with other methods of acknowledging the reality; ➢ able to use different information sources and to regularly update a personal knowledge.
	2. Content of the taught subject	➢ knows the objectives and tasks of science education and the content of the taught subject i.e. knowledge that needs to be acquired by the secondary school students; ➢ knows the content and didactical attitudes of general science education standards; ➢ able to identify events and phenomena that should increase students' interest, help with perceiving disagreements between the ideas of science and real phenomena, assist in creating the situations of cognitive conflict;

		➢ able to choose training aids efficient at solving cognitive conflict.
	3. Didactics of the taught subject	➢ knows and optimally apply specific forms, methods and models of science education; ➢ able to outstandingly develop the process of science education in secondary school i.e. to plan cognitive and research activity involving students, to raise real teaching goals and tasks and to suitably choose training material and resources required for teaching.
	4. Researching	➢ understands the core of scientific research; ➢ knows the main methods of scientific research; ➢ able to successfully plan research, be charged with implementing it in practice, to prepare research report and evaluate results; ➢ understands and is able to use mathematical procedures when analyzing research data; ➢ understands and is able to use research data in daily work dealing with the problems of different format;
	5. Use and application of ICT	➢ able to use ICT i.e. has computer literacy skills allowing to make the educational process more diverse; ➢ able to efficiently apply ICT in the educational process optimally using the Internet, broadens the possibilities of teaching/learning, stimulates educational alterations; ➢ able to apply ICT for the purposes of science education.

	6. Value-based attitudes	➢ perceives nature as a value; ➢ able to identify the possibilities of natural science education in secondary school in the context of other subjects taught.
	7. Safety and welfare	➢ knows and perceives teacher's ethical and legal responsibility for students' physical safety during the classes in sciences; ➢ able to properly/safely arrange, look after and apply different material during the classes in sciences; ➢ encourage students to follow necessary safety rules in the classroom, ensure safety of equipment devoted to the teaching process and guarantee safety of students' activity during the classes in sciences; ➢ knows requirements for exemplary behaviour with animals; safely, humanely and ethically behave with animate organisms in the classroom;
2. Pedagogical practical activity	**1. Critical thinking**	➢ knows classical and modern concepts of science education, understands the main differences between them, perceives the qualities and drawbacks of classical and modern concepts of science education; ➢ knows situation in science education at national, European and worldwide level; able to rationally make profit on experience of other countries; ➢ acknowledges the alternative methods of reality perception; ➢ accepts learning as students' individual efforts to develop personal thinking, build and broaden personal knowl-

		edge rather than a process of conveying knowledge;
	2. Practical pedagogical activity	➢ able to optimally combine classical and modern concepts of science education in practice and to prefigure the effective measures of an educational impact; ➢ able to organize the teaching/learning process through communication and collaboration, initiate productive students' social interaction building personal knowledge through collaboration; ➢ manages to identify student groups able to use the most optimal strategies to resolve cognitive conflict; ➢ able to conform to alterations; in order to develop different student abilities, frequently changes activities, teaching strategies and methods; ➢ able to create a learning environment stimulating the development of students' ideas; ➢ perceives the importance of metacognitive abilities; able to develop both cognitive and meta-cognitive abilities.
	3. Modeling the process of cognitive conflict	➢ flexible about creating problematic situations; able to individualize the above mentioned situations depending on student cognitive abilities, the style of dealing with problems, sex and social and cultural experience; ➢ able to identify the students experiencing cognitive conflict; offers support in resolving the introduced conflict, making decisions; ➢ able to attract students to the process of cognitive conflict.

	4. Problem solving	➢ able to quickly and effectively deal with the issues of science education and the questions of the quality of students' educatedness; able to initiate qualitative alterations in science education.
	5. Creativity and innovativeness	➢ able to create original ideas; announces initiatives; is innovative. ➢ able to create suitable, interesting problematic situations attracting students to cognitive conflict.
	6. **Communication**	➢ able to foster a positive relationship with the community; ➢ able to collaborate and to do teamwork; ➢ able to disclose and present the achievements in sciences and science education to society; ➢ able to defend an individual position with considerable self-respect;
	7. Evaluation	➢ able to notice alteration in student activity, to identify learners' achievements and progress and to regularly evaluate the self/educational process; ➢ able to identify an agreement between students' achievements and science education standards at national level; able to establish the evaluation criteria of achievements; ➢ uses different evaluation methods and forms; ➢ able to provide valuable and purposeful feedback information encouraging the development of students' scientific thinking; ➢ on the basis of the evaluated data, advances the process of science educa-

		tion making the impact on the results of teaching/learning;
	8. Professional improvement	➢ able to individually raise professional qualification (seeks for regular advancement, participates in the events of teacher training, is interested in the latest methodical and scientific information on the issues of science education, adequately evaluates and apply it in practice); ➢ able to take over good experience of colleagues, advisers and students and use it to change individual abilities; ➢ benevolently accepts advice from the colleagues having wider experience; ➢ able to share good individual experience with those who are less experienced.
	9. Safety and welfare	➢ able to stimulate positive students' abilities such as interest, the feeling of psychological safety etc. ➢ able to reduce negative students' emotions such as fear, distrust, anxiety etc.

It is clear that complete unification will hardly be reached; moreover, the latter project is not aimed at achieving these objectives. This principled and weighty question should be seriously considered in common European space. Such a need directly reflects the problems of today's school. Novelties and financial support are received and information communication technologies should improve students' abilities in schools; however, research carried out at national and international level in different countries show that not all learners improve their results. The tendency that the results achieved by the teachers using modern technologies in the classroom are worse can be noticed. The teachers of sciences are not always effective users of ICT as they frequently feel lack of competencies in this field. Nevertheless, students' involvement in sciences is tendentiously decreasing (in the classes of upper-secondary school in particular), there is shortage of attractive science teaching and learning material etc.

based on reality-based problems and ICT. Therefore, a baseless thing is an over-focus on teacher's competencies linked with modern ICT. In this case, researcher's competence remains one of the most important points. The ability to plan, organize and conduct various investigations involving students is certainly one of the most important competencies. Natural sciences have been, are and carry on staying an experimental area. The process of science education, which is too much theoretical and remote from reality, determined the situation that the interest in sciences and technologies reached a very low level in developed countries.

Hence, a crucial point is to highlight what model of competencies should be applied by universities in order to train teachers of sciences able to effectively act in present conditions.

CHAPTER 4

DESCRIPTION OF THE MODULES PREPARED FOR THE IQST PROJECT

General Background

Prepared by: Danuše Nezvalová

Module is defined as a unit of education or instruction with a relatively low student-to-teacher ratio, in which a single topic or a small section of a broad topic is studied for a given period of time.

In all of the participating countries one can observe a lack of science teachers, mainly of physics and chemistry teachers, as well as a lack of students in this teacher training. There is not doubt that science teaching has a crucial role to play in shaping the future development of EU. There is a remarkable commonality in the problems and context for science teacher training internationally. There is a need for intellectually honest and open self-appraisal of teacher educators should be the key agents of worthwhile changes in the teacher training programmes. The motivation and the interest for science studies is a little bit lower that we could expect in the period of new technologies. This has implications with regard to styles of teaching, curricular content, interpersonal relations for teacher education. There is a need to develop new ways in initial training of science teachers. All participating countries feel a reduction of quality in physics, chemistry and biology knowledge of children and an additional lack of quality of physics, chemistry and biology teachers. There is an urgent need of the quality initial science teachers. There is a need of new approaches to this training especially with the regard to the implementation and application of constructivists theory in science teacher training. There are the reasons why international group cooperating in the project designed five new modules to implement constructivism in science teacher training.

The overall aim of the project is to:

- contribute to the improvement of the quality of initial science teacher training in the participating countries;
- analyze and compare teacher training programs, review and develop training modules;

- to design five new modules;
- provide a framework for individual to extend and develop relevant elements of his/her own competence;
- enhance the participants' knowledge of aspects of European dimension and the principles of constructivist theory in science teacher training;

The initial science teacher training program will be shaped and influenced by some important propositions, that maybe described as a constructivist approach to teaching and learning. These propositions illustrate the value of articulating principles that guide and direct science teacher education program. Understanding these propositions through science teacher education practice shapes both the course structure and the pedagogy of the teacher educators involved in the program, which will be designed to be responsive to the needs of the student teachers as they prepare for their teaching careers.

In the project new modules will be designed:

- Development procedural skills in science education-constructivist approach: responsibility of BG partner;
- Training module based on socio-cognitive constructivism: Floating and sinking of an object in a liquid: responsibility of CY partner;
- Assessing Science for Understanding-a constructivist approach: responsibility of CZ partner;
- European Dimension in Integrated Science Education: responsibility of LT partner;
- Using the Laboratory to Enhance Student Learning and Scientific Inquiry: responsibility of TK partner;

Case Study 1

DESCRIPTION OF MODULE: BULGARIA

Prepared by: Ani Epitropova

MODULE	**DEVELOPMENT PROCEDURAL SKILLS IN SCIENCE EDUCATION – CONSTRUCTIVIST APPROACH**
Volume of module (credit, hours)	Four credits, 160 hours
The brief description of the module	The module is design as one lead to action of pre-service science teacher students. They have to reach an understanding of the aims of science education in the framework of constructivist approach. The focus is particular on the development of procedural skills. Significant and specific teaching strategies will be introduced and explore as will their influence on student's cognitive, communicative and social development. The basic elements of visual literacy and varied visual tools will be examined. The content of the module include varied tools as collecting, interpreting and communicating data as tables, diagrams, charts, using symbols and numbers. Students will produce their own educational resources that promote active learning.
Competencies to be achieved	Pre-service teachers students must demonstrate that: 1. they have a secure knowledge and understanding of the subject, namly Science they are trained to teach; 2. they define, describe and understand the aims of science education – STL in the framework of constructivist approach; 3. they know the role of process skills in science education, dimensions and nature of progression in process skills; 4. characterize, explain, give examples and demonstrate strategies for supporting process skills development.
Goals of studies	• Define and describe the aims of science education and reached an understanding of what is STL; • Build and develope process skills in Science; • Use efectivly varied teaching strategies to implement develpoing of procedural skills;

Content of module (topics)	1. Scientific and technology literacy. Components and levels of scientific literacy 2. Constructivist approach in Science education 3. Building and developing scientific process skills 4. Strategies for supporting process skills develpoment and asessment 5. Plan, organize and deliver an active learning project
Strategies of teaching / training	The activities include lectures, seminars, inter-active workshops, practical work. There will be an emphasise on practical activities supported by a strong theoretical mainstay. Students will implement they knowledge and skills in lesson planing and perfoming.
Distribution of hours of the module	Theoretical works – 10 hours Practical works –32 hours Home work / Individual project ect. – 58 hours Self-studies – 60 Total: 160 hours
Final evaluation criteria	Plan, organize and deliver active learning project
Strategies and technics of evaluation of achievements	Evidnece of achivement and understanding are present in the proces of teaching, paticulary in how pre-service teachers comunicate subject knowledge, present complex ideas, confidently use strategies for developing and evaluating procedural skills, plan and set targets and lesson, follow-on disscussions with tutor.
References (main sources)	1. Reinders Duit, The constructivist view in science education – what it has to offer and what should not be expected from IT, http://www.if.ufrgs.br/public/ensino/N1/3artigo.htm 2. Active strategies in the teaching of nature and man in the 1-4 grades, Ani Epitropova, Plovdiv, 2004, "Macros"; 3. Elaine Wilson, Powerful pedagogical strategies in initial teacher education, Teacher and Teaching: theory and practice, Volume 11, Number 4, 2005 4. Bonwell Charles C and James A. Eison, Active Learning: Creating Excitement in the Classroom, http://www.ntlf.com/html/lib/bib/91-9dig.htm

Case Study 2

DESCRIPTION OF MODULE: CYPRUS

Prepared by: Nicos Valanides

MODULE	**Training Module Based on Sociocognitive Constructivism: Floating an Sinking of an Object in a Liquid**
Volume of module (credit, hours)	3 ECTS, 180 hours
Theoretical background of the module	The theoretical background that guided the design and development of the present schedule is aligned with the socio-cognitive perspective of learning and the nature of science. Some of important assumptions of this perspective are for example the following: 1. Learning results from the interaction occurring between an individual's experiences and his or her current conceptions and ideas. 2. The process of learning depends on the extent to which the individual's conceptions integrate with new information. 3. Personal construction of knowledge occurs through the interaction between the individual's knowledge schemes and his or her experiences with the environment. 4. The socio-cultural perspective considers the construction of knowledge as a social process, where social transactions and discourse are considered to be the basis for any subsequent learning. 5. Conceptual change is considered a complicated and dynamic process, which is affected by a variety of factors, beyond the cognitive ones, such as motivation, goals, and perceptions of the task. 6. Inquiry learning within the socio-cognitive perspective incorporates many aspects of the nature of science and its processes. 7. Hands-on activities are valuable when coupled with minds on or cognitive engagement.
The brief description of the module	The present module is an attempt to familiarize primary school teachers, lower secondary school teachers, and prospective teachers for primary and lower secondary school with the basic assumptions of the socio-cognitive perspective of learning. The module is also an attempt to provide a concrete example of teaching/learning, using a sinking/floating scenario. Thus, the module represents an attempt to teach the different concepts regarding sinking/floating using the described theoretical framework and involving the

	learners in an inquiry process (active learning/learning by doing). This approach focuses on the learners' initial conceptions and how to achieve conceptual change. Within this framework, different ways for identifying learners' alternative conceptions and factors (cognitive and affective) affecting conceptual change are considered very important. Consequently, the learning environment should also encourage rich interactions among the learners and between the teacher and the group of learners.
Competencies to be achieved	The main competencies that should be achieved can be summarized as follows: 1. Science teachers must become competent in diagnosing their students' alternative conceptions, using mainly qualitative approaches and formative evaluation approaches. 2. Science teachers must be able to design and develop learning environments conducive to conceptual change taking into consideration their students' conceptions. 3. Therefore, science teachers must be able to invest on discrepant events that challenge students' existing alternative conceptions. 4. Science teachers must be able to identify discrepant events that are interesting to and engaging for the students, and are well structured, so that students can be scaffolded to realize the discrepancy between their existing conceptions and the phenomenon. 5. Science teachers must be competent to structure problem situations that can provide scaffolding towards possible solutions. 6. Science teachers must be equipped with the required abilities for correctly recognizing whether their students experience cognitive conflict or not. 7. Science teachers must have the flexibility to differentiate a problem situation according to students' characteristics (e.g., cognitive ability, performance, gender, social and cultural background, etc) in order to enable more students to experience cognitive conflict. 8. Science teachers must be able to provide the necessary means for their students to resolve the discrepancies between the phenomena they observe and their existing conceptions. 9. Science teachers must be able to provide valuable feedback as to the kinds of reasoning implemented by students, and to help them develop their scientific reasoning skills. 10. Science teachers must be competent of identifying non-cognitive factors engaged in a cognitive conflict situation and to incorporate these factors productively in the learning process. 11. Science teachers. must become competent in undertaking their roles as

	facilitators and supporters, when students attempt to resolve their cognitive conflict situations. 12. Science teachers must be able to promote productive social interactions among their students in ways promoting collaboration and shared responsibilities for the knowledge construction process, so that groups of students become real learning communities. 13. Science teachers must be able of recognizing their students' conceptual change by identifying students' cognitive gains or conceptual advancement. 14. Science teachers must be competent of evaluating their own and their students' conceptions based on criteria compatible with the tentative nature of science.
Goals of studies	Upon the completion of this module, the pre-service and/or in-service science teachers should be : 1. to understand and define the basic tenets (principles) of socio-cognitive constructivism. 2. to design and implement teaching scenarios based on socio-cognitive constructivism and following an inquiry-based approach. 3. to appreciate the importance of teaching scenarios that invest not only on cognitive but on affective factors well in the process of knowledge construction. 4. to become competent in conducting small scale action research. 5. to continually evaluate students' conceptions and use the evidence for designing more effective teaching/learning situations conducive to conceptual changes.
Content of module (topics)	The content of the module relates to the different factors affecting the sinking / floating of an object in a liquid. This content can be easily used for primary and lower secondary school students, and it takes into consideration that all or some of the students remain concrete thinkers and cannot use abstract concepts. It is thus important to provide observable evidence to the students that challenges their existing conceptions.
Strategies of teaching / training	The content of the module and the teaching / training strategies or approaches will be clarified by describing an indicative sequence of steps that should be followed during the training. This sequence clearly represents the basic principles of socio-cognitive constructivism and how to implement them, by providing specific examples: 1. Learners' conceptions should be initially identified and presented to the whole group, so that the participants (teachers or prospective teachers) will be familiarized with the variety of existing conceptions.

2. There exist multiple ways for identifying learners' conceptions. A specific example relates to the scenario in Figure 1, where two identical cylinders containing colourless liquid(s) in different quantities. Cylinder A contains less liquid and a sinking egg, while cylinder B contains more liquid and a floating egg.

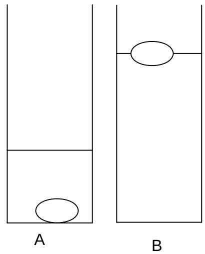


Figure 1. Two identical cylinders containing different quantities of colorless liquid(s), where an egg is either floating or sinking.

After the presentation of the two cylinders, learners should be called upon to express their existing conceptions in an attempt to explain and justify the floating/ sinking of each egg. For example they may be asked to state in writing their conceptions relating to the specific scenario, or they may discuss in a whole group their conceptions.

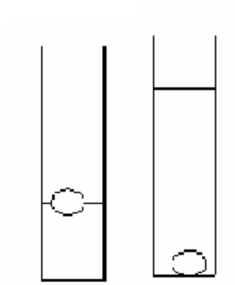
3. Learners' conceptions should be somehow made public, so that learners' are familiarized with the spectrum of the existing (pre)conceptions, and, consequently these should be challenged through specific experimental results, in an attempt to foster cognitive dissonance that will trigger the cognitive processes (assimilation and accommodation) for dissolving this conflict.

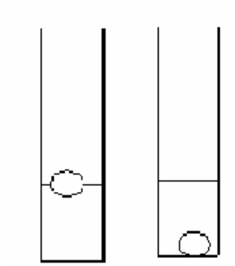
4. From the situation presented in Figure I, learners' may attribute sinking/floating to different properties or characteristics of either the liquid or the object (egg)., such as, the quantity of the liquid, the kind of liquid(s) (i.e., the liquids in the two cylinders are different), or to differences between the two eggs (i.e., one egg is boiled but not the other) etc.

5. Any of the existing alternative conceptions or (mis)conceptions constitutes learners' explanatory frameworks and should be taken into consideration for inducing conceptual change through presenting discrepant events conflicting a learner's conceptions.

6. Several teaching strategies for challenging students' expressed conceptions are consequently presented in an attempt to provide specific examples and clarify the whole approach. These strategies or experiments are always dependent on the specific alternative conception, as it is exemplified in the following experiments, where different learners' conceptions from the research literature are considered:

• *Quantity of liquid*. In most cases, learners think that the quantity of the liquid causes the different outcome in Figure 1. In such a case, the outcome of specific experiments may cause cognitive disequilibrium. For example, by decreasing the quantity of the liquid in cylinder B, so that it will become equal to the quantity of the liquid in cylinder A, in Figure 1. Other examples include the presentation of any information that contradicts the idea that the quantity of a liquid affects the sinking/floating of an object. More specifically, the following combinations of two cylinders containing colourless liquid(s) constitute discrepant events to the expressed conception:





These are just few examples that can challenge the idea that the floating/sinking of an object depends on the quantity of the liquid.

• *The eggs are different (i.e., one egg is boiled but not the other)*. For those learners who expressed this explanatory framework, discrepant information can be presented by exchanging the two similar eggs in the two cylinders in order, or even putting alternatively the same egg in the two cylinders.

• *Kind (density) of the liquid.* In many cases, primary and/or secondary school students insist that the determining factor for floating/sinking is exclusively the kind of liquid. Thus, they insist, for example, that any object in cylinder A will sink, and any object in cylinder B will float. This conception expresses an over-generalized conclusion from a limited set of experiences. In such a case, different objects that can either floats or sink (i.e., a piece of metal, a piece of wood etc.) can be put in cylinder containing tap water.

• *Kind (density) of an object.* In other cases, primary and/or secondary school students suggest that the determining factor for floating/sinking is exclusively the kind of object, that is, floating or sinking is an exclusively property of the objects. Thus, objects have the property to either sink or float irrespective of the kind (density) of the liquid to which they are immersed. This idea can be challenged by immersing the same object in two different liquids so that the object floats in one of them and sinks in the other.

• *Mass (volume or size) of the object:* Research evidence indicates that a prevalent conception among primary and/or secondary school students relates to the idea that whether an object floats or sinks depends on its mass (volume or size). This conception can be challenge, for example, by immersing a big object in liquid and immersing next progressively smaller pieces of the same object in the same liquid (i.e., a big piece and very small pieces of plasteline in water). The outcomes of these simple experiments can clearly indicate that the mass of an object does determine whether it will sink or float.

The aforementioned possibilities can be easily faced and treated by having prepared a set of four identical cylinders containing different quantities of either water (cylinders B and D) or salt water (cylinders A and C) and a floating or sinking egg, as it is indicated in Figure 2.

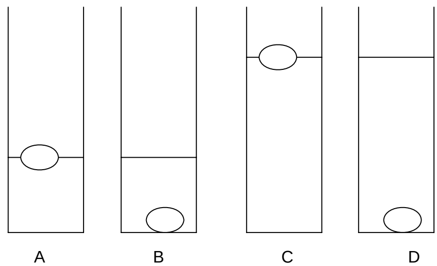


Figure 2. A set of cylinders presenting an egg floating or sinking

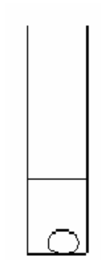
It is however necessary to stress that any kind of experimentation cannot be determined in advance, but it should rather follow the identification of the learners' existing conceptions, as it was described previously. Different learners construct different explanatory ideas depending on their experiences, their age, their cognitive abilities, and other idiosyncratic characteristics. Obviously, learners' conceptions should not be ignored but these should not only be identified but should be also taken into consideration. These conceptions should be challenged by presenting to the learners conflicting information. This does not mean that teachers should rush to propose specific information or specific experiments, but they should offer to the students the opportunity to discuss and test their ideas, so that they really reach the stage of cognitive disequilibrium.

7. The stage of cognitive disequilibrium does not guarantee that the learner will automatically abandon his/her conceptions. These conceptions are usually resistant to change.

8. Thus, the learners should be also involved in a series of inquiry based activities that should be aligned with socio-constructivistic principles.

9. Some indicative examples where students are scaffolded to answer specific questions, are presented below:

i. How can you make the egg in a cylinder, like the one below, to be floating?



Learners should be allowed to propose and test their existing ideas (i.e., adding more water, using a wider cylinder) and should be finally guided to compare the water in the cylinders in Figure 1. They can for example taste it, or measure the mass of equal quantities of liquid from each cylinder, so that they will be sensitized that one of the cylinders in Figure 1 contains salt water. They should then be guided to find out (a) how the amount of salt in the same quantity of water affects sinking and floating of the egg, (b) whether the floating/ sinking pattern for other objects (i.e., a piece of wood or a piece of metal) resembles the floating/sinking pattern of the egg, and (c) what kind of differences exist and why.

ii. Do different objects of the same volume (i.e., identical cubes from different material, such as, wood, candle, plastic, aluminium etc) follow the same pattern of sinking/floating in the same liquid? Learners should be guided to compare the mass of the cubes and reach a conclusion explaining the differences. Learners can also use floaters of equal volume having progressively increasing mass (i.e., floaters of equal volume from plastic tubes closed from both sides and containing different amount of material, such as sand, so that some sink in the bottom and the others float totally of partially immersed in water. The learners should be guided to reach the conclusion that “objects having the same volume have higher tendency to float as their mass decreases, while objects of more mass have higher tendency to sink.

iii. Is it possible to make an object sinking in a liquid to float in the same liquid and how? For example, learners should be guided to use a piece of candle that sinks in alcohol and make it float by heating it and transforming its shape to resemble a boat. Learners can also wrap a coin in aluminium foil and immerse it a container of water. They then can make it float by transforming the aluminium foil into a small boat carrying the coin.

	iv. Do different objects of the same mass but unequal volume (i.e., floaters from plastic tubes closed from both sides and containing a different amount of material, such as sand, so that all have the same mass) follow the same pattern of sinking/floating in the same liquid? Learners should be guided to compare the obvious difference in volume (i.e., different length of plastic floaters made from pieces of the same plastic tube) and the mass of the tubes, and reach a conclusion explaining the differences in floating/sinking in a container of the same liquid. The learners should be guided to reach the conclusion that "objects having the same mass have higher tendency to float as their volume increases, while objects of less volume have higher tendency to sink. *v. Do different objects of the same mass but unequal volume (i.e., floaters from plastic tubes closed from both sides and containing a different amount of material, such as sand, so that all have the same mass) follow the same pattern of sinking/floating when immerse in different liquids ?* Learners should be guided to compare the floating/sinking pattern of the floaters when immersed either in different liquids (i.e., water, salt water alcohol) and reach the conclusion that the sinking/floating pattern of the floaters is different for different liquids. For example, the pattern of floating/sinking of the floaters depends on the kind (density) of the liquid as well. *vi. Do different objects of the same volume (i.e., identical cubes from different material, such as, wood, candle, plastic, aluminium etc) follow the same pattern of sinking/floating when immersed in different liquids (i.e., water and alcohol)?* This comparison can be made by immersing objects of the same volume but having different mass (i.e., floaters from plastic tubes closed from both sides and containing different amount of material, such as sand) in either a container of water or a container of alcohol or a container of salt water. *vii. What is the relation between the volume of an object that is immersed in a liquid and the volume of displaced liquid?* Different experiments should be performed to exemplify that the more an object is immersed the more is the volume of the displayed liquid. *viii. Is the mass of the displayed liquid equal when the same object is immersed in different liquids?* Different experiments should be performed where the same object (sinking) is immersed in different liquids and measure both the volume and the mass of the displayed liquids. *ix. When an object immersed either in a liquid or a gas (air) sinks or floats partially or totally immersed?* Similar balloons containing either air or helium can be used. The floating helium balloon can be made to sink by externally putting on it different amounts of sticky material, so that it will sink or balance in the air. Students should be guided to understand that on the balloon act two opposite forces, that is, the weight (downward direction) and another force having upward direction (up-thrust), and that their relative magnitude determines whether the balloon will sink, balance in the air, or move upward (floating). *x. When the same object (i.e., an egg or a floater) sinks, balance or float in salt water? Or how the amount of salt dissolved in water determines whether the same object (i.e., an egg) sinks balances or floats?* Learners should be

allowed to propose and test their existing ideas by progressively dissolving more and more salt in a container of water (without changing the amount of water) until saturation will occur. (Saturation also relates the temperature of water. Consequently, how the temperature of a saturated solution affects floating and sinking can be furthermore examined.)

xi. Archimedes' principle (Calculating buoyancy): The volume of displaced liquid. Learners can also experimentally "test" Archimedes' principle by hanging an appropriate object, for example a metallic cylinder, on a dynamometer and measuring its weight. Then they should be guided to examine how the reading of the dynamometer changes as they progressively immerse more and more portion of the object into a volumetric cylinder containing a liquid (i.e., water) and compare their experimental evidence. Based on Archimedes' principle when a body is partially or completely immersed in a liquid, then it experiences an upward force that always equals the weight of the displaced liquid, and consequently the more liquid is displaced the higher the up-thrust. Thus, by progressively changing the part of an object that is immersed into the liquid, learners should examine how its weight changes and correctly conceptualize how the weight of an object hung on a dynamometer changes They can also observe that the weight of the object, as it is measured by the dynamometer, may reach progressively zero, and a floating object becomes practically "weightless."

xii. Archimedes' principle (Calculating buoyancy): The kind (density) of displaced liquid. Learners can also experimentally "test" Archimedes' principle by immersing the previous object hung on a dynamometer in different liquids (i.e., water, salt water, alcohol) so that each time the volume of displaced liquid is exactly the same, so that they correctly conceptualize the effect of the kind (density) of a liquid on the reading of the dynamometer. Thus, learners can easily compare their experimental evidence and conclude that it suggests that the kind (density) of a liquid affects up-thrust, that is the higher the density, the higher the weight of the displaced liquid. Thus, by progressively comparing the weight of the displaced liquid when the same portion of an object is immersed into different liquids, they cans correctly conceptualize how the kind of a liquid (density) affects the force of up-thrust. They can also observe when the weight of the object, as it is measured by the dynamometer, may reach progressively zero, and what the differences in the volume of displaced water are when different liquids are used.

10. Finally, it should be mentioned that the list of presented ideas is not exhaustive but only indicative. These approaches should be learner-centered where the role of the instructor and the role of the learners change. From this perspective, learners become responsible for their own learning and share autonomy and activities in the teaching/learning situation. Discussions, individual and team work; presentations; involvement of learners in the design, implementation and assessment of teaching interventions; or even synchronous or asynchronous electronic communication are good strategies for a shared construction of knowledge.

Distribution of hours of the module	1. Strategies and ways for identifying learners' existing conceptions (2 teaching hours). 2. Strategies and ways for challenging learners' conceptions identifying learners' existing conceptions (5 teaching hours). 3. Teaching interventions conducive to conceptual change (4 teaching hours). 4. Strategies and ways for evaluating learners' gains or progress in conceptual understanding (3 teaching hours). 5. Homework /individual projects/asynchronous and synchronous electronic discussions etc. (42 hours) This distribution takes into consideration the idea of ECTS and learners' working load. (For every teaching hour, learners are required to invest addition time of 3 hours, while 13-15 teaching hours correspond to 1 ECTS)
Final evaluation criteria	1. Ability to to employ different techniques (i.e., individual and group interviews, questionnaires,etc.) for identifying learners‘ conceptions. 2. Ability to design and implement strategies challenging learners' conceptions (i.e., design experiments that constitute discrepant events to learners' conceptions). 3. Ability to design and implement teaching approaches that take into consideration learners' conceptions, and can foster conceptual understanding and growth. 4. Ability to encourage feelings of interest and motivation that can lead to cognitive engagement of learners. 5. Ability to guide group work and other forms of collaboration. 6. Ability to continuously implement formative evaluation strategies.
Strategies and techniques of evaluation of achievements	1. Electronic portfolios 2. Synchronous and/or asynchronous electronic discussion 3. Student projects 4. Other formative and/or summative evaluation techniques, such as, individual and group interviews, classroom discussions, questionnaires tests, etc.

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Case Study 3

DESCRIPTION OF MODULE: CZECH REPUBLIC

Prepared by: Danuše Nezvalová

MODULE	**Assessing Science for Understanding – a constructivist approach**
Volume of module (credit, hours)	2 credits, 60 hours
The brief description of the module	Assessment and learning are so closely related that if the outcomes are not assessed, students and teachers likely will redefine their expectations for learning science only to the outcomes that are assessed. Rather than checking whether students have memorized certain items of information, assessment need to probe for students´ understanding, reasoning, and utilization of knowledge. The module is focused on the questions: what is classroom assessment and which classroom assessment techniques are effective in science education and what are the main principles of authentic assessment.
Competencies to be achieved	1. Competency to assess students´ learning and progresses in science education; 2. Competency to use effective and adequate classroom assessment techniques; 3. Competency to assess learners´ prior knowledge, understanding, skills, attitudes, values and self-awareness; 4. Competency to assess own science teaching and to make change and improvement in the quality of science education.
Goals of studies	• To understand purpose of classroom assessment; • To characterize the classroom assessment; • To plan and implement classroom assessment projects; • To choose the right technique of assessment; • To realize wider choice of assessment technigues.
Content of module (topics)	1. Purpose and characteristic of classroom assessment. 2. A constructivist approach in classroom assessment. 3. Planning and implementing classroom assessment projects. 4. Techiques for assessing knowledge and skills (background knowledge

	probe, focused listing, misconception/preconception check, minute paper, one-sentence summary, journals, concept maps, portfolios, etc.); 5. Technics for assessing learner attitudes, values and self-awareness (classroom pools, self-confidence surveys, interest checklist, self-assessment); 6. Assessing learner reactions to instructions (electronic mail feedback, group feedback, reading rating sheets...).
Strategies of teaching / training	Discussion, group work, cooperative learning, team work, portfolio,microteaching, presentation, independent work, individual work.
Distribution of hours of the module	1. Theoretical works – 10 hours (seminar) 2. Practical works – 20 hours (laboratory experience 3. Individual project work – 20 hours 4. Self-studies – 10 hours Total: 60 hours
Final evaluation criteria	1. Quality of presentation 2. Quality of Assessment Project 3. Quality of microteching presentation 4. Ability to work in team
Strategies and technics of evaluation of achievements	1. Presentation – 20 %; 2. Assessment Project – 50 %; 3. Microteching presentation – 20 %; 4. Team work – 10 %.
References (main sources)	1. Thomas, A., Angelo, K., Cross, P. *Classroom Assessment Techniques.* San Francisco: Jossey-Bass, 1993. 2. Mintzes, J. J. *Assessing Science Understanding. A Human Constructivist View.* San Diego: Academic Press, 2000.

Case Study 4

DESCRIPTION OF MODULE: LITHUANIA

Prepared by: Vincentas Lamanauskas

MODULE	**EUROPEAN DIMENSION IN INTEGRATED SCIENCE EDUCATION**
Volume of module (credit, hours)	4 credits, 160 hours
The brief description of the module	The module focuses on introducing foreign experience in the field of integrated science education to the would-be teachers of sciences, discusses the conception of science education and the main tendencies towards the development of integrated science education, assesses the theoretical and practical aspects and modules of integrated science education as well as its application in practical educational activities. The module concentrates on the analysis and principles of development of an integrated science education curriculum. The educational tools (material, didactical, intellectual, information-communication etc.) of science education are described. The qualities and drawbacks of integrated science education are revealed. The integral results and their evaluation are learnt to be understood. Along the implementation of an integrated course (subject) adequate teaching methods are learnt to be choisen. The single cases of experience based on teaching integrated sciences are studied (case study).
Competencies to be achieved	1. Develop knowledge of integrated science education in comprehensive school; 2. Demonstrate understanding of the knowledge base for science literacy, process/inquiry skills, content, attitudes, technological understandings and the relationships among, science, technology, and society; 3. Ability to reveal the qualities and drawbacks of integrated science education; 4. Ability to identify the models, levels and degree of integrated science education; 5. Ability to perceive the compatibility requirements between integrated science education and other types of curricula; 6. Design developmentally appropriate integrated science curriculum for secondary aged children utilizing appropriate goals, concepts, and evaluation; 7. Ability to design the curricula of integrated science education (in the establishments of formal and non-formal education); 8. Ability to choose adequate teaching methods;

	9. Ability to choose an appropriate optimal evaluation strategy covering the fields of integrated science education and students' achievements; 10. Demonstrate an understanding of the constructivist approach through effective questioning, assessment, and reporting techniques within the science curriculum etc.
Goals of studies	1. Define the conception of integrated science education; 2. Describe the specificities, qualities and possible drawbacks of integrated science education; 3. Define the priorities of the European Union education policy in the field of science education; 4. Establish the main tendencies towards integrated science education in the European countries; 5. Assess the basic models of integrated science education and application practice; 6. Introduce the main principles of designing (planning) integrated science education curricula; 7. Assess the most efficient evaluation strategies of integrated science education, teaching/learning etc.
Content of module (topics)	1. A conception of integrated science education; 2. Some philosophic, didactic and social aspects of integrated science education; 3. The main tendencies of integrated science education development; 4. Integrated science education in the context of the constructivism theory; 5. Integrated science teaching in terms of the constructivist approach; 6. The models of integrated science education; 7. The integrated science education curricula and its designing principles in comprehensive school; 8. The science education tools and ways of producing them in the collaboration process; 9. A constructivist approach to integrated science education: teaching would-be teachers to do science; 10. Designing a integrated science methods course for initial science teachers; 11. Contextual teaching and learning of integrated science in lower and upper secondary schools; 12. The specificities of integrated science teaching in lower secondary school; 13. The specificities of integrated science teaching in upper secondary school;

	14. The evaluation strategies of integrated teaching/learning; 15. The collaboration peculiarities of science teachers;
Strategies of teaching / training	Cognitive and interactive etc.; discussions, individual and team work; presentations
Distribution of hours of the module	Theoretical works – 32 hours Practical works – 10 hours Home work / Individual project etc. – 58 hours Self-studies - 60 Total: 160 hours
Final evaluation criteria	1. Quality of designing a curriculum of integrated science education; 2. Quality of designing a project integrated science education; 3. Ability to work in group; 4. Quality of delivering etc.
Strategies and technics of evaluation of achievements	1. Curriculum preparation and presentation – 30 %; 2. A project aimed at organizing students' integrated science education activities – 30 %; 3. Team work – 10 %; 4. Final exam (test) – 30 %
References (main sources)	1. Abell S., Lederman N. (Eds) (2007). Handbook of Research on Science Education. New York: Lawrence Erlbaum Associates, Inc. 2. Bandiera M., Caravita S. & all (Eds). (1999). *Research in Science Education in Europe*. London. 3. Bybee, R. W., Powell, J. C., Trowbridge, L. W. (2007). *Teaching Secondary School Science: Strategies for Developing Scientific Literacy*. New Jersey: Prentice Hall. 4. Behrendt H., Dahncke H., duit R. et al. (Eds). (2001). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers. 5. Blum A. (1994). *Integrated and General Science* //The International Encyclopedia of Education, Vol.5. P.2897-2903. 6. Chaille, C. & Britain, L. (1999). *The young child as a scientist: A constructivist approach to early science education.* New York: Longman. 7. Fensham, P. (Ed), & others (1994). *The Content of Science: A Constructivist Approach to Its Teaching and Learning*. Bristol: Falmer Press, Taylor and Francis, Inc.

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Case Study 5

DESCRIPTION OF MODULE: TURKEY

Prepared by: Feyzi Osman Pekel

MODULE	**USING THE LABORATORY TO ENHANCE STUDENT LEARNING AND SCIENTIFIC INQUIRY**
Volume of module (credit, hours)	4 credits, 164 hours
The brief description of the module	The laboratory has been given a central and distinctive role in science education, and science educators have suggested that rich benefits in learning accrue from using laboratory activities. We are living in an era of dramatic new technology resources and new standards in science education in which learning by inquiry has been given renewed central status (Hofstein & Lunetta; 2003). This module has focused on the questions how science laboratory resources are used, how students' work in the laboratory is assessed, and how science laboratory activities can be used by teachers to enhance intended learning outcomes, current models of how students construct knowledge, information about how teachers and students engage in science laboratory activities.
Competencies to be achieved	▪ to know the steps of scientific process, ▪ to understand science content, ▪ competency to explain the nature of science, ▪ competency to explain the causes , results and correlations of scientific events meaningfully, ▪ to develop concepts and relationships from observations and to infer from them scientifically. ▪ to be awere of alternative experiments of the same event.
Goals of studies	• to improve prospective teachers' understanding of science concepts; • to foster a learning environment supporting conceptual understanding; • to promote positive attitudes toward learning and teaching science (biologhy, chemistry and physics in particular); • to improve the nature of science; • to improve scientific process skills.
Content of module (topics)	1. Constructivist science and lab education resources.

	2. Constructivist science teaching techniques (such as conceptual change approaches, analogies, text etc.) 3. Scientific process skills 4. Meaningful learning, nature of science etc.
Strategies of teaching / training	• Team work, discussion, individual work. • Cooperative learning techniques (not only student-student interactions but also student-teacher interactions) • Constructivist lecture– constructivist laboratory type approach, • Conceptual change approaches (using analogies, modelling...) • Inquiry-centered approaches; • Cognitive and interactive approaches.) 1. The student is involved actively and assumes responsibility for his or her own learning. 2. The preconceptions of the students are obtained by various methods, for example, teacher asking questions after the students have a chance to explore with materials or consider a problem. Students are asked to generate questions, predictions, explanations. 3. Problems are posed by the teacher to create dissatisfaction with the learner's present knowledge. 4. Work is performed in groups or teams. Discussion within the group is required. Teams report to class. Work is criticized by other groups. Groups report out and make presentations to the class. 5. Additional applications are sought by the students (as in NSES).
Distribution of hours of the module	Theoretical works – **14 hours** Practical works – **28 hours** Home work / Individual project ect. – 12 hours Self-studies 28 hours Total: 82 hours (for one semester)
Final evaluation criteria	• Quality of experimenting • Quality to explain cause, results and correlations of related concepts. • Ability to work in the group.
Strategies and technics of evaluation of achievements	■ Performance tests: % 40 * Through asking open ended questions before and after or doing experiments (Real life problem solving situations, scientific reasoning, to suggest similar alternative experiments etc). ■ Experiment reports (% 20) Checking the reports of the student recorded about the every experiment. ■ Final exam: % 40

References (main sources)	1. National Research Council (NRC) 1996 Washington DC National Academy Press. 2 Posner, Strike, Hewson, Gertzog, 1982, Science Education, Vol 66. 3 Colburn, A. 2000. Constructivism: Science Education's "Grand unifying theory", the Clearing House September/October pp 8-12. 4 Liang and Gabel D, 2005, Effectiveness of constructivist instruction to science instruction for prospective elementary teachers. Int. J of Sci. Educ. 27, 10, pp 1143-1162. 5. Hofstein, A; Lunetta V.N. 2004 , The Laboratory in Science Education: Foundations for the Twenty-First Century *Sci Ed* 88:28 – 54, 2004;

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