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THE PATHWAY TO HIGH QUALITY SCIENCE TEACHING

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Science Teachers' Training Across Europe: Overview of the Four Reports

The main goal of the reports presented in this project – based on an European partnership of science educators from 6 European countries (Belgium, France, Germany, Greece, Italy and Romania) -- was to design the basic principles and guidelines of a common framework for science teacher training across Europe. Each of the four reports represents part of a coordinated effort to achieve this main goal, as diagrammed in Fig. 1 below. While most of the work in these reports focuses on the pre-service training of high school science teachers, the common framework also includes in-service training and the continuous life-long learning of teachers. Through these experiences, as well as developments in the field of professional development design and evaluation, our research team has arrived at some new thinking about teachers training and professional development design that is reflected in the proposed design framework. A major innovation of the approach is a tighter link among standards and a vision for student learning, analysis of student learning and other data, and professional development goals and plans. This effort acknowledges the need to clearly connect teachers training and professional development to student learning.

The first report (WP1: Teachers' Competencies) presents 12 Desired Competencies of Science Teachers, based on (a) a literature review on the concept of competencies, as well as (b) studies in each of the partner countries on the needs of science teachers. A variety of stakeholders (pre-service teachers, practicing teachers, teacher educators and policy-makers) participated in a variety of methods (e.g., questionnaires, interviews, focus groups, etc.). The resulting data was analyzed to generate the Desired Competencies as well as to suggest implications for science teacher education.

The second report (WP2: The Effective Science Teacher's Profile) uses these Desired Competencies, as well as a comparison study of existing science training programs in the partner countries and Examples of Good Practice (EGPs) to generate the Effective Science Teacher's Profile, which is represented as a job advertisement. The EGPs were chosen to elicit the desired competencies. The comparison study also presents common problems which characterize the existing science training programs.

The third report (WP3: Exemplary Models of Science Teacher Preparation Programs) presents the rationale, methodology and results of cross-cultural experiments involving some of the EGPs presented in the second report. The EGPs were implemented in countries different from those who designed them. The experiments tested whether the "triggered competencies," as identified by the implementing countries, matched or mismatched the same competencies identified by the designer countries.

The fourth report (WP4: The Development of a Common Science Teachers Training Framework) integrates the empirical work (e.g., literature review, surveys and cross-cultural experiment) with the designed products and formulations (e.g., Desired Competencies, EGPs and Effective Science Teacher Profile) in order to generate the basic principles and guidelines of a framework of science training in Europe. This section argues that the Desired Competencies should be converted into common standards and suggests how this may be done, inspired by the methodology developed in this project as well as work conducted in

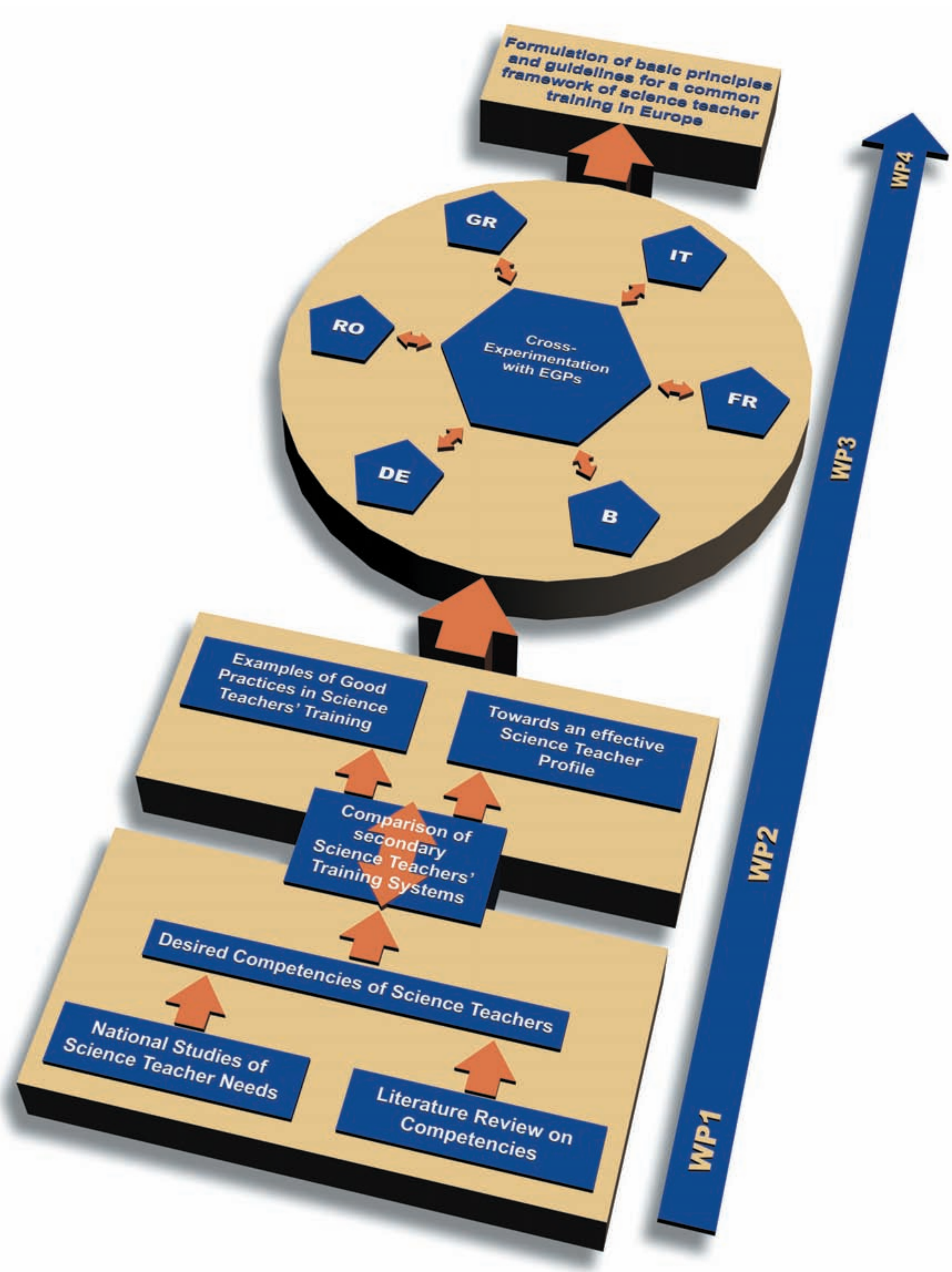

Figure 1.1: *Overview of the evolution of the project's work distributed in the main Four WPs.*

the United States.

The following diagram represents the design of the project, "Science Teachers' Training Across Europe." Empirical work (e.g., literature review, studies and cross-experimentation) are represented in italics. Designed products and formulations (e.g., Desired Competencies, EGPs, Effective Science Teacher Profile, Principles and Guidelines) are represented in bold. The empirical work and the products/formulations are matched to their respective reports (WP1-WP4) and the interactions between them are represented with arrows.

The process mapped out can be used to design both small- and large-scale teachers training and professional development, from an individual school's program to a statewide or national initiative. It can guide designs that involve a single strategy such as a workshop or study group or a complex program, combining several strategies either simultaneously or over time.

Whatever the grain size, the design framework provides a map for crafting teachers training and professional development to achieve the desired goals for students and teachers.

The framework describes teachers training and professional development design at its very best—an ideal to strive toward, rather than an accurate depiction of how it always happens or a lockstep prescription for how it should. Given limited resources, especially time, teachers training and professional developers may not always have the luxury of giving their full attention to every input in the model. The curriculum developers and the educational policy makers who helped to develop the framework extracted its components from what they actually did and what they wished they had done better. With the benefit of hindsight, they helped to construct a tool that alerts planners to important bases to cover and pitfalls to avoid. For programs just being designed, planners can take advantage of the knowledge and experience of others who have preceded them down the path. If programs are already under way, the framework can stimulate reflection and refinement. Wherever planners are in their process, they can hone in on the parts of the framework that best serve their purposes, knowing that no planning process is perfect, and that even the "best laid plans" are subject to the whims and serendipity of change.

While the design framework looks rational and analytical, teachers training and professional development design is more art than science. It is fueled by vision and passion; requires great skill, knowledge, and creativity; and continues to evolve as the designer strives for greater mastery—better results for students, teachers, and schools.

Report of Work Package 1

1 Teachers' Competencies

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Introduction

In European countries, there is an urgent need for high quality initial training, supported by good induction and continuing professional development.
European Report on quality of school education:
"Sixteen Quality Indicators", May 2000.

Upgrading the initial education and in-service training of teachers and trainers so that their knowledge and skills respond both to the changes and expectations in society, and to the varied groups they teach and train is a major challenge to the education and training systems over the next 10 years.
Report from the Education Council to the European
Council on the Concrete Future Objectives of Education and Training Systems, February 2001

The way to interest children in mathematics and science is through teachers who are not only enthusiastic about their subjects, but who are also steeped in their disciplines and who have the professional training – as teachers – to teach those subjects well.
Before It's too Late. A report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century, U.S. Department of Education, September 2000.

Despite the dramatic transformations throughout our society over the last half-century, teaching methods in science classes have remained unchanged. The basic teaching style in too many science classes today remains essentially what it was two generations ago. This is the main outcome of surveys taking place in Europe and in the US (Europe 2000, EDU18 2001, NCMST 2000). The last years there is a growing body of research on how teachers of science will develop strategies to ensure that teaching is effective and matched with what is known about effective learning.

The national teachers training systems and curricula in Europe are based in traditional standardized models not taking into account, most of the times, the outcomes of the research undergone in the field of science teaching (STEDE, 2002). As a result they are losing the chance to respond to the challenges of the 21st century and they are failing to capture young people's interest for scientific ideas. In addition, the structure of science teachers training systems is not uniform across Europe and the national educational training curricula targeted to science teachers have significant deviations in their structure and context depending on the country. For instance in Italy teachers for secondary schools must attend, after having obtained their university degree, a two-year course in-school training. In Germany there are specialized University departments to prepare science teachers for secondary education while in Greece there is no initial science teachers' training. The way to interest children in science is through teachers who are not only enthusiastic about their subjects but who are also steeped in their disciplines and who have the professional training to teach these subjects as well. **Better science teaching is therefore grounded, first of all, in improving the quality of teacher preparation and in making continuing professional education available for all teachers.**

Furthermore International assessments, such as the recent Third International Mathematics and Science Study (TIMSS) (Stigler, 1999) , which tested students of 41 nations, show a wide range of attainments in science by children across Europe. Students' achievements are neither related to the amount of time for science in the curriculum nor related to the amount of money spent on science education. Students will need not only to know scientific and technological information and to be able to do scientific experiments, but also to be able to know how to analyze and synthesize scientific and technological information. Factors such as the quality of teaching and learning and teachers' training and professional development programs should be taken into account in order to meet successfully the challenges that science education faces today.

These challenges make obvious the need to focus on and improve the training of science teachers. The need for high-quality teaching demands a vigorous response that unifies the efforts of all stakeholders in science education.

The European co-funded project (Socrates programme), SCIENCE TEACHERS TRAINING ACROSS EUROPE: Establishing a pathway for a common science teachers training framework aims at developing a common initial and in service training framework for science teachers across Europe in order to facilitate the implementation of the "Report on the future objectives of education and of training systems" (EDU, 18) 2001 using in particular, the exchange of experience between policy makers, curriculum developers, researchers, teachers' trainers and teachers from different countries. The partnership does not intent to develop a common science teachers' training curriculum for all European counties. The partnership - through an extended survey - aims to develop a series of main principles and standards that could be applied to the different national training curricula across Europe, taking into account and respect the differences and the diversity of the existing systems and approaches. The partnership aims to develop a framework that will give common answers to common European problems in the field of science education.

General Aims, Objectives and Outcomes of the "Pathway" Project.

The focus of the project will was to observe and evaluate the structure of science teacher education and therefore design and test an innovative and effective training framework. The project aims to contribute to the improvement of the quality of science teaching. The overall contribution of the project was **the determination of the basic principles and standards for science teachers' training across Europe,** that will help teachers a) to increase their ability to monitor student's work, so they can provide constructive feedback to students and redirect their own teaching, b) deepen their knowledge of the subjects they are teaching, c) sharpen their teaching skills, d) keep up with developments in their fields, and in education in general and e) generate and contribute new knowledge to the profession. In this framework, focus was put on possible contributions by ICT, also in agreement with the EU global recommendations about basic science education of the citizen. In fact, the informatics revolution is producing in the schools a twofold, deep mutation of the boundary conditions within which the scientific formation is taking place: on one side the computer is more and more widely used as a cognitive and operational tool, extremely powerful and versatile as it is; on another side it allows the access in diffused an flexible modes to a network of explicit, sharable competence supporting a permanent education.

The general aims of the project was to:

- **Contribute to the improvement of the quality of scientific teaching** in order to promote its attractiveness and its effectiveness concerning in particular the content of the initial and in-service teachers training curricula. This was achieved by bringing together policy makers, curriculum developers, researchers, teachers' trainers and teachers from different countries in order to design a common training framework based on the most important parameters of science teaching. Establishing **a common European** training framework in science teaching is expected to enhance the professional mobility of science teachers across Europe since it will provide the base for the unification of science teachers' professional skills (one of the main aims of Bologna Declaration (Bologna, 1999)).

- **Perform a correlation survey and analysis on how the different national science teachers' education programs prepare teachers to teaching science.** The work of the partnership was based on the first results of the STEDE (Science Teachers Education Development in Europe) Thematic Network, which is comparing and contrasting the structure and function of science teacher education across Europe and surveying how distance learning technologies can facilitate the initial and in-service training of science teachers (STEDE, 2002). The aim of the partnership was through this survey to identify successful approaches and expand the pool of exemplary institutions and well-prepared new teachers. In order to do so rigorous criteria are needed beyond those already used by teacher's preparation institutions.

- **Identify and assess a series of case studies to be used as examples of good practice.** The partnership aims to identify exemplary models of teachers' preparation that can be widely replicated. Amongst these, emblematic research-based guide lines and materials. These case studies were tested in different environments across Europe during the life cycle of the project. The portfolio assessment method was adopted through the implementation of these case studies.

- **Determine the main principles and standards of an effective training framework.** The determination of the underlying principles that should govern a science teachers' training framework was based on the concepts and the theoretical approaches deriving from recent educational research on the field and the data collected from the application of the exemplary models. The partnership aims at the development of a pathway for a common science teachers training framework that imparts a deep understanding of content, teaches prospective teachers many ways to motivate young minds, especially with the appropriate use of technology, and to guide them in active and extended scientific inquiry, and instills a knowledge of – and basic skills in using – effective teaching methods in the discipline. The proposed framework is giving more emphasis on continuously assessing student understanding, supporting a classroom community with cooperation, shared responsibility and respect and working with other teachers from other disciplines to enhance the aims of the school curriculum.

- **Prepare a series of four reports on the teachers' training framework.** The project's reports present the conclusions deriving from the observational and comparison research concerning the current situation in science teachers' training curricula and propose a science teacher' training framework based on the parameters that could guarantee a high-quality science teaching.

The intergraded report **"The pathway to high quality science teaching"** aims to be the first step on a journey of educational reform that might take many years. The achievement of the high quality science teaching requires the combined and continued support of all involved actors, researchers, policy makers and curriculum developers, science teachers' educators, teachers, students and parents.

Project's approach and methodology

The project through an extended survey across Europe, which was mainly based on the work of the STEDE network, plans to identify the kinds of teacher preparation programs that are most effective. Then the partnership assessed these exemplary models in different environments in order to improve them and expand them. Based on this assessment the partnership aims to develop the main principles and standards of an effective science teachers training framework.

In order to meet its objectives the project will evolve through the following steps:

- Identification of the science teachers' needs
- Correlation survey on the existing training systems
- Identification of successful approaches – case studies across Europe
- Assessment of the exemplary models in different environments (teachers' preparation institutions, schools) across Europe
- Design and Development of a common training framework

In order to realise the above-described plan the project evolved through the steps that are described in Figure 1.2

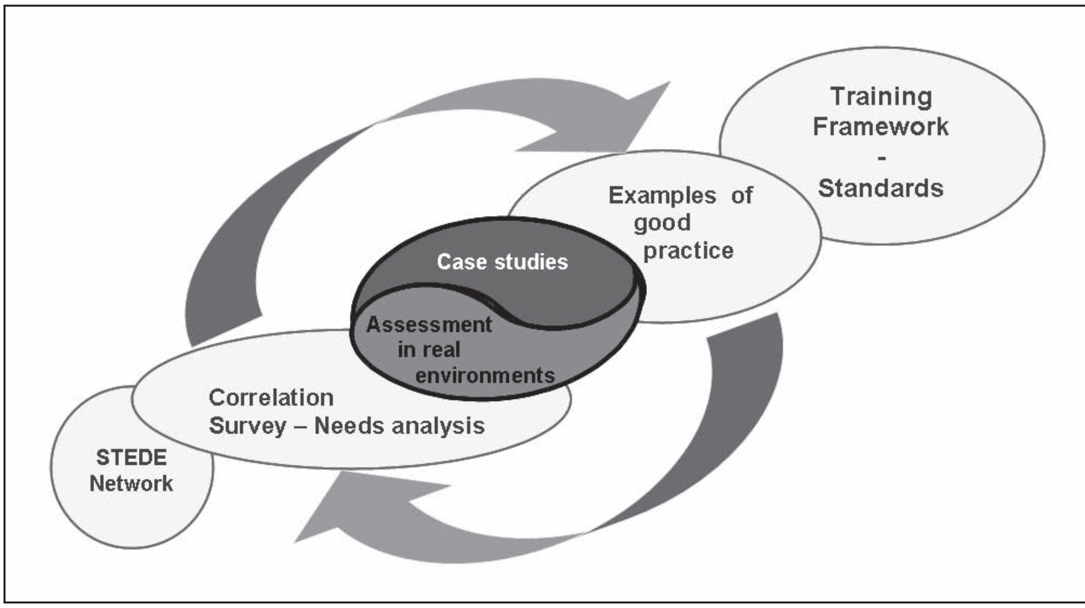

Figure 1.2 *The project's approach: The pathway to high quality science teaching through the development of a common training framework.*

Following the clearly defined common goal of Bologna Declaration, to create a European space for higher education in order to enhance the employability and mobility of citizens and to increase the international competitiveness of European higher education, the project aims to bring together the European science teaching community in establishing the pathway to high quality teaching.

1.1 The pathway to high quality science teaching

1.1.1 Toward the solution

The two core premises of this report are simply stated and they undergird every change we recommend:

(1) Now, more than ever, European students must improve their performance in science. That is the burden of the case presented thus far.
(2) The second premise points in the direction of a solution: The most direct route to improving science achievement for all students is better science teaching.

In other words, better teaching is the lever for change. To call for higher student achievement and high-quality teaching as the most direct route to change seems obvious on the surface, but recent educational reform recommendations have not been sufficiently guided by this clear linkage.

The evidence for the effect of better teaching is unequivocal. The most consistent and most powerful predictors of higher student achievement in science are; (a) full certification of the teacher and (b) a university degree in the field being taught. Conversely, the strongest predictors of lower student achievement are new teachers who are uncertified, or who hold less than a minor in their teaching field.

The difference better teaching makes is often dramatic. The difference better teaching makes for students is paralleled by what can also happen for teachers. A focused professional development experience led by qualified teachers, mentors, and colleagues is the indispensable foundation for competence and high-quality teaching.

As school gets under way, many underprepared and out-of-field teachers will take charge of science classrooms. They, as well as their better-prepared and more knowledgeable colleagues, must have access to ways to continually improve their teaching. Only a tailored system of professional development provides that access.

Thus, if we are to create the kind of science education Europe needs, we have to start rebuilding at education's very foundation—teaching itself.

1.1.2 We need to capture a vision of high quality science teaching

What kind of instruction in science can justifiably be called "high-quality teaching?"
A core premise of high-quality teaching is that the ability to teach, contrary to myth, is not "something you're born with"; it can be learned and refined over time. Specific teaching skills—for example, the ability to distinguish between what is most important for students to learn and what is hardest for them to understand—can only be acquired through training, mentoring, collaboration with peers, and practice.

High-quality teaching requires that teachers have a deep knowledge of subject matter. For this there is no substitute.

In high-quality teaching, the process of inquiry, not merely "giving instruction," is the very heart of what teachers do. Inquiry not only tests what students know, it presses students to put what they know to the test. It uses "hands on" approaches to learning, in which students participate in activities, exercises, and real-life situations to both learn and apply lesson content. It teaches students not only what to learn but how to learn. High-quality teaching not only encourages students to learn, it insists they learn.

High-quality teaching, especially in the sciences, focuses on the skills of observation, information gathering, sorting, classifying, predicting, and testing. A good science or mathematics teacher encourages students to try new possibilities, to venture possible explanations, and to follow them to their logical conclusions.

High-quality teaching fosters healthy skepticism. It encourages students to submit their work to questioning by others, to pull things apart and put them back together, and to reflect on how conclusions were reached.

High-quality teaching allows for, recognizes, and builds on differences in the learning styles and abilities of students. It has the deepest respect for students as persons; it corrects without squelching; it builds on strengths rather than trying to stamp out weaknesses.

High-quality teaching is grounded in a careful and thorough alignment of curriculum, assessment, and high standards for student learning.

To keep its edge, high-quality teaching must be continually reshaped by the institutional structures that support it, i.e., by professional development, continuing education, the effective use of technology, and recognition and rewards.

Finally, the effectiveness of high-quality teaching can be evaluated by the performance and achievement of the students who receive it.

1.2 Science teachers' competencies

1.2.1 Defining the concept of competency

Many researchers, trainers and associations, currently working on proposing standards for science teachers' education and profession, have tried to analyse the new role characterising the science teacher by focusing on the involved "competencies". This concept is considered relevant in all professional fields and particularly in education research, given the fact that these processes are based on interactions amongst human beings.

A definition proposed by De Ketele (1996) is the following: "A competency is a set of organized capacities (activities), which act on contents in a given category of situations in order to solve a problem." In this definition a competency is described as an ability to carry out a specified task or activity to predetermined standards of attainment. According to Spector and la Teja (2001) "competency refers to a state of being well-qualified to perform an activity, task or job function. When a person is competent to do something, he or she has achieved a state of competency that is recognizable and verifiable to a particular community of practitioners. A competency, then, refers to the way that a state of competencies can be demonstrated to the relevant community".

In such definitions the notion of competency is confined to the ability to perform a discrete task or "discrete workplace requirement". The notion that tasks and workplace requirements can be discrete from knowledge, skills, values, attitudes and context is problematic.

A parallel evolution of a more complex view of competency from many researchers in the last decade recognises a concept which incorporates "the ability to transfer skills and knowledge to new situations and environments" as well as the performance of tasks expected in the workplace. This "broader" concept can include among others: the performance of tasks, the management of a series of tasks, the ability to respond to irregularities and contingencies, the capacity to deal with the complexities of the workplace including taking responsibility and working with others, the ability to put one's knowledge, skills and attitudes to new tasks and to new situations, not putting aside respect of others human beings or tolerance of other values.

Pellerey (2001) has reconstructed the evolution of the competency concept during the last years; now it means not only the mastery of knowledge and methods, or the ability to manage them, but also the ability to integrate different kinds of knowledge, and to use them synergically. Therefore to be competent in a certain area implies the ability to mobilize one's own knowledge and to transform it into concrete doing: "competency is an individual characteristic and is built (through self-experience and formation) in a given field and in a given area of problems. It includes the content of the learning process as well as the context where it happens and the ability to apply the grasped content" (Goggi, 2002).

A competency has been defined as "a collection of resources (knowledge, know-how, knowledge to be) mobilized to solve problems in a particular context". (Roegiers 1997, Jonnaert & Vander Borght 1999).

In the STTAE (Science Teachers' Training Across Europe) project the partnership has agreed to refer to the definition of competency given above by Perrenoud, Jonnaert, Roegiers, Dillon and Vander Borght.

All the researchers involved in the study of competencies in different professional fields have focused on the concept of mobilization (Le Boterf 1994, Perrenoud 1999), i.e. "the ability to make operational (ready) the one's own resources in order to solve a category of problems (problems with similar characteristics)".

Several starting viewpoints may be used when addressing the problem of identifying the main competencies required to teachers. As when defining hierarchies, the definition is not unique and several types of classification and/or categorisation are valuable.

1.2.2 Classifications

A general framework that can underlay whatever type of competencies' classification is supported by the Italian team. Thinking of the interactions a teacher is involved, a representation in a 3D orthogonal Cartesian space can be useful (see Figure 1.3).

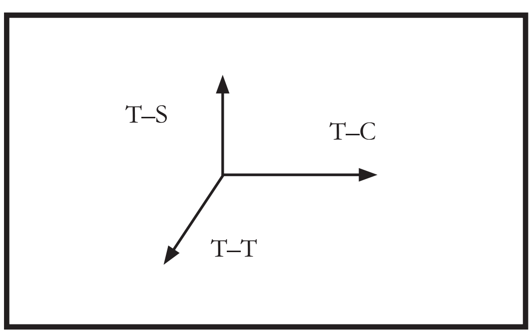

Figure 1.3: *The three axes can represent, respectively, the interactions of the teacher with him/herself (T–T), the ones with the individual student and the class (T–S), the ones with the global context of the school (T–C).*

Several competencies refer mainly to interaction of type T-T, for instance those related to personal beliefs, ideas, opinions, attitudes, practices, as: - the action of reflecting upon strength and weakness of one's own teaching strategies and techniques; - the identification of weak disciplinary knowledge areas that need to be reconstructed and/or re-thought; - the action of eliciting one's own intuitive epistemologies and models about what teaching processes are; - one's location in a continuum ranging from an extreme inspired to behaviourist teaching models to an extreme inspired to constructivist or constructionist teaching models; - the aimed goals and interests in implementing the current teaching; -and so on.

Other types of competencies refer mainly to interactions of type T-S, for instance those related to: - owns ideas about learning processes; - the capabilities of implementing different learning environments and tuning them to the class characteristics; - the choice of approaches that enhance the students' motivation and interest; - which assessment methods are chosen and why; - the capability of guiding the class toward a learning convergence, while respecting the learning dynamics of the individual student; - and so on.

Finally, (T – C) is the interaction type to which mainly refer competencies like the ones required to the teacher in order on one hand, to interact constructively with: - the school administration; - the central or local educational authorities; - the students' families and the territory/environment and, on the other hand to make "best choices/practices" in relation to: - the contents of the syllabus (which ones to be emphasised more and less); - and so on.

Metaphorically, the dimensions of this 3D space can be thought as three basic colours.

A specific competency can be seen as a point in this space. Its' "colour" derives from the mix of different "colours" representing the axes.

The literature about teachers' competencies is very rich (the bibliography reports a non exhaustive list). The articles may be divided in two categories, the ones (group A) whose focus is on "the individualisation of the main components, the main skills needed to be a good science teacher" and the others (group B) where the focus is on "what science education is needed by young people today". This last group is, in our opinion, interesting since the issue of students' competencies is strictly connected with that of teachers' competencies, even if the two sets are not overlapping.

As far as group A is concerned, the question on how "to individualize the main components, the main skills needed to be a good science teacher" is addressed by Barnett and Hodson (2001) with the aim "to draw together the ideas which can usefully be synthesized into an environmentally based framework to help clarify the knowledge that good teachers possess, and how that knowledge is deployed in diverse ways to suit the particular educational context". Their starting point involves two key ideas started from the mid-1980s: the Teachers' Personal Practical Knowledge and their Pedagogical Context Knowledge. As far as the Personal Practical Knowledge is concerned, the authors claim that this is basically rooted in the teacher's class experience. The items included in the Pedagogical Context Knowledge are: academic and research knowledge, pedagogical content knowledge, professional knowledge and classroom knowledge. A list of the components of Science Teachers' Knowledge is also given by the authors quoted above; here are some examples:

- Scientific knowledge
- Personal philosophy of Science Education
- Use of strategies for assessing science learning
- Use of strategies for integrating science with other subjects
- Political and sociological knowledge of schooling
- "Psychological" knowledge of students
- Facilitation of learning

As far as group B is concerned, Osborn, J. and Millar, R (2000) answer to the reported question "what science education is needed by young people today?", by indicating the main problems related to the science education curriculum: "young people lack familiarity with scientific ideas…..school science fails to develop and sustain the sense of wonder…" A list of reasons for such problems are then presented by the authors such as e.g. : "the science curriculum can appear as a catalogue …it lacks a well articulated set of aims…assessment is based on exercises…"
One can infer that in order to overcome the problems outlined by Osborn and Millar the science teachers should:

- be familiar with scientific ideas
- present the curriculum in a coherent way
- develop students' sense of wonder and curiosity
- have knowledge of pupils' scientific capabilities (referred to their age)
- have knowledge of the most useful assessment tasks
- integrate science and technology
- know and analyse the scientific issues that permeate contemporary life
- be open to investigation and innovation practices
- be able to adapt the science curriculum to the diversity of interests and aptitudes of young people

Other researchers (Mellado 1998, Niess and Scholz 1999, Magnusson et als. 1999, Loughran et als 1999, Loughran et als 2001,) have tried to analyse what Science Teachers (ST) know and what they do in their classrooms in terms of different kinds of Knowledge and Competencies recognised as relevant. They report that these are very difficult to factorize or to separate in well defined groups and that a picture that can capture them and their relationships is that of a net where, as first order approximation, regions of similarity can be pointed out, evidenced, but not enucleated from the context. The recent literature and many reforms in the field of science teacher education suggest (Zeidler 2002), that teacher preparation has a "threefold structure" with the anchoring pillars being Subject Matter Knowledge (SMK), Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK). This structure is based on Shulman's work ("Those who understand: Knowledge Growth in Teaching" Shulman, 1986b).

1.3 Methodology - Framework of research

The framework of the research methodology of the project is based on two main axes, a) the analysis of the STEDE network results and b) a series of surveys carried out by the Universities at each of the participating countries. The main aim of the STEDE project was to compare the structure and function of science teacher education across Europe and to survey and analyze how education programs prepare science teachers to teach science in the primary and secondary phases. For the needs of of our survey, we have taken the above results into account, and focused on preparing the framework for the selection of the results concerning specific "examples" of good practices, namely a selection of promising national approaches of courses developed for prospective science teachers. The tools used in these surveys were questionnaires administered to Expert Science Teachers and Prospective Teachers. The design of the questionnaires took into account the framework suggested by Shulman (1986a) referring to subject matter knowledge (SMK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK). Theses three categories will also serve as a basis for the analysis of the collected data described in the following sections.

1.3.1 Initial teacher training

The system of training teachers which has evolved can vary considerably from country to country, and even within one country , due to different factors, like:

1. the educational culture of the country;
2. the historical development of teacher training;
3. the school system;
4. financial resources;
5. the supply and demand for teachers;
6. or other factors not listed.

However the spectrum of systems had two ends which were recognisable by most of the group.

1. Concurrent degrees in which science, teacher education and classroom practice were integrated into a single degree. As the degree progresses then the balance between science and science education studies normally changes. Students may choose to become a trainee teacher before the course commences or at some point along the way.
2. Consecutive degrees in which a science degree is first obtained and then a masters degree or a diploma course follows, either immediately after the degree or after a break of many years.

It should be said that there are many variations between these two extremes.

The ideal teacher
In order to clarify the teacher training process we collected together some ideas of how we would recognise an ideal teacher Teachers should be aware of:

1. their own concepts and understanding of science and the effects of these teaching;
2. their understanding of the philosophies of science and their effects on their methods of teaching;
3. the variety of teaching methods and be flexible in using them;
4. their students' conceptual understanding of science;
5. their student's interests;
6. the 'world view' as seen by young people;
7. and be positive and respectful towards their stu-

dents;

8. and be sensitive to the classroom situation.

Mind the gap

1. There are many 'gaps' between different aspects of teacher training and closer communication should be encouraged so that every partner understands what the other is doing. For example the senior professor of science needs to understand what is happening in science education across a wide field such as in the primary schools. Some of the gaps identified exist between primary schools, secondary schools, HEIs, initial teacher training institutions, in-service education institutions, education research, and the policy makers. These links between different communities flow in many directions and are extremely complex; policy makers and higher education are not there just to dictate to the schools otherwise messages may not be passed along the way. Even the simple words and concepts which we use such as model, research, aim and tool may have different meanings in the school and HEI environment. If there is no common language then there is no communication. This language problem pales into insignificance when considering the 'world languages'; few teachers are able to read education research journals which are frequently written in English.

2. The gap between Teaching and Learning. One of the major definitions of teaching is that teaching should bring about learning. If the student is not learning then the teacher is not teaching however much the teacher is talking, nothing is being absorbed by the student.

3. The gap between the theory drawn from research in education and the practice of education acquired by the 'reality shock' on entering a school. Researchers in Education should be encouraged to write for the practising teacher and not just for themselves. Education journals contain too much jargon which cannot be penetrated by the practising school teacher. Trainee teachers should be taught how to access and apply the resultsof educational research in the same way as PhD science students are taught how to do literature searches. Final assessments of trainee teachers, such as in written projects, should assume a knowleodge.of research related to their project. By learning how to access the research literature the new teacher would have access to continuing self education which could build into in-service training and further accreditation. Some thought about the idea of assigning a week to the discussion of the same topic in both the HEI and the schools made a lot of sense. For example the topic of Language could be discussed from the point of view of research on language use in general and language use in science education which could be discussed in the HEI. In school, trainee teachers could discuss the use of text books and written work for different aged pupils. In this integrated way the research topics would make more sense in the school environment. Trainee teachers need to be exposed to schools early in their training so that what they learn in the HEI has relevance to the practical situation in the classroom. Trainee teachers also need a lot of time to reflect on their experiences both alone and with the several groups to which they belong in the HEI and in schools. Filling every minute of the trainee teacher's day with timetabled activities is counter productive.

4. The gap between Academic Science and Science Education (didactics, pedagogy, school practice). The didactics of science need to have more impact on the way in which the science courses themselves are taught in the HEI.

5. The gap between teaching in science departments and science education departments. This gap is frequently created because trainee teachers must move amongst many departments in the HEI many of which may have little idea of what the other is teaching and how they are teaching it. There was also concern about the relative amount of time which a trainee teacher spends on different aspects of their course. This could be a real problem for European accreditation of teachers. A related issue is the number of academic subjects which a trainee teacher must take such a science, other sciences, mathematics, and whether they are relevant for their future career.

6. The gap between those who are professional scientists and the rest of society in which they live and work. This is a major problem which needs to be addressed at many levels. The Science in Society movement has done a lot of good work

but there is much still to be done. The wider community has a very important influence on the careers of young people and so the image of the scientist and the science teacher within the community is a very important influence on pupils. The relationship between teachers and policy makers of all kinds may also have weak links.

7. The gap between science societies and teaching societies. Both of these types of society need to talk together at the highest levels. Too many Scientific/Physical Societies tend to be exclusive institutions and school teachers are not welcomed as members. Sadly it is often the shortage of teachers or changes to the school curriculum which causes Science/Science Societies 'to sit up and take notice'. Support for the teacher trainee is essential as in many cases they may have no representation in either an academic or professional society. It was discovered that commitment to teachers from the Academic Societies varies from country to country and many of them have no contacts with schools. Indeed many Societies have either a passive or even a negative attitude towards the training of science teachers. It was suggested that all national societies affiliated to European Physical Society EPS) could do a survey of the percentage of their members who were school teachers. The services which the Societies provide for schools could also be surveyed.

8. The gap between the 'conditions of service' between scientist, science teachers and science teacher trainers is very real and it is felt most by those, such as mentors, who have to work in both institutions.

9. The gap between science teachers and the rest of the teachers in school needs to be considered if only because a pupil may work with up to eight teachers in a day and the message about common topics, such as energy, could be very different from each teacher and perhaps counterproductive to the learning process

10. The gap between graduates from different countries and the international job market has consequences for all, particularly across the rapidly expanding European Union. Validation of qualifications, so that trained teachers can teach across the European Union, still need more attention.

11. Gender issues were discussed as a Gap because of the greater number of male scientist than female scientist in most countries though some countries reported that it was not a problem.There was little time to discuss the efforts which are being made to encourage more girls to take up the physical sciences and engineering. An example of research using video tapes of a lesson in which male teachers taught boys and girls separately and then together caused some teachers who took part to be ashamed of how they ignored girls in mixed classes. The IUPAP conference on Women in Science in Paris in 2002 was referred to. The Science Olympiad appears to attract a disproportionate number of boys while the International Young Physicists' Tournament attracts a higher proportion of girls. Multicultural issues were also mentioned but the topic was too big for us to discuss in detail. Like gender issues it was more relevant to some countries than others but all felt that gender, multicultural and social issues should be part of the education of all trainee teachers. We discussed no further than declaring that there should be fairness in considering the culture and preferred learning styles of all: being fair to an accurate account of the history of science; being sensitive to considerations of subject content and religion.

In addition other areas were mentioned which included, the gap between education and parental understanding and the whole issue that knowledge plays within the cultural context.

Reducing the gaps

Here are some ways on how some of the above problems could be alleviated

1. We need to ensure that there is public awareness of what teachers and teacher trainers do.

2. Science education articles need to be written for science research journals. The articles need to be integrated into regular issues of the journal because academic scientists have a habit of putting special teaching issues of a journal into the waste bin! More information on international comparisons such as TIMMS and PISA should provide interest to academics about the relative effectiveness of their own school system.

3. Teacher training for all HEI professors and lec-

turers needs to be developed. Some countries are beginning to experiment with this training and accreditation for HEI professors.

4. All those involved in training teachers need to talk together and arrange conferences together rather than crying out in despair. Web sites need to be set up in local areas to link all those with a professional interest in science education. These web sites could be used, for example, to convey information rapidly on changes within one sector of the education system to another sector.

5. Maybe the only way to reduce the gaps in the education and training of science teachers is to create a discipline of Science Education and Teacher Training.

If some of these gaps are reduced then maybe the transformation from a trainee teacher into a teaching professional will be improved and made more coherent.

Mentoring

The trainee teacher is caught between two aspects of his/her training; the classroom practice aspect and the HEI learning. In integrated courses the trainee teacher has to behave as a professional teacher for part of a week and as a student in higher education for the rest of the week. The trainee teacher is caught between the demands of those who teach him/her in the school and the HEI.

Mentors/tutors appear in many guises. They may be:

1. school teachers who receive trainee teachers into their school in addition to doing their own teaching in the same school. Some of the mentors will either be paid extra for doing this work, be allowed a lighter teaching load in school or receive nothing at all. Others will spend 50% of their time in school and the other 50% in the teacher training institution.

2. school teachers who are invited to spend a year in an HEI and then return to their school;

3. employees of the HEI.

What is clear is that the role of the mentor needs to be more clearly defined. The first priority of most mentors is to the school students that they teach. If trainee teachers are to teach the mentor's classes then the responsibilities of the student teacher, the HEI teachers and the mentors need to be carefully worked out. For some mentors their status within the school increases and promotion ensues; others just feel over worked with the authorities taking little notice of their problems. Some of those involved in mentoring suffered from a lack of time for thinking and doing research because of living in two worlds, but at the same time seeing the importance of this interface between the HEI and schools..

Mentors have a variety of duties in school:

1. Introducing trainee teachers to the school.

2. Linking what is learnt in the HEI to the knowledge needed in schools. Mentors should be part of the course design team in the HEI.

3. Helping the student teacher to come to terms with the complex demands within schools from designing the curriculum, setting and marking tests and examinations, and looking after school students and their problems.

4. Some may have to assist the trainee teacher to plan, teach and evaluate their lessons. This is normally the role of the mentor when the mentor shares the same subject specialism as the student teacher. This role normally requires helping the student teacher to evolve from a role of observing lessons, through team teaching with the normal classroom teacher to teaching complete lessons on their own. This may have followed a period of simulated lessons in the HEI for which the mentor might also be responsible. Trainee teachers take an enormous amount of time to plan their early lessons fully and so call on the mentor's time for continuous help. Trainee teachers also need to practise self evaluation and critical reflection on their lessons with their mentor. Some mentors may video the student trainee teaching and then analyse their lessons according to some evaluation grid.

5. Mentors spend a great deal of time encouraging weaker trainee teachers and in the end they may have to recommend that the trainee should fail to qualify as a teacher. The Code of Practice for this will need to be clear and unambiguous as in some countries this can lead to litigation as well as a feeling of having failed the student.

6. There are also the training needs of the mentor to consider and their training of other school colleagues who will not have the advantage of close links with the HEI.

7. Many mentors in school deal not only with trainee teachers but also newly qualified teachers at the beginning of their teaching career. 'Probationary' periods may last one or more years and links back to the HEI should be made so that evaluations of the training process, in the light of early teaching careers, can be made.

8. Mentors should also have a strong commitment for the creation of a community in school and the HEI which is interested in life long learning and educational research.

9. At the end of this long list thoughts must be given to what should be done with weak mentors.

When a trainee teacher teaches a class then the school students may not be taught as well as they would have been if their normal class teacher had taught them (sometimes they may be better taught!). School student results might be impaired and parents and school authorities complain.

Everyone agrees that professionals have to take their first professional steps be they surgeons, lawyers or teachers and that they need to practise on someone but few wish the practice to be on them! Student teachers have the problem of being on 'both sides of the desk'. One day they may be demanding work from their school students in school and the next their teachers in the HEI may be demanding work from them. This can lead to problems for the student teacher of an identity crisis nature.

Another problem was identified for some, that of language. The word 'mentor or tutor' was reserved by us for the school teacher who takes on the role of looking after student teachers in school but what of the person who is employed by the HEI and who looks after trainee teachers in the HEI and in school. This person may be called 'supervisor', 'subject lecturer/tutor', 'methods lecturer' and so on. The problem here may be caused by the way in which the teacher training is carried out in the HEI. It may be the responsibility of one department, such as an Education Department to being the responsibility of many departments such as the Science Department, Didactics Department and the Pedagogy. Department The supervisor is seen by us as someone in the HEI who prepares a trainee teacher for work in school. It was extremely difficult to assign a name to all the roles played in schools and HEIs which would reflect accurately what was done in different countries but this is the best we could do.

Recommendations

1. The mentor should be fully affiliated both with the school and the HEI so that the experiences of the trainee teacher are coherent.

2. The consequences of this would be improved communication between the school and the HEI and the mentor would be able to participate in the design of the trainee teacher's curriculum.

3. The mentor's status would increase and they would be seen as the central person concerned with the learning and welfare of the trainee teacher.

4. Mentoring requires resources of time, money and materials. The job of a mentor is too important to be left to the 'goodwill' of those doing it. Mentoring can also be a lonely job and mentoring teams need to be set up.

Examples of skills for science teachers

It is not enough just to list all the skills which a teacher needs to have but it is also important to find ways to teach these skills. It is also no longer enough, if it ever was, to say that teachers are born as teachers and that they know instinctively what to do. We must also remember that a science teacher is a physicist as well as a teacher and these two 'poles' may not be equally balanced in the consciousness of any one teacher.

1. Subject knowledge (science knowledge) is learnt in many ways in the HEI. In some cases science trainee teachers are taught alongside future physicists and engineers and there is no differentiation of their courses. Others are taught their science in an integrated science and education course. Yet others will do a science, or cognate science, degree with no intentions of becoming a teacher at the beginning of their course.

It would be helpful to future teachers if science professors had some understanding of pedagogic, didactic and science education research knowledge so that trainee teachers were taught their science in a way which would relate to the methods of teaching they were to use in school. Teachers need to have their science knowledge firmly rooted in the Science in Society issues of the day and so will need to generate their own relevant information. Teachers also need knowledge from related subject areas such as physics, biology, chemistry, earth sciences, astronomy and mathematics to list but a few. Trainee teachers need to work on their own knowledge searches as part of the assessment of their course.

2. Methodological skills are needed so that teachers are able to translate their science knowledge into lesson plans. Lesson planning need pedagogical knowledge drawn from educational research as well as subject knowledge.

3. Practical skills need to be developed by trainee teachers so that they can design and set up experiments and investigations in school using standard equipment but they also need to be able to design low-cost demonstrations using everyday materials found around the home and the home workshop. Practical work in primary schools is based on using everyday materials both for reasons of cost and also relevance to the pupils.

4. In today's world no science teacher can be without computer skills. Pupils expect science lessons to use up to date equipment for the normal 'office skills' of writing a report using word processing, producing charts and graphs using spreadsheets, using databases and the internet io search for scientific information, and communicating using e-mail. Experiments can now be attached to data loggers and the results analysed in more detail than ever before with great ease. However ICT workshops at this Seminar were dealing with this topic and so it only required a mention here.

5. Trainee teachers must be able to translate curriculum statements into teaching routes. National teaching schemes govern the curriculum structure and examination syllabuses are often the real teaching guidelines for use in the classroom. Each school needs to be able to develop their own teaching curriculum which relates to their school and then each teacher needs to develop his/her own lesson plans which take into account the needs of all the pupils they have to teach. It is at the classroom interface that teachers can use their imagination and enthusiasm for the subject which will motivate their pupils. It is also here that considerations of the social, cultural, multicultural, and ability of the students can be taken into account.

6. Teachers need to be able to construct a variety of educational tools for monitoring their pupils and evaluating their work. Testing materials need to be designed and the answers marked with the results being conveyed to their pupils in ways which will improve pupil progress. Examinations need to be coherent with the teaching scheme. Pupils taught by modern day methods, such as teaching for understanding or using techniques developed using constructivist theories, will not do well on examinations which assume rote learning and memorisation. Many courses today stress the phenomenological side of science more than the mathematical, problem solving side and so examinations stressing equation manipulation and mathematical processes would not reflect the teaching process.

7. Self evaluation: Evaluating one's progress and success or failure as a science teacher is a skill which has to be taught. Check lists are frequently produced so that an observer in a lesson can make objective judgements using defined criteria. Trainee teachers are encouraged to evaluate their own progress using the same grids. 'Every action has a consequence' to quote freely from Newton and the trainee teacher needs to be able to connect what s/he has planned and carried out with the effects on his/her pupils. Knowing the epistemology and history of science as well as the aims and methods of teaching science aid the trainee in evaluating his/her progress.Trainee teachers are full of idealism for their new career and they should try to keep it; the jaded 'old timer' may have more knowledge of the practicalities of the classroom but they can dampen the enthusiasm of the trainee teacher. Trainee teachers evaluating the best and worst

teachers they have met may help trainee teachers to understand what the pupil expects from a teacher.

8. Communication skills: Without communication then nothing would pass between teacher and taught. There are many aspects to this huge topic which requires a seminar of its own. Obviously the language used needs to be understood by the pupil. The teacher's talk needs to be planned and questions need to be developed; worksheets may have to be written for the differing ability levels in the classroom; posters can be used by teachers and pupils in order to convey the results of the teaching process to everyone.

9. Consciousness of school complexity: Schools are very complex institutions and those who look after trainee teachers in school need to realise how daunting a school can be. The mentor has an important role in introducing the trainee teacher to the school.

10. The teacher is an individual but s/he is also involved in team work belonging to many different teams. The pupil belongs to a complex home-school environment. The pupil also belongs to a class (many classes) and to the school as a whole. The teacher belongs to these too, as well as belonging to the school staff and all the educational support services. A teacher who cannot work as a member of these interacting teams will be a trial to his/her colleagues. Trainee teachers need to learn team working skills by working in groups during their training .

11. Recent educational research has shown that there are a variety of teaching and learning styles and so teachers need to have many teaching styles which can be matched to individual learning styles of pupils. Unless a school employs individualised teaching schemes then this means that teachers should 'play fair' in using different teaching and learning styles in their lessons. There needs to be coherence between the aims, evaluation and teaching style in their classrooms. Teaching strategies for a lesson may include one or more of the following styles:

- chalk and talk
- teaching for understanding
- discussion
- kinetic activities
- investigations
- discussions
- study groups
- workshops
- co-operative learning
- games and simulations
- information searches to find their own material
- informal learning: field trips to museums, amusement parks, industry
- collecting information from the science news
- and many, many more.

The total list is probably only limited by the imagination of the teacher. Trainee teachers in particular need to be encouraged to try out new ideas and to follow them to their logical conclusion, submitting their work not only to the critical evaluation of others but also to the trainers who must learn to use the variety of teaching and learning styles too. Trainee teachers need to learn in their own way. to work autonomously and to learn to ask the right question. To begin with they will probably copy their mentor and other teachers, they may teach as they were taught, but eventually they will develop their own methods.

12. Coherence: Trainee teachers need to synthesise their knowledge gained from science, pedogogics and didactics so that they can relate to their specific situation in their school in a coherent way.

13. Pastoral skills and knowledge: Teachers have to care about their pupils and their backgrounds otherwise learning docs not take place. The level of pastoral care varies from country to country but most teachers would recognise the role they play as a "home room" tutor. Interaction with parents, counsellors, careers guidance counsellors, social services and the medical profession may be part of the teacher's role and the skills required for this extended role need to be taught.

14. Some saw that there were different levels in teacher training. First a base level in which stu-

dents are taught their subject knowledge followed by a first level when they are taught some models of teaching science and finally a second level when they are taught how to teach. Others saw the process in a more integrated way.

How do you teach all these cognitive and affective skills? A teacher who had them all would clearly be super human! The European Science Education Network (EUPEN) investigation on teacher training is a valuable resource for the discussion of teaching skills.

1.3.2 In service science teacher training

In-service training is considered to be an important component in the education of a teacher, helping to assure a high quality of performance in the classroom, from kindergarten to university level. With special regard to science, new developments and research results in different fields, new methods in didactics, new tools, either from the experimental side or with regard to computer facilities, demand a continuous effort to cope with these tasks. Another important aspect of in-service training concerns the exchange of experiences and materials between teachers. Whereas at university level this part of further education lies in the sole responsibility of the individual person, at school level there exist established programs for in-service training courses in many countries. An immense variety of these national or regional programs can be observed with respect to, e.g., content, duration, finances or acceptance by the teachers. And, contrary to the initial education of a science teacher, where a lot of didactic literature exists on comparisons of different systems, on evaluation and quality assurance, the field of in-service training has been left much more unexploited, both at the national as well as the international level.

Attractiveness of in-service training

Statistics of in-service training courses in many countries reveal that only a minor percentage of teachers are attending such courses regularly or often, whereas the rest does not participate. This unsatisfactory situation is amplified since the already motivated and creative teachers are usually within this smaller group, while on the contrary teachers who might need motivation and support do not take the offer of in-service training. Therefore the increase in the number of attendees of in-service training courses was seen as a major concern. Several suggestions in this direction were proposed and discussed:

Voluntary versus compulsory systems: In some countries teachers have to attend in-service training courses, in some countries the participation is completely voluntary. Workshop B favoured strongly a voluntary system, since motivation, e.g., will surely not be created by pressure.

Bonus system: Slovenia has a very refined bonus system for teachers: There exist several steps in the career of a teacher which he/she can but need not take. The steps are connected with a raise in salary, but also being given more competencies at school. A system of points is established, and it needs a well-defined number of points to proceed to the next grade. These points can be earned in different ways, in the following just those related to in-service training are mentioned: attendance at in-service training courses in Slovenia or abroad (the amount of points depends on the type of the course), contribution to such a course (e.g., lecturing), organization of an in-service training course.

In some countries, new equipment is given only to those schools of which at least one teacher has been attending the course related to this equipment.

Quality: There was a long discussion how to assess and, in a next step, to improve the quality of in-service training. With regard to the attractiveness of a course for the participants, quality should be indicated by the participants themselves, either in questionnaires or by recommendation to colleagues. But questionnaires are useful just for short-term evaluations. Long-term evaluations about the benefit of in-service training courses do not exist, but would be very valuable, and therefore should be regarded as a challenge to researchers in the field of science didactics.

Needs: For sure, the attractiveness of in-service training is increased when it meets the needs of the teachers. These needs are discussed in the chapter "Content", see below. Ready-to-use material:

Experience has shown that teachers appreciate in-service training where ideas and material are discussed and distributed which can be immediately implemented in the classroom.

ScienceTeachers In-service Training in Greece

Contribution by Christos N. Ragiadakos, Pedagogical Institute,
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A.1 INTRODUCTION

Continuing training should not be viewed and used as a substitute of initial training

The competencies of the science teachers have been recorded and categorized in the other sections of the present report. In the present analysis of teachers (in-service) continuing training we will assume this categorization, which contains the following four categories:

- Subject matter knowledge
- Pedagogical knowledge
- Pedagogical content knowledge
- Instructional technology knowledge

In higher education level and in departments giving access to teaching professions one objective of the basic studies (initial training) is to instruct students on the teachers' competencies. Generally, the needs of in-service teachers are not the same with the needs of students to be teachers, because the former does not have the study time of a student, he should not be viewed as student and, in principle, should be viewed as competent enough teacher, as he is already employed teacher. One could not claim that ALL employed teachers have ALL the requested competencies, but on the other hand continuing training should not be used as a substitute of initial training. Therefore we first have to outline the framework of continuing training and as we will see below the instruction techniques of initial training are not effective in continuing training. A priori, the in-service training helps the teacher to accumulate on his teaching experience; therefore different training techniques should be used (e.g. modular training, in-school training).

The framework of continuing training

The fundamental purpose of continuing training is to improve teachers' performance and to support teachers to meet the changing demands of their work due to their professional development during the 35 years of professional activity. The first direction concerns scientific changes in the above mentioned four categories of competencies and the second direction has to do with the expectations of each individual teacher to become either an educational executive or a scientific specialist. In these two continuing training directions we should also include the "morale" support interactions that help the teacher needs to bypass the everyday teaching routine.

In a well structured school organization with a powerful and responsible Principal/manager and the teachers of each discipline structured into a department with responsible, senior teachers and simple teachers, the continuing training has also to be organized at the school level too. In the context of continuing training the school activities and plans should be taken into account. The existence of school program in parallel to the perspectives and professional development of each individual teacher, makes continuing training a highly complicated procedure, which cannot be organized and accomplished by a central state organization.

Contining training has to be planned at the school level and in complete connection with school objectives

The antecedent analysis indicates that the objectives and procedures of continuing training should differentiate with those of initial training because the needs and obligations of in-service teachers are not the same with those of the students. Therefore we suggest the following classification of continuing training:

The three general categories of continuing training

- Competencies improving training
- Curriculum reform supporting training
- Professional evolution supporting training

These three general categories will be developed below with special emphasis to the science teachers' continuing training.

During the Community Support Framework II (CSF II) program, a large-scale continuing training of teachers has been undertaken in Greece. The objectives, procedures and outputs are surveyed in WP2. This intensive training revealed the possibility that continuing training may be more harmful than useful, because it could disturb the school functioning. During the implementation period (1996-99) of this intensive training the teachers abandoned their classrooms and were attending seminars and conferences. They were finally tired of all these seminars. This experience revealed that while the teachers consider continuing training very important, the majority of them prefer to be trained by different training modes (e.g. Open University or during sabbatical period). It remarkable that the centralized Greek educational system does not encourage the training method of collaborative activities, which are common in the other countries and Greek teachers do not essentially know this training procedure, therefore it does not appear in the statistics. The results of the TABLES A.1 and A.2 from a small scale research of Pedagogical Institute are quite representative.

The majority of teachers agree on the importance of continuing training

TABLE A.1

Question: How do you classify teachers' continuing training?

	Teachers from urban areas	Teachers from semiurban areas	Teachers from rural areas
	%	%	%
Very important	82	68	87
Important	17	27	12
Not important	1	5	1
Useless	0	0	0

Source: G. Typas and M. Papachristou, Dioikitiki enimerwsi, Issue 22, January 2002

Teachers prefer long period training

TABLE A.2

Question: What institute/procedure do you prefer for teachers' continuing training?

	Teachers from urban areas	Teachers from semiurban areas	Teachers from rural areas
	%	%	%
ODL	39	30	37
One year sabbatical	42	46	42
For 3 months period	12	21	16
Other	7	3	5

Source: G. Typas and M. Papachristou, Dioikitiki enimerwsi, Issue 22, January 2002

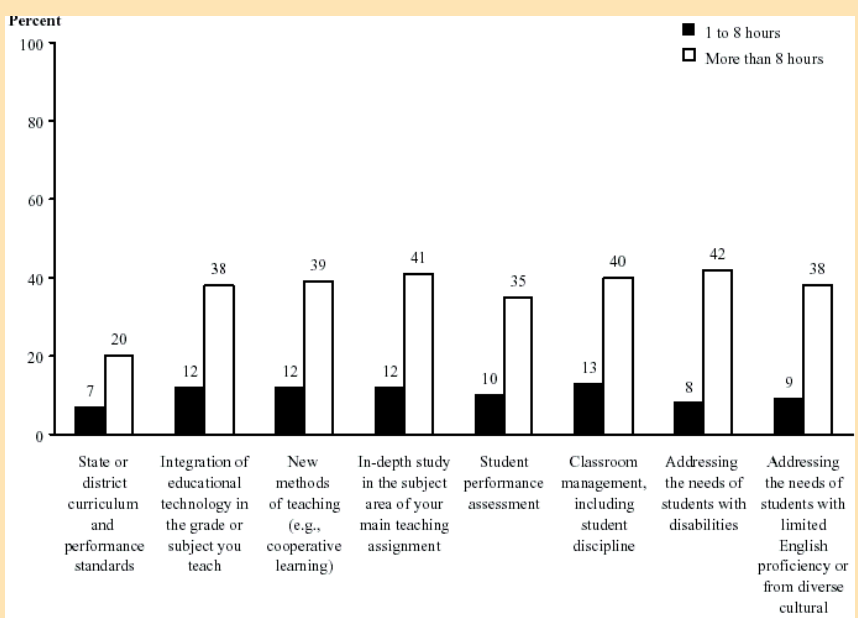
The concern for high quality teachers is quite general and many studies and efforts have been undertaken in order to improve the teachers quality. A report[1] of the USA National Center for Education Statistics indicates (FIGURE A.1) that:

A NCES research also indicates that teachers agree on the importance of continuing training

- Virtually all teachers participated in professional development activities (99%) and at least one collaborative activity (95%) in the last 12 months. Participation in professional development activities typically lasted from 1 to 8 hours, or the equivalent of 1 day or less of training.
- Nineteen percent (19%) of teachers had been mentored by another teacher in a formal relationship; 70 percent (70%) of teachers who were mentored at least once a week reported that it improved their teaching "a lot."
- Increased time spent in professional development and collaborative activities was associated with the perception of significant improvements in teaching. For every content area of professional development, a larger proportion of teachers who participated for more than 8 hours believed it improved their teaching "a lot" compared with teachers who participated for 8 hours or less.

Figure A.1. –*Percent of full-time public school teachers who participated in professional development activities in the last 12 months indicating the extent to which they believe the activity improved their teaching a lot*

Short period training does not affect teachers performance



SOURCE: U.S. Department of Education, National Center for Education Statistics, Fast Response Survey System, Teacher Survey on Professional Development and Training, 1998.

Well structured school organization is prerequisite for any attempt of continuing training

In order to assess the impact of continuing training on teachers' performance there must be some indicators which directly or indirectly indicate the effect of the teachers' training on the final "product", which is the achievement of their students. There must be a method to understand: When a low performing school turns around; what is going on in the schools of the same district but with large differences of the performance of their pupils; and how a school can eliminate performance gaps between its Greek and minority students. In many countries such evaluation procedures of schools and teachers exist through a combination of internal and external evaluators. Unfortunately, in Greece no such a system exists, therefore nobody knows "what happens in the classroom". According to the survey in WP-2, a large scale of science teachers' training has been undertaken in the context of CSF II program, with main objective to increase the number of experiments performed by the students in the school. We now know that despite this intensive training this objective has not been achieved. Our opinion is that the reason of this failure is the non existence of a school internal organization and an educational evaluation procedure. The CSF II training experience has indicated that before establishing a formal continuing training procedure, the following four indispensable features of school organization, which are common place in the other European states, should be first established:

- The teachers have to be grouped in disciplinary departments directed by a senior teacher with evaluation authorities on the teachers of his discipline. The school itself must have a Director/Principal with clear evaluation authorities over all the teachers of the school;

- In parallel to the internal evaluation system there must be an external evaluation system of the school outputs.

- The classrooms have to be attributed to each course like in the other European countries and not to permanent groups of pupils. In this case the classrooms are completely abandoned and turn out to become too dirty for students. All the science classrooms have to be well equipped and assigned to the science teachers' team.

- All the permanently employed teachers must stay at school through the whole school program (at least 7 hours per day like all the other state employees).

Without this school structure any teachers training program has minimal effect.

Summary of the section

Summarizing the present introductory section we point out that a) the needs of in-service teachers are not the same with those of the students to be teachers; b) the initial training methods are not generally effective in continuing training and c) an effective school organization and an evaluation system are necessary for maximising continuing training effect.

A.2 COMPETENCIES IMPROVING TRAINING

During the 35 years of the teachers professional life the amount of new scientific subject matter, which could (or should) be taught at school, is not generally so large that cannot be covered by self reading and the teacher book of the didactic packet. One can easily realize that by simply looking back at the science progress the last 30 years. In Physics and Chemistry there were no fundamental changes that should be transferred (introduced) to curriculum. The elementary particle models related to the evolution of the universe and the new materials discovered are too advanced to be taught at the high school level. In Biology the situation may be slightly different, because the discoveries on human genome have some consequences on everyday life and they should be introduced in upper high school curriculum. But even a teacher who received a biology degree (diploma) before 30 years knows the genes formation dynamics and he does not essentially need additional help (special scientific courses, workshops or conferences) in order to understand the developments. Instead, he needs special practical mentoring and/or "coaching" on how to teach the new scientific discoveries in the classroom[2].

The last 30 years there is no simple enough (easy to understand) discovery in science, which should be introduced to curriculum

In the context of pedagogical (content) knowledge the scientific progress is much slower. It is known that different models and theories have been developed and strong arguments on different pedagogical issues have appeared. But the last 30 years no revolutionary wave changed our conceptions and fundamental assumptions in pedagogy and in human behaviour. Instead there are indications that things may change the next 30 years. The weak (in terms of reliability and validity) measuring technique based on "questionnaire" is going to be replaced by the newly discovered techniques of Neuroscience. The new apparatus based on Positron Emission Tomography and Magnetic Resonance seems to be strong enough to elucidate the brain functioning mechanism. The outputs of this kind of knowledge are necessary for future teachers. Therefore any curriculum planning of initial training should take into account the Neuroscience scientific foundation and results in the Neuronal Pedagogy framework.

The last 30 years there is no new discovery in pedagogy which should be applied in high school

The preceding analysis indicates that the dominant objective of continued training cannot be the scientific knowledge on the subject matter of the teacher or on scientific pedagogical issues, as long as initial training program is properly designed and fulfilled. Continuing training on scientific and pedagogical matters should be viewed as a smooth professional development, where each individual teacher discovers his weaknesses and tries to find the way to improve his corresponding competencies. The best procedure for that, seems to be the method of collaborative activities, which may be:

The continuing training method of peer collaborative activities

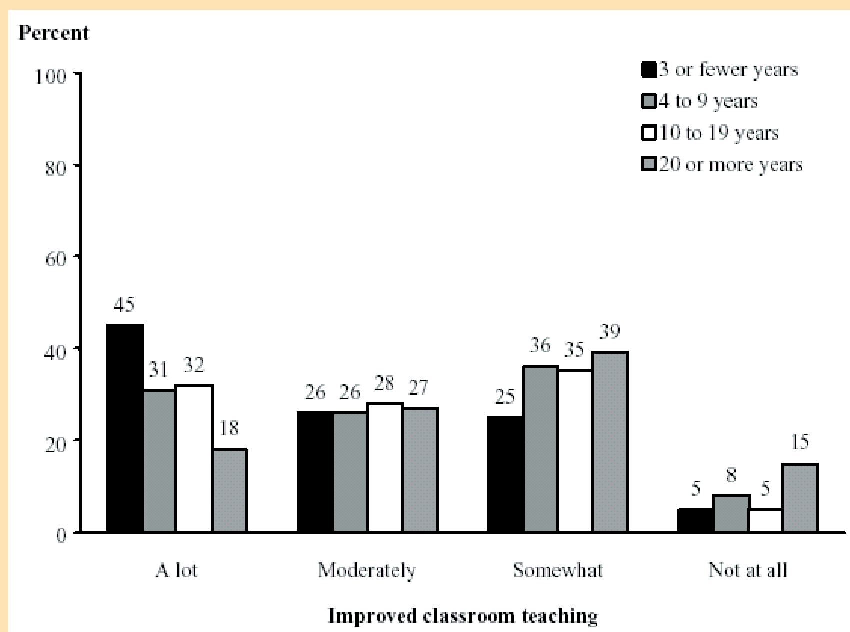
- A common meeting session for the science team teachers of the school;
- Regularly scheduled collaboration with other science teachers;
- Being mentored by another science teacher in a formal relation;
- Mentor another science teacher in a formal relation;
- Networking with other teachers outside his school and;
- Individual or collaborative research on a scientific or pedagogical topic of mutual interest.

Traditional methods (e.g. seminars, conferences) of improving professional development are generally criticized

Therefore traditional approaches to professional development (e.g., seminars, workshops, conferences) have been criticized for being relatively ineffective because they typically lack connection to the challenges teachers face in their classrooms. It has been noticed that the majority of lecturers in this kind of seminars are young post graduate students without teaching experience, where they present their PhD work. Research has shown that these training procedures are not likely to produce any long-lasting

Mentored teachers (experienced and non-experienced) improved their teaching performance

Figure A.2 *—Percent of full-time public school teachers indicating the extent to which being mentored improved their classroom teaching, by teaching experience: 1998*



SOURCE: U.S. Department of Education, National Center for Education Statistics, Fast Response Survey System, Teacher Survey on Professional Development and Training, 1998.

The innovations in the teacher competency of Instructional Technology have recently reached unpredictable ranges

It is generally recognized that the present times a great educational transition takes place in the context of the third category of competencies, the "Instructional Technology". Up to now these competencies were restricted to the appropriate use of the overhead projector and the TV apparatus, which are easily used and teachers were familiar with from their every day life. The rapid development of PC technology and the decrease of their prices made their educational use effective[4]. Especially the multimedia features of PCs may actually be combined with the new fast DSL Internet lines and the wireless (WI-FI) facilities in order to start the development of a completely computerized educational system. According to the preliminary results of the

SOCRATES program "METABOOK: Creation and Experimental Application of Multimedia Electronic Book in High School Physics", which is developed by a multinational collaboration coordinated by Hellenic Pedagogical Institute[5], in the new e-educational era the following technological changes will soon take place:

- All the schools will be connected with fast internet (DSL connections) and the school campus will be covered by properly placed "access points (hot spots)", which will permit wireless connection with the school server and through it the internet, the library, the administration and all the other school and state facilities (services).
- All the high school teachers and students will be provided notebooks with wireless facilities. Many European states have already started relative experimental programs.
- All the paper books will be gradually replaced by hypermedia ebooks, which will be downloaded through internet.

Figure A.3 *–Desirable ICT skills according to official recommendations for the initial training of all teachers (except specialist ICT teachers). Lower Secondary Education (ISCED 2), 2000/01.*

	B fr	B de	B nl	DK	D	EL	E	F	IRL	I	L	NL	A	P	FIN	S	UK (E, SC)	UK (W)
ACQUIRING SKILLS IN ICT FOR PERSONAL USE					●			●			●	●				○	●	●
Use of word-processing programmes					●			●			●	●				○	●	
Use of data-processing programmes					●			●			●	●				○	●	
Use of educational software programmes					●							●				○	●	
Use of the Internet					●			●				●					●	
ICT FOR TEACHING APPLICATIONS			●		●			●			●	●				●	●	●
Use of word-processing programmes					●			●				●				●	●	
Use of data-processing programmes					●			●				●				●	●	
Use of educational software programmes					●						●	●				●	●	
Use of the Internet					●			●			●	●					●	
NO RECOMMENDATIONS	●	●		●		(:)	◍		◍	●			●	◍	●			

	IS	LI	NO		BG	CZ	EE	CY	LV	LT	HU	MT	PL	RO	SI	SK
ACQUIRING SKILLS IN ICT FOR PERSONAL USE	●		●				●	●	●	●		●			●	
Use of word-processing programmes			●					●				●			●	
Use of data-processing programmes			○									●			●	
Use of educational software programmes			●									●			●	
Use of the Internet			●					●				●			●	
ICT FOR TEACHING APPLICATIONS	●		●				●	●	●	●		●			●	●
Use of word-processing programmes			●												●	
Use of data-processing programmes			○												●	
Use of educational software programmes			●					○				●			●	
Use of the Internet			●					●							●	
NO RECOMMENDATIONS		(:)			●	◍					◍		◍	◍		

● Compulsory ◍ Institutional autonomy ○ Optional

SOURCE: EURYDICE "Basic Indicators on the incorporation of ICT into European Education Systems" Annual Report 2000/01.

Very few European states have foreseen the ICT revolution and included in the curriculum of the teachers initial training

Large scale ICT continuing training of teachers is actually needed

FIGURE A.3 indicates that these deep changes in instruction technology have not been foreseen by all European states in order to incorporate ICT competencies in the objectives of their teachers' initial training systems. Therefore in many states the majority of teachers are not familiar with PCs and they have to be trained on in-service. Because of their technological background science teachers have an apparent advantage. Large scale in-service ICT training programs have been undertaken or are in progress in all European states (see WP-2, Greece). But we should take into account that "Even when teachers are provided with ample access to technology it may not be enough to simply train them how to use it. Teaching an educator how to use Netscape or conduct an Internet search only scratches the surface of what he or she needs to know in order to successfully utilize the Internet in the classroom. In many respects there is a pedagogical digital divide at play: numerous teachers have not been exposed to constructivist teaching styles or community-building professional development opportunities among their peers. In order for teachers to embrace the Internet effectively they must be given opportunities to experiment and explore, to interact with each other, to learn the benefits of collaboration. Professional development must be an ongoing activity among a community of educators rather than a sporadic attempt to introduce educators to new software tools"[6].

ICT continuing training should be considered in a general School Technology Plan

It is evident that the effective use of ICT in the new e-school era becomes the key issue of the teachers' professional development training, which should be seen as part of a more general School Technology Plan which would provide the necessary technocratic Action Plan for the ICT integration in the European educational systems. In the USA and the advanced European states (UK, Germany, France etc) these critical issues have been already discussed and the first steps have already been taken.

Incentives are always necessary in order to boost the training output

While a combination of collaborative activities and teachers/school evaluation seem to be generally accepted that they are the most effective training procedures, they need special incentives and substantial economic support to be initiated. The economic support could be a specified amount of the national subsidy/support to be directed to teachers professional development. This money could support peer to peer collaboration and the formation of teachers' networks. Another kind of incentives would be the foundation of national and/or district awards for high performance teachers.

Summary of the section

In this section we described continuing training in the category of professional development in the direction of improving teachers competencys. Statistical data show that the method of courses (used in basic studies) should be replaced by the collaborative activities, which are more effective for in-service training. We also emphasize that current continuing training should focus Instructional Technology, where a large knowledge gap for the teachers appears.

A.3 CURRICULUM REFORM SUPPORTING TRAINING

Every state government is trying to make the necessary educational reforms in order to respond to the smooth societal changes. The educational system has to anticipate these changes and to prepare the youth to face or to cope with the new challenges (e.g. chemical/biological dangers, European integration). This procedure has to follow well planned steps, because any mistake may lead to social and/or age gaps which may be the origin of social disturbances. These changes should take place in the general context of a periodic curriculum reform and not after a simple change of Minister. We think that a reasonable time period for reforming curriculum cannot be less than the natural cycle of primary and secondary education, which is the twelve (12) years for the majority of the European states. A larger period of 18 or 24 years may be more convenient. Each curriculum cycle should start at least after six (6) years of application and evaluation of the previous curriculum. Each curriculum reform has to follow some precise steps, which we will describe below, with special emphasis to continuing training.

The reforms of educational standards and curriculum have to be organized and implemented regularly (every 12 or 18 years) following well planned steps which have to include teachers training too

STEP 1: Immediately after the completion of the previous 12 or 18 years curriculum cycle, a national board (with 11 members) for the curriculum reform is appointed. After six months, the new board determines and make public the standards and priorities of the new curriculum in order to initiate a debate in the educational community (they should be uploaded raised to a curriculum dedicated web site). Special emphasis should be given to the interdisciplinary contemporary social issues (drugs, racial/religious discrimination etc), which have to be approached by all disciplines. These standards take their final form after a six months discussion period.

Four necessary steps of a curriculum reform

STEP 2: The curriculum working groups in the different disciplines are chosen after a general national proclamation. The task of these groups is to develop the new curriculum according the final standards and interdisciplinary guidelines of the Curriculum Board, which continues to overview the curriculum reform. The first draft of the curriculum is delivered after one year and it is discussed by the educational community one year more. The final form of the curriculum should be submitted and formally approved by the Government in the middle of the fourth year.

STEP 3: Every school disciplinary department should participate in the discussions of the educational standards and during the discussion of the curriculum itself, devoting some regular meetings of the teachers' group and possibly submitting a report which has to be uploaded in the dedicated curriculum web site. We think that these open discussions are very useful to teachers' professional development and they help the curriculum developing workgroups to find new teaching approaches of difficult issues. The primary objective of the science curriculum is to achieve fundamental scientific and technological literacy of the future citizens. Therefore any new science curriculum has to smoothly integrate the new scientific and technological achievements. The experience of in-service teachers could be very helpful in the procedure to trace the instructional routes of these scientific achievements. They also enhance the "morale" of the individual teacher, giving him a way to participate to the national mobilisation for the formation of the educational objectives.

Teachers' interventions to the regular curriculum reform through a public debate, published in the special curriculum web page consist an effective training procedure.

STEP 4: The next two years the new books are developed by the publishing companies, which will be presented to the teachers of the school disciplinary departments who will finally choose the appropriate book for their school. We think that collaborative activities that take place during this "book choice period" highly enhance professional development and the "morale" of teachers, which are the primary objectives of continuing training.

STEP 5: The first three (3) years of the application of the new curriculum and books, their evaluation has to be performed by a qualified workgroup which will be formed by the Curriculum Board after an appropriate proclamation. During this period, mentoring of young teachers from the senior ones should be stepped up. Special emphasis should be given to the ways of integration to each course of the interdisciplinary social issues like drugs, racial/religious discrimination etc, which have to be approached by all disciplines. Special training of all young teachers on these issues is indispensable because a bad approach may cause more harm than good. On the other hand, because of the technological changes, the role of the science teacher as peer mentor for Instructional Technology for all the other disciplines becomes eminent in a well structured school.

Summary of the section

Concluding the present section we want to point out that the regular curriculum reform may be used to provide the cause and the pace of professional training, which should be primarily done through teachers' peer collaborative activities. Outputs of these activities should be taken into account by the curriculum reform workgroups as explicit feedback information. All this public debate should be done public through a special curriculum web page. We think that special emphasis should be given to the interdisciplinary issues (e.g. drugs, European integration), which have to be approached by all disciplines.

A.4 CAREER DEVELOPMENT SUPPORTING TRAINING

Many teachers expect and look for career development

In the previous sections we essentially focused on the teacher professional development, which is directly related to the first two training categories of continuing training. But it is well known that many teachers, as individuals, are interested in getting higher rank school positions (e.g. principals), in getting better paid teaching specialisations (e.g. teachers of pupils of special needs, teachers of schools abroad), in getting a job in a higher educational level (e.g. a university position), or even completely changing profession.

For many teachers, to have their expectations fulfilled, new higher level training is needed. In many cases this training cannot be accomplished in the context of school educational system, because new professional degrees are necessary, which are administered by higher education institutions. The most effective way for a teacher to receive the necessary degree, which could give him the competencies to advance the job ladder, i.e. to become school principal/director, deputy principal or central and district educational cadre, is through the Long Distance (Open) Universities. Relevant courses (e.g. “School Administration”, “Management”) are offered by all Open Universities. It is for the interest of the state to train the educational personnel using Open and Distance Learning (ODL) because they continue to work. Therefore the fees of this kind of training of employed teachers should be paid by the state.

Trainings aiming to help teachers to get a higher rank school position

Science teachers may also be interested in receiving special university courses to acquire expertise on how to teach science to pupils of special needs. While this kind of courses may also be received through the ODL system, the necessary long practice period needs a sabbatical leave from the school. In any case specialized university departments should develop the programs and set the standards for this kind of specialized continuing training.

Training aiming to help teachers acquire specific teaching techniques (e.g. for pupils of special needs)

The fundamental objective of the European integration is the fusion of all the European cultures through the multicultural co-existence and mutual respect. Multinational and multicultural schools are going to play a crucial role in this long period. The teachers of these schools have to have special qualifications like speaking more than one language, and having studied in more than one European state. Therefore European Union helps and should continue to help teachers mobility and training in many European nations. These teachers are necessary to staff the multinational and multicultural schools, the number of which is expected to increase in the future.

Trainings aiming to help teachers to learn more than one European language

The training system should also take into account the scientific aspirations of a minority of teachers to take a PhD in their scientific field. In physical sciences the research is actually too advanced to be done by independent school teachers. It is usually done in large laboratories and very specialized university groups. The educational system should give the possibility to a very short number of teachers and after special examinations to take a sabbatical scientific research period for studies in specialized scientific laboratories.

Training for an advanced academic carrier

In this last section we analyse the third category of continuing, training which deals with the training needs of teachers interested in receiving an additional Higher Education degree which could permit them to develop their career. That is teachers who want to get higher rank school positions, teaching specializations, advanced scientific positions, etc.

Summary of the last section

Trainer

Participants of in-service training courses often claim that the presentations are too academic, too far off the school reality, that the content is not applicable. On the other hand, a professional education should also contain theoretical background, which means, for the profession of a science teacher, information on new developments in different areas of science as well as new results in educational research.

In order to avoid an unwanted bias to some extreme, the organization, as far as the content is concerned, should be done by a coherent team of experts from universities and schools. Ideal would be a group of persons with the following qualifications: school experience, experimental skills, deep knowledge of the subject, didactics of science and general pedagogy. This should ensure that trainers and lecturers are recruited from the same broad range of fields, too. Also a coordination with pre-service education should be aimed at.

Method

It is a didactic commonplace that teaching should be done by applying different methods. Reality shows a somewhat different picture, particularly when university teaching is concerned. In-service training has some advantage in this respect, since it is done mostly by various persons therefore exhibiting (hopefully) different teaching styles.

An important aspect with regard to the method should be that the participants of in-service training courses should be active on different levels. This activity is seen as a mental activity, a creation and production of ideas and material, an ongoing giving and taking of experiences, a processing and not just an input of information. Laboratory work, for example, is not an active method by itself.

Content

The content should be very strongly oriented on the needs of customers, i.e., the teachers. The EUPEN initiated a survey in which teachers of five European countries expressed their training needs. Results can be seen in EUPEN Series. Vol. 4 (Eds, H. Ferdinande, S. Pugliese Jona, H. Latal, Univ. Gent, 1999). One outcome from this survey, as well as from the discussions in the workshop, was that there is more interest in courses in science, less in didactics of science and least in general pedagogy.

It is important that teachers express their needs very clearly. But there are also implicit needs which are not so obvious to the customers themselves (e.g., the adaptation of a new teaching method); the organizers should be aware of this and offer and advertise also such kind of courses.

Organisation

It was already stated above that the planning of the programs of in-service training should be done by a team of experts of different fields. In the following, we will address the administrative organisation. The survey has shown that there is a big variation of how this is done in different countries. In some countries, there exist special institutions dedicated (at least partly) to in-service training - very often they are decentralized, operating on a regional level. In other countries, universities are given the duties to organize in-service training or they take over this task voluntarily, maybe to gain profit in some form. There exist also examples where in-service training is offered by private enterprises.

Money: It was a general consensus that participants should not have to pay for in-service training (a contribution to attractiveness). But the government should not take over the costs for the organization more or less anonymously, the amount should be visible. The money should be given directly to teachers. In paying the course, the participants should see how costly it is, therefore (maybe) getting a feeling that it has some value.

Examples were also given where industry is sponsoring in-service training; this could he a welcomed extra, but not the basis of a system.

Location: A training centre would facilitate the organisation of regular courses. But this should not preclude other possibilities, for example excursions to location of interest with regard to science. But also locations interesting for other reasons (skiing resort, beach,...) should be taken into consideration when the costs are manageable.

Time: A big issue in some countries concerns the question whether in-service training courses should take place during school time or in vacations. Arguments are the following ones:

School time - Yes. because in-service training is part of the job / No, because the time is taken from the

students who have a right for regular classes.
Vacation - Yes, because teachers have more vacations than other workers anyway / No, this would not help to attract participants.

Duration: A kind of mixture is seen as the most adequate system: starting from one-hour lectures (like a talk at university where a person introduces some topic including a short discussion), to half-a-day seminars (in the afternoon, the teacher can be at school all morning), to courses which last for several days up to a week (this gives the opportunity to work on one topic intensively and also allows for time to communicate among each other).
Another possibility would be to meet for some time (for example half a day) every week or once a month. This would support a continuous work on one topic, where the teacher could also practice the new ideas, proposals, material with her/his school classes.

Distance training: In-service training is maybe the most appropriate place for education at distance. It implies improvements in several aspects (independence of time and location, fast information exchange with the trainer and among the participants) and should be pursued with effort.

Conclusions
An enhancement of attractiveness is an important step towards successful in-service training programs. A bonus system, an offer closer to the needs of teachers, a user-friendly administration could bring an impetus in this direction. Teams of experts should develop more coherent and systematic programs. The participants should take a more active role. Research projects on topics of in-service training should be initiated and addressed more often at international conferences.

1.3.3 Project's Survey in Italy

The Italian contribution is a synergic combination of work done by the two Italian groups involved in STTAE. It reports about an investigation performed among in-service teachers and prospective teachers of the Teacher Education Graduate Schools (TEGS) in the Universities of Palermo and Napoli.

Survey of Napoli University
An open-ended questionnaire about teachers' competencies was administered to a group of 42 Trainee Teachers (TT), attending the two-years TEGS in Napoli during the course of "Didactics of Science II". This questionnaire had been structured in a way to obtain specific information on TTs' ideas about competencies for teaching Science.
Students of this course were at their second year ("sophomore"), in the TEGS, and at the end of their training paths which enables them to teach both Mathematics and Science. They had attended most of the classes in the "Pedagogy Area" and the "Disciplinary Area". The theme of competencies had been discussed in some courses of the "Pedagogy Area", and a general definition had been given, independent from the discipline: " a general cognitive capability with reflexive characteristics". According to this definition, the competencies are concerned with general cognitive skills; are independent from specific tasks, and involve basically reflexive mental processes.
At the level of each discipline in the "General Didactics" class (25 hours) and in "Laboratory of General Didactic" (20 hours), the teachers in the courses focused on specific competencies needed in each disciplinary area. During the laboratory activities, the TT were asked to write about the competencies related to their specific subject matter.

Below follows the outline of the survey in the University of Palermo.

Survey of Palermo University
The investigation developed at the TEGS of Palermo, involved two different groups of science teachers:

a) a group of 10 Expert Science Teachers (ESTs) engaged as supervisors of the apprenticeship activities carried out by the TEGS.

b) two groups of Trainee Teachers (TTs): -the first one composed of 38 "freshmen" TTs (at the start of their two year course); -the second one composed of 18 "sophomore" TTs (prospective teachers in the areas of science, math, biology and earth sciences) that had been selected in order to participate in " Comenius European Mobility" and that had almost completed their training course.

a) The investigation procedure among the Expert Science Teachers (ESTs)

The ESTs participated in a two afternoon workshop devoted to reflecting about the new tasks and responsibilities actually required of science teachers and how they can be translated in the new competencies that have to characterise the new teacher role.

A researcher (expert in cognitive science) introduced the topic by characterising the workshop as a research workshop and describing the instrument of metareflection (Schön, 1988) as the main instrument to be used. Teachers have been requested to reflect on their successful and unsuccessful teaching experiences in order to come up with a catalogue of competencies that they have been requested to display in their practical teaching experiences.

A working definition of competency has been negotiated as a set of behaviours involving knowledge, abilities, cognition, and all that is necessary in order to identify problematic situations, to research possible solutions and to properly try (test) them.
The workshop has been structured in different phases:

I. In the first phase teachers have been requested to point out a first classification of areas of competencies, each one involving a well defined aspect/characteristic of the teacher professional behaviour. In particular, teachers have been invited to analyse responsibilities, behaviours and abilities actually required of teachers, in order to develop an educational process aimed towards effective student learning. The researcher reported different results of studiess (Belair, 1997) that identified 9 areas of competencies, different but correlated, related to school objectives and aims that can define the "profile" of the new "Professional Teacher". They are defined as fields of Transversal Competencies (transversal to all the disciplinary teaching areas). ESTs have been requested to identify, for each field some descriptors (operative behaviours that are supposed as external manifestation of the competencies).

II. During the second phase, ESTs have been requested to identify and factorise the competency areas in detailed individual competencies and/or knowledge that can be relevant in defining a profile of the "Science Teacher".

III. The last phase involved a whole group discussion in order to negotiate an outcome document describing the first categorization in competency areas as well as their factorisation.

During the first two phases teachers worked in groups of two, discussing their experiences and outlining the behaviours and abilities they have been requested to exploit. The five groups have been guided by the researcher that, sometimes, introduced small periods of whole group discussion in order to avoid digressions of some group toward very particular details.
b) The investigation procedure among the Trainee Teachers (TTs)

The two groups of TTs have been requested to answer the open-ended questionnaire. Before the questionnaire administration, a class discussion has been performed in order to clarify the meaning of the word "competency". Moreover, some examples of target competencies have been suggested through the description of events/contexts, where a target competency could have be shown, exploited and/or be responsible of the success or failure of the event.

1.3.4. Project's Survey in Belgium

The Belgian team suggested that the possibility to compare results of the inquiry at the international level should be very interesting. Their research was based on the survey developed by the group from the Universities of Palermo and Naples. Their questionnaire (see Appendix A.5) is a translation of the Italian one and their methodology is as close as possible to the one used in the reference survey.

The investigation has been performed at the Laboratoire de Pédagogie des Sciences, University of Louvain. 23 science teachers from the upper secondary schools (French Community) with different expertise and 15 science trainee teachers were asked to reply to the questionnaire, not simultaneously.

1.3.5 Project's Survey in Romania

It is obvious that an essential condition to assure the efficiency in the science learning process is the system of competencies of science teachers. To gain, to model, to develop the competencies means a continuous process, a long term process, which begins during teachers' pre-service training and ends during in-service training and, moreover, during teachers' continuous self-development.

The investigations of the Romanian team about the setting up and the development of the science teachers' system of competencies were organized in two snapshots/ parts:

A) The context of a focus-group

B) The context of an inquiry, based on a questionnaire.

The focus group was organized with 24 chemistry mentors, at the beginning of January 2004, in Cluj-Napoca city. The participants were asked to engage themselves in discussions about those competencies mentors aim at future chemistry teachers. Thus, this focus group tried to answer the following questions, by using their personal didactical experience and the data offered by the literature:

1. How can we define and operationalize the concept of competency in the case of chemistry teachers?
2. What taxonomy of competencies is adequate and operational for chemistry teachers' training?

With a view to elaborate an inventory of the most important competencies of science teachers, the Romanian team has used as a research method the inquiry and as a research tool a relative questionnaire. Their work focused on a sample consisting of 58 subjects selected randomly: 40 chemistry teachers (selected randomly from a large group of teachers present in a training activity), and 18 students (selected randomly from the group of students, section Chemistry and Chemistry-Science, year IV, Faculty of Chemistry and Chemical Engineering, "Babeş-Bolyai" University of Cluj-Napoca). The questionnaire was composed of the same type of items, included in the open-ended questions.

1.3.6 Project's Survey in Greece

In order to propose the basic principles and standards of a training framework for science teachers, the Greek group investigated the teachers themselves. During this phase of the project the University of Athens team performed a survey among Greek science teachers in order to determine their current needs.

The data acquisition instrument was a questionnaire with two open ended questions. The sample of the survey was 30 Greek Science Teachers. The Greek science teachers' questionnaires were distributed and collected within June and September 2003.

1.3.7 Project's Survey in Germany

A questionnaire similar to the Italian one, was administered to 50 biology teachers in the Ludwigsburg University.

1.3.8 Project's Survey in France

The goal of this survey is not to compare different samples of subjects involved in science teachers training. The conceptions related to these competencies are not the same if we interview different kinds of experts:

- Science University teachers are mainly focused on the scientific contents

- Science Inspectors are also focused on the general pedagogy

- IUFM science teachers are more focused on their science contents and on Science Education (Didactics of their Science)

- Researchers are mainly focused on their own research discipline.

In consequence, the French team decided to ask only some "experts", in research (didactics of science and chemistry, or biology and environment) and in science teachers training. Each expert answered either immediately or by e-mail.

1.4 Survey analysis

1.4.1 The proposed categorization of competencies and method of analysis

The reported investigations produced a categorization of competencies which will be presented in the following sections. The data comes from different samples: freshmen Teacher Trainee (TT) (questionnaire); sophomore TT (questionnaire); expert teachers and experts in disciplinary didactics and teacher education.

The data showed some general characteristics as well as differences.

The competencies' categories take into account the reported literature and keep in mind the situation of the science teacher education in each partner country.

As a result, the profile of the science teacher is defined through two broad categories defined as General Characteristics and Professional Competencies:

- General Characteristics are, in many cases, independent from subject or disciplinary content. They refer to the teacher general knowledge, verbal knowledge and cultural level. Teacher beliefs and attitudes about teaching and learning play also a relevant role. In fact, teachers may have varying levels of motivation to teach and be motivated by goals not entirely consistent with increased student learning. A variety of influences, both internal and external to the teacher, can motivate the teachers both toward and away from what they believe to be good instruction.

Professional Competencies, that can be shaped and altered by professional development activities and are referred to the subject and related skills.

In the following, the focus is only on the Professional Competencies since the aim of this first work package (WP1) is to find the specific competencies for a Science Teacher in order to link them to the local training programs curricula (WP2) and to, later, envisage examples of "good practice" in the WP3.

1.4.2 Method of analysis

In order to allow the development of a common list of competencies based on the data from the teachers of all participating countries, the analysis was carried out in several steps:

1. An initial independent analysis was performed by each country and is presented in the following sections.
2. For each country, the competencies from step 1 were organized according to the three main categories suggested by Shulman: SMK (subject matter knowledge), PK (pedagogical knowledge) and PCK (pedagogical content knowledge). In some cases, e.g. the list of competencies from Italy, this step was already carried out in the initial analysis by the country.
3. Each competency was judged as low (L), medium (M) or high (H) on the basis of its relative strength. For each country this analysis is described in the end of the relevant sections.
4. For each main category, all the associated competencies found by the various countries were accumulated and categorized into subcategories enabling the creation of a common list of competencies.
5. The integration of results from the different countries based on the teachers' responses, and enriched by experts' views lead to the list of common competencies described in Table 1.1.

Table 1.1: *Teachers, students and experts contributions to the Desired Competences*

Teachers and Students Contribution	Experts Contribution
Subject Matter Knowledge (SMK)	
SMK1: Competencies related to subject matter/content knowledge	
• Scientific knowledge • School content knowledge • Knowledge of unifying theories in Science • The ability to operate with correct information	
SMK2: Competencies related to the nature of science including inquiry knowledge and skills	
• Knowledge about the discipline • Knowledge of models • Connection of theory and practice • Knowledge of ethical approaches • Attitudes befitting a scientific ethos • History and Philosophy of Science	• Modeling • Inquiry knowledge and skills • Epistemology
SMK3: Competencies in framing a discipline in a multidisciplinary scenario	
• Applications of Science in daily life • The discipline in a multidisciplinary scenario • Articulation with other disciplines • Link with everyday life sciences	• Link with science, technology and society in a personal context • Link with mathematics
SMK4: Competencies in knowledge of contemporary science	
• Adaptation in new contexts • Knowledge of contemporary science	
Pedagogical Knowledge (PK)	
PK5: Competencies in mastering and implementing a variety of instructional strategies	
• Familiar with learning theories • Knowledge of relationships between teaching strategies and learning practices • Varied teaching practices (or methods) • Professional tools for classroom and curriculum managing • Continuous and formative assessment • Learning groups • Motivation, human relationship • Valorization of the constructivist and socio-constructivist paradigm • Monitoring learning processes and offering continuously cognitive and affective feedback • Creating a stimulative climate, • Encouraging free expression of the pupils • Respecting the pupils, their intellectual particularities, expectances, difficulties they encounter, their educational needs, their preconceptions (empathy) • Establishing a real communication link between the teacher and the pupil • Willingness to offer supplementary assistance, if necessary • Adopting a flexible and creative behavior in order to develop the creativity of the pupils • Being able to use technical equipment	• Competencies related to assessing conceptual change • Criteria based summative evaluation of students • Relating formative to summative evaluation

PK6: Competencies in sustaining autonomous life-long learning	
• Being flexible and able for cooperation • Being a team player • Autonomous work	• Life-long learning • Learning skills, e.g.critical analysis of science popularization; using various resources such as internet, library, etc.
PK7: Competencies related to self-reflection and meta-cognition	
• Adapting a reflexive behavior (metacognition) • Self-assessment • Adapting critical and self-attitude • Studying his/her own practice	
Pedagogical Content Knowledge (PCK)	
PCK8: Competencies related to the area of teaching/learning processes within the domain	
• Knowledge of educational methodology and science education • Representations of the content suitable for teaching • Pedagogical methods and tools scaffolding learning • Imparting of contents • Implementation of knowledge • Offering examples and pictures which are adequate and accessible • Presenting alternative explanations	• Adapting the scientific language to students
PCK9: Competencies in using laboratories, experiments, inquiry, projects, modeling and outdoor activities to build understanding and skills of students	
• Assuring the links between theory and practice • Developing practical abilities • Laboratory skills • Imparting close-to-practice knowledge • Doing age adequate experiments • Going on field trips	• Didactics of problem – based or project-based learning
PCK10: Competencies addressing students' common sense knowledge and learning difficulties	
• Being aware of students' common-sense knowledge • Being aware of students' learning difficulties	• Being Familiar with research about students' common sense knowledge and learning difficulties • Identifying epistemological obstacles
PCK11: Competencies in the use of ICTs	
• Using ICT • Integrating the multimedia resources in the activities • Creating material resources, to use educational software	
PCK12: Competencies in the knowledge, planning and use of curricular materials	
• Producing educational materials • Familiarizing with science curriculum • Planning lessons	• Knowledge and use of various curricular materials • Designing teaching-learning sequences to learn scientific concepts and/ or processes (laboratories) • Defining goals and learning opportunities for students

1.5 General comparisons and conclusions

1.5.1 Integrating the results: the common list of competencies:

In this section we compare the answers given by science teachers, prospective teachers and experts in science teaching in the participating countries and draw some general conclusions.

These competencies refer to a teacher's general knowledge, verbal knowledge and cultural level, or, in other cases, to his/her beliefs and attitudes about teaching and learning.

In order to find the common competencies we merged the lists of the competencies mentioned by teachers in each country within each of the three main categories following Shulman (1986 a): subject matter knowledge (SMK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) (see Table 1.1). For each main category, all the associated competencies in the list were further sorted into subcategories. As can be seen, on the one hand, there are some redundancies in the list since the statements were collected in different countries. On the other hand, the list associated with each competency provides a rich description. This characterization can be further enriched by considering experts' views. The Table 1.1 describes the results emerging from this analysis, deleting the redundancies and adding ideas of experts that were not mentioned by the teachers.

The following list summarizes the titles of the common competencies.

Subject Matter Knowledge (SMK)

1. Competencies related to subject matter/content knowledge (SMK1)

2. Competencies related to the nature of science (NOS) including inquiry knowledge and skills (SMK2)

3. Competencies in framing a discipline in a multidisciplinary scenario including STSP (Science, Technology, Society in a Personal context) and mathematics (SMK3)

4. Competencies in knowledge of contemporary science (SMK4)

Pedagogical Knowledge (PK)

5. Competencies in mastering and implementing a variety of (especially student-centered) instructional strategies and assessments attending to individual differences (PK5)

6. Competencies in sustaining autonomous lifelong learning (PK6)

7. Competencies related to self-reflection and metacognition (PK7)

Pedagogical Content Knowledge (PCK)

8. Competencies related to the area of teaching/learning processes within the domain (PCK8)

9. Competencies in using laboratories, experiments, inquiry, projects, modeling and outdoor activities to build understanding and skills of students (PCK9)

10. Competen cies in addressing students' common sense knowledge and learning difficulties (PCK10)

11. Competencies in the use of ICTs (PCK11)

12. Competencies in the knowledge, planning and use of curricular materials (PCK12)

Below, are presented some conclusions regarding the above mentioned competencies that came out as common from the surveys of each of the participants' institutions. These conclusions are based on the results of the surveys with teachers, experts and the literature review. The relative emphasis of the competencies in each of the countries that were expressed by the teachers, can be found in Table 1.2. A summary of the overall strength of each competency in the different countries, which have adopted the proposed categorization, is presented. The strenght is labeled with H (high importance), M (medium importance) and L(Low importance) based on the surveys performed in each country. Taking into account that 5 countries have performed the relevant survey we consider as significant Competencies that have been labeled with H in at least 3 countries.

Table 1.2: *A summary of the overall strength of each competency in the different countries, which have adopted the proposed categorization. The strenght is labeled with H (high importance), M (medium importance) and L(Low importance) based on the surveys performed in each country. Taking into account that 5 countries have performed the relevant survey we consider as significant Competencies that have been labeled with H in at least 3 countries.*

	SMK1	SMK2	SMK3	SMK4	PK5	PK6	PK7	PCK8	PCK9	PCK10	PCK11	PCK12
	H	H	H	—	H	—	—	H	—	M	—	—
	M	H	H	—	L	—	L	H	M	—	H	—
	H	—	—	H	H	L	H	H	H	—	H	—
	H	H	L	H	H	L	H	H	H	—	H	L
	—	H	—	H	H	H	—	H	H	—	—	L
	▲	▲	—	▲	▲	▼	▼	▲	▲	—	▲	▼

1.5.2 Conclusions

The conclusions are presented according to the three main categories of competencies.

1.5.3 Subject matter knowledge (SMK)

Competencies related to subject matter/content knowledge (SMK1)

The competencies related to subject matter knowledge are recognized by all the participating teachers in this survey. It is unquestionable for them that every science teacher should have a rich understanding of the subject they teach and appreciate how knowledge is created and organized in their subject.

A teacher training program should be centered on the acquisition of the competencies related to this area. Yet, as the numerous lists of competencies show, acquiring subject matter knowledge alone does not produce effective teaching.

Competencies related to the nature of science (NOS) including inquiry knowledge and skills (SMK2)

Understanding of the nature of science, namely the goals, values and assumptions inherent in the development and interpretations of scienctific knowledge (Lederman, 1992), as well as inquiry knowledge and skills are important objectives of science education. The importance of knowledge about the nature of science is acknowledged by most cozuntries. However, the competency of knowing history, philosophy and epistemology seems to be generally low in the minds of many of the participating teachers, although experts in science teacher training and didactics are convinced in their usefulness for teaching and learning science.

Significant indicators for identifying as useful such training in a science teacher education program are presented only by the surveys in Italy, Greece and France. In the other countries, the participants do not seem to realize the benefit of it and do not regard it major competency. This difference could be linked with whether historical and philosophical aspects of science subject matter have been included in the curricula of the participating countries.

Science teachers should acquire not only knowledge about inquiry, but also practice it, in order to acquire inquiry skills. Such experience will enable them to scaffold their students in inquiry learning. There is little doubt that science teachers who know something of the history and philosophy of their subject can enliven their class room presentations. If teachers are acquainted with the rich history of their subject, then the quality of teaching and learning may be improved. Concepts such as law, evidence, scientific method, causation, objectivity, experiment, explanation, are going to appear in many science classrooms. This requires familiarity and competency in history and philosophy of science and thus a science teacher education program should prepare a teacher to engage students with historical, and broadly cultural, questions.

Competencies in framing a discipline in a multidisciplinary scenario (SMK3)

A science teacher should know how to relate science with other subjects and to frame phenomena in a multidisciplinary context. Science teachers who teach one discipline should be able to relate its content to relevant content in other disciplines (interdisciplinarity) or in disciplines such as mathematics or technology (multi-disciplinarity) and relate also to societal and personal aspects. Phenomena by their nature involve various disciplines: so a teacher should be able to search for explanations involving the single discipline and at same time frame it in a multidisciplinary scenario. This competency is mostly acknowledged by teachers in Greece, Italy and Belgium.

Therefore, a science teacher training program should offer trainees the knowledge and awareness of the relationships between disciplines. This competency cannot be accomplished in the framework of a strict disciplinary-separate training program. Furthermore, prospective teachers should be provided with instruction that facilitates the identification and development of concepts that unify the traditional science disciplines. In such a training there should be included specific learning opportunities and instruction that would help prospective teachers to develop such interrelationships.

Competencies in knowledge of contemporary science (SMK4)

Teachers' opinions about the usefulness of knowing contemporary science varies and seems to be high in the minds of the Greek, Romanian and German participants in this survey. Generally, in most of the participating countries, "modern" science topics are relegated to the last year of secondary school. So, their usefulness more probably reflects the teachers' need to broaden their general background, in part because of personal interest and in part in order to be able to interact more efficiently with interested students.

Therefore, sufficient scientific academic preparation in these topics should perhaps be offered in a science teacher education program.

1.5.4 Pedagogical Knowledge (PK)

Competencies in mastering and implementing a variety of (especially student-centered) instructional strategies and assessments attending to individual differences (PK5)

Methodologies for science teaching are abundant. Cooperative learning models, concept mapping, model building, role playing, games, simulations, analyzing case studies, problem solving, inquiry strategies, field trips, electronic media presentations, and reflective self evaluation are examples.

Experienced science teachers must be able to exercise the professional judgment needed to match learning opportunities to a variety of existing conceptual frameworks and learning styles. They must provide learning opportunities which are flexible, diverse, challenging and accessible which stimulate students' curiosity about the world around them. A teacher who offers diverse learning opportunities makes it more likely that each student will learn science at some level.

A teacher training program, therefore, should allow science teachers to acquire competencies in using available instructional models. Prospective teachers should be provided with methods to assess the needs of classes and individual students, and should show an ability to choose from among a variety of activities and strategies to meet those needs. Teachers should learn and practice how to communicate knowledge to their students, in order to take into account their different learning styles, reasoning strategies and previous ideas. This involves the knowledge of different teaching strategies coherent with the students' representations.

Competencies in sustaining autonomous lifelong learning (PK6)

Except for the German participants, there were few responses on competencies related to the area of teachers' self-learning after they receive their training. Associated with that, are the mentioned competencies for the general use of bibliography, books, libraries and the skills for a critical analysis of documents of science popularisation (in journals, magazines, books, radio, TV, etc.).

A science teacher training program should provide opportunities to future teachers to use the scientific literature, media, and technology (e.g. Internet) to broaden their knowledge. During their education, science teachers must also be allowed to develop understanding of the logical reasoning that is demonstrated in research papers and how a specific piece or research adds to the accumulated knowledge of science. Such knowledge should also support teachers in using a variety of technological tools, such as computerized databases.

Competencies related to self-reflection and meta-cognition (PK7)

In this survey, except for the Romanian participants, there were few replies concerning the competencies related to the process of assessing and monitoring one's own thinking in order to develop self regulation and learning. Self-regulation is the ability to use and develop knowledge, skills and attitudes acquired in one context in another context.
A teacher training program should provide prospective teachers with the knowledge and awareness of their own thinking processes. For instance,

it should encourage more active learning processes such as group interactions, cooperative learning, learning in authentic environments, and practices such as self-assessment and peer assessment. Or, in addition, it should instruct prospective teachers to develop checklists that they can use to monitor their own meta-cognitive control or to promote reflection by the development of their personal portfolio.

1.5.5 Pedagogical Content Knowledge (PCK)

Competencies related to the area of teaching/learning processes within the domain (PCK8)

Science teaching experts and many teachers participating in the questionnaires agree that attention towards disciplinary contents seems no longer to be the only aim of science education or the only focus of the teachers' work. Science teaching cannot continue to be viewed as the simple pseudo-academic transfer of contents that used to be. Science teachers not only have to know and understand subject matter content, but also how to teach that content effectively; knowing how to organize, sequence and present the content and transform it into forms that "are more accessible" to students.

Therefore, a teacher training program apart from offering the necessary disciplinary or content knowledge, should offer a science teacher the ways and opportunity to learn about transforming this knowledge into pedagogical content knowledge. The competencies related with the above are acknowledged by the majority of the participants in this survey, and, as many experts' studies in science education have demonstrated, should be recognized as such.

Appropriate teacher education—as the survey of the Italian team has shown, by focusing on the diversity of the answers between "freshmen" and "sophomores"— is the key process for the science teachers to become aware of how necessary is the integration of competencies about disciplinary content and pedagogy in order to be able to use them "to transform teaching processes into creation and management of effective and motivating teaching/learning environments".

Competencies in using laboratories, experiments, inquiry, projects, modeling and outdoor activities to build understanding and skills of students (PCK9)

The laboratory skills of an ideal science teacher and his competency in the use of experiments and labs are mentioned by the majority of the participants in this survey. In addition to practical work, participants also underline the importance of exploring theoretical ideas through modeling enabled by computerized environments. competency In recent years the learning environments considered in formal science teaching have expanded to include problem- and project-based learning as well as learning in informal settings. Except for some responses on competencies related to the area of informal learning in the Germany survey ("going on field trips" –section 3.7), there were no indications for identifying as useful such skills in the minds of the majority of the participating science teachers.
It is therefore unquestionable that all science teachers should be trained in not only "doing" each of the experiments in the science curriculum but also in guiding discussions with children about the implications of the results of these experiments.

This could be facilitated if science teachers receive special training programs. Learning from experiments and laboratory, from projects, from modeling or from other modes of inquiry, is far from trivial, as various studies on the various forms of inquiry have shown. Therefore, prospective science teachers need to experience science learning through the different forms of inquiry and laboratory experiences. Through their training, teachers could treat experiments and lab work not only as "confirmatory" exercises.

Another aspect of the same discussion, also mentioned in this survey, is the technical support and training that all science teachers should receive concerning lab safety issues and resolving technical problems that they or their students could encounter. Science education programs should pay more attention into the learning of science in social and technological context, such as field trips, arranged visits to museums or to industries and institutions that engage in scientific or technological research in their field, etc. A science teacher education program should help teachers to understand the process of scientific fieldwork, to learn about the use of museum resources in the classroom, for example by participating in hands-on activities and explorations using museum objects and specimens. It could also train them in planning various activities of their own for use with their students such as field investigations, active inquiry activities and so on.

Competencies in addressing students' common-sense knowledge and learning difficulties (PCK10)

Science Education research has studied many of these difficulties and the underlying reasoning strategies. Many are related to conflicts between common-sense knowledge and scientific knowledge. A science teacher should be able to understand students' difficulties with respect to the objectives targeted by learning materials and make appropriate revisions in the sequence of learning activities as needed to increase the likelihood of obtaining the stated objectives. These aspects were mentioned by experts, but only the Italian teachers as they progressed in their training realized their importance.

Thus, a science teacher training program should provide prospective teachers with instruction that facilitates the identification of common student misconceptions in science disciplines, their source, and other learning obstacles and difficulties. Teachers aware of these difficulties and, during their education have received relevant instruction, are more likely to have the ability to choose among a variety of activities and strategies in their own classroom in order to facilitate student learning. Moreover, if teachers-to-be work with students and do a lot of practice work during their training in a variety of authentic and diverse settings, they can more easily acquire the desired competencies.

Competencies in the use of ICTs and Ets (PCK11)

Most of the teachers and experts participating in the survey consider that a science teacher should have sound competencies in the use of ICTs (Information and Communication Technologies) and Ets (Educational Technologies) and in their implementation in subject areas and infusion across the curriculum. They think that those who teach science should incorporate computers, multimedia, and other technology into instruction since these tools can enrich a classroom environment and enhance learning, when used both as cognitive and as laboratory tools. A teacher with such competencies, though, not only knows how to use ICT and ET tools, but understands how and when the use of these educational, information and communication technologies are appropriate for specific purposes in science education.

Nowadays, in many European countries schools are being equipped with hardware and software resources. However, many science teachers are not yet confident in using these technologies. Possibly, due to lack of adequate training, many of them tend to resist and fear the incorporation of educational technologies into their classroom. Teachers in many of the participating countries are given short —if any— courses on how certain software packages work, but are not taught how to integrate the use of ICT and ET in classroom.

Many of the participants in this survey recognize the use of ICTs as a competency for a science teacher, and this can be interpreted as revealing their need to become confident in the use of learning technologies by becoming competent users. This can happen only when science teachers receive appropriate training and, through a suitable training program, realize the relevance of the learning technology, how it will enrich their teaching and how their students could benefit from its use.

Competencies in the knowledge, planning and use of curricular materials (PCK12)

The need for delivering content in a coherent, cumulative, organized and balanced way is a need that teachers realize only when they start to work in school. Therefore, it is not surprising that prospective teachers hardly mentioned this competency. It was, however, mentioned by the experts. The transition from desired goals, to actual activities that lead to their realization is a complex skill that requires learning. Furthermore, it is imperative that teachers would be acquainted with existing relevant curricular resources, and would be able to evaluate how they can contribute to them. Teachers should also learn how to customize existing materials to their needs.

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F1
F2

Report of Work Package 2

2 Towards an Effective Science Teacher's Profile

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Introduction

The first report of this project (Report of WP1: The Science Teachers' Competencies) aimed at defining desired competencies for secondary science teachers. These desired competencies were identified by practicing science teachers, pre-service science teachers and policy makers. Each of these competencies can serve as a desired goal for pre-service training programs. What pre-service training programs exist? How are they similar and different? What problems do they raise? What are Good Practices address these problems and embody the desired competencies? Based on these competencies and Good Practices, what is the profile the effective science teacher?

In this report (WP2: Towards an Effective Science Teacher's Profile), the research team of the project will try to answer these questions. In particular, we will attempt to demonstrate the pathway towards the generation of a common profile of the effective science teacher across Europe, as an important step towards creating strategies and programs that will produce effective science teachers. First, we describe the different secondary school science pre-service teacher training systems within the partner countries (Greece, Germany, France, Belgium, Romania and Italy), compare them and identify common problems.

Then, we bring together the data regarding the desired competencies, the pre-service training programs in order to generate what we call "the Profile of the Effective Science Teacher". We proceed by analyzing this profile, to identify components which relate to the desired competencies as well as other components that do not.

Finally, we describe the proposed a series of Examples of Good Practices (EGPs) which can be part of pre-service programs that will develop the desired competencies. These descriptions are presented as "Good Practice Pattern Cards". Identifying of Examples of Good Practice of teacher preparation around Europe, and finding ways to encourage others to multiple their success, are basic to reaching a common training framework for science teachers across Europe. The EGPs presented in this report will serve as the basis for the cross-cultural experiment presented in the following report (WP3: Exemplary Models of Science Teacher Preparation Programs). These EGPs will be treated as case studies in the framework of the survey of the project. The portfolio assessment method was adopted to evaluate the implementation of the EGPs in the different cases.

2.1 Comparison of Secondary Science Teachers Training Systems

The profile of an effective science teacher cannot be proposed without a consideration of existing teacher training programs. For this reason, the partners of WP2 conducted national surveys of such programs. In this report, we present pre-service science teacher programs, compare them and present common problems.to lead to formulate problems and to propose possible solutions. Indeed, we think that problems and solutions depend widely upon the context in which they have been encountered.

In the following section, we will report the results of the comparison between partners' presentations in order to design a profile of an effective science teacher. We will focus on the upper secondary school teacher education. This comparison could also be helpful for the implementation of the Bologna process and the harmonization of Science Teacher Education Across Europe.

The comparison will focus on the diploma required for teaching in secondary schools, the science majors, the pedagogical and didactical approaches, the goals of science teaching education and problems reported by science teacher educators linked with examples of good practices which could be considered as solutions to these problems.

2.1.1 Diploma requirements to teach science in secondary schools

After conducting surveys and comparisons of the systems of the participating countries we have identified three main approaches in science teacher education:

- Specialization in science teaching after a science university degree. In this approach, science teachers receive two distinct diplomas (e.g., Belgium for upper secondary schools; in Italy since 1999, pre-service teachers attend a two-year specialization course).
- Integration of science and pedagogical studies into one diploma (e.g., Belgium for lower secondary schools; Germany and Romania).
- No specialization in science teaching (e.g. Greece)

  In some countries (e.g. Greece, Italy), potential teachers have to undergo a specific assesment process that is performed at National level in order to accede to the profession.

2.1.2 Science majors

A science major represents an area of science study. The majors correspond to the groups of scientific disciplines that are actually taught in secondary schools..

In Italy, there are two main science majors :

- Physics Informatics and Mathematics,
- Natural Sciences : Biology, Botany, Earth science and Chemistry.

In France, there are three main science majors:

- Physics and chemistry (united in one discipline)
- Natural Sciences : Biology and Geology (called Life and Earth Sciences : SVT)

- Mathematics

In other countries (Belgium, Germany and Greece), science majors are almost the same: when students get a degree in one discipline, they are allowed to teach another one. Nevertheless, this is not the case in Romania, where students who receive a degree in one discipline are not allowed to teach another one; in this particular context, the only way to teach in more than one discipline is to get a degree in each discipline.

2.1.3 Pedagogical and didactical approaches

Pre-service education for science teachers includes approaches to pedagogy (how to teach students in the broader sense) and didactics (how to teach specific topics). In-service education is mainly based in a variety of different pedagogical approaches that are mainly implemented during workshops, seminars, conferences, summer schools and on-line, distance learning cources.

Nevertheless, there is a great variety in the amount of time devoted to these approaches, in the participating countries (e.g. from 60h (Belgium) to 379h (France)).

2.1.4 Goals of science teacher education

The goals of the pre-service programs of the participating countries are very close to each another. The following list comes from Belgium, but the goals of many of the other countries are quite similar:.

1. Being informed about his/her role inside the school institution and exercising the profession as it is defined by legal texts.
2. Mobilizing knowledge in social sciences to accurately interpret the real classroom situation to better adapt to the students.
3. Mastering disciplinary and interdisciplinary knowledge and justifying pedagogical action.
4. Being able to conceive, assess, evaluate and regulate teaching strategies.
5. Being able to plan, manage and evaluate teaching situations.
6. Showing his/her general knowledge in order to engage the interest of students in the cultural world.
7. Having developed relational competencies linked to the professional demands.
8. Being able to measure the ethical outcomes linked with his/her everyday practices.
9. Being critical and autonomous towards past and future scientific knowledge.
10. Being able to work in a team inside the school.
11. Being able to study his/her own practice.
12. Maintaining efficient partnerships with the institution, colleagues and the students' parents.
13. Organizing continuing education.

2.1.5 Problems

I. In the different countries, a **lack or insufficient knowledge of the discipline(s)** which are supposed to be addressed in the teaching process has been reported. Reasons for this could be, at least for Belgium and Italy, the fact that student-teachers trained to teach one discipline (Physics or Biology or Chemistry or Earth Sciences) in (upper) secondary schools are required to teach Sciences , (i.e. Physics and Biology and Chemistry and Earth Sciences). No university degree provides such transversal competencies. This is also the case for student-teachers graduated in Mathematics who are allowed to teach Physics.

II. Lack of reflective practice especially epistemological reflection about how science is constructed.

III. The knowledge of the discipline supplied by the university curricula is in many cases **focused on contents** (laws, theories and models) **not focusing much on those processes** which characterize the discipline and on connections with the real phenomena. This way of teaching science leads to a rather poor ability to set up secondary school activities from this perspective.

IV. Compartmentalization of the disciplines (Biology, Chemistry and Physics). Any understanding of natural phenomena within every day life and the environment requires an interdisciplinary methodology. 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. Furthermore, overcoming the compartmentalization of the different subjects is increasingly requested. This approach is accompanied by the belief that most students learn best working with meaningful problems and issues in real-world, and in collaborative groups where communication is of the essence. Additionally, most problems in science are closely linked to each other, for instance, studying photosynthesis is difficult to perform without studying the physics of light, the chemistry of light reactions, and energy flow and use in the cell. Consequently, as in the real world where successful people integrate their knowledge as they resolve the problems they face, children in our schools should learn to integrate all of their knowledge, bringing all of their resources to bear on whatever problem they are facing. Similarly, science topics could feature problems and issues that require the use of specific science concepts and skills from various science disciplines where students are expected to use this same combined language in their responses.

V. Usually, University Courses use a **teaching approach based on a lecture format classes**; experimental science courses include some laboratory activities, usually restricted to a mere verification of regularities and laws presented during the class periods and/or receipts. This situation may derive from the fact that the future teacher will pass their students their direct learning experience as university students. Research results confirm that teachers often transfer in their class-work the methods perceived and the contents learned when they where students, usually simplifying the approaches by referring to the teaching styles/models presented by textbooks. This way of teaching will conduct to a perception of Sciences as Truth rather than process built by men in order to reply to their questions.

Often courses in education are totally separated from the instruction in content as well as in disciplinary didactics, epistemology and history; teachers have to necessarily synthesize by themselves in order to solve their specific teaching and learning problems.

The problems reported above are rather widespread among partners countries. Other problems are more related to the local context. For example:

VI. Greece does not have any initial science teacher training. Moreover to become effectively a teacher, graduated have to succeed a national contest and get an appointment to science courses in secondary schools. This last step can take several years which leads to a loosing of expertise in scientific and pedagogical knowledge. The in-service science teachers framework is presented in detail in order the situation in Greece, which is rather particular, to be explained in detail.

VII. Changes in Romanian society which had belonged during 50 years to East European Block, affect the formative side of education. It leads to a change of the pupils' mentality, which were used to think like robots executing without thinking all the "commands of the superiors". So the new task as teacher educator is a great challenge.

Table 2.1 summarizes the main features of Secondary School Science Teacher Training systems in Belgium, France, Germany, Italy and Romania. All of these systems focus on pre-service training. Greece, as mentioned above, has no formal pre-service teacher training.

ScienceTeachers In-service Training in Greece

Contribution by Christos N. Ragiadakos, Pedagogical Institute, Greek Ministry of Education and Religious Affaires

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1. INTRODUCTION

Teachers' training is usually distinguished into (a) pre-service training of would-be teachers and (b) in-service (continuing) training. Every future science teacher has to attend and complete successfully Science studies (Physics, Chemistry, etc) at a university department (4 years), where he or she receives initial training in scientific and pedagogical skills. The present report focuses on in-service teacher training, with a special emphasis on science teachers. Care has been taken to use the terminology of the recent EURYDICE report on "The teaching profession in Europe"16, although it may not be always possible because of the particularities of the Greek educational system.

The report is restricted to the teachers' in-service training

1.1 Greek education system

The Greek education system is completely centralised, which differentiates it from other European educational systems. Almost everything derives from the Ministry of Education; this situation has severe consequences regarding school functioning. The present report should be viewed in the context of the Greek education system, therefore we find it necessary to provide some simple statistical data and next some characteristic practices.

The Greek education system is centralized

Initially we present some data concerning the number of schools, students and teachers in lower and upper secondary education in TABLE 1, and the number of the educational staff (staff and cadres) in TABLE 2.

Table 1: Greek Secondary Education (2001-2002)

	Number Of Schools	Number Of Pupils	Number Of Teachers	# Of Science Teachers*
Public Lower Secondary	1.843	331.207	36.005	7.200
Private Lower Secondary	117	19.286	2.329	465
Public Upper Secondary	1.237	226.427	21.903	4.380
Private Upper Secondary	104	17.401	1.926	385

Source: Statistical Department of the Ministry of Education

* Estimated value

Table 2: Structure And Personnel Of The Greek Education System			
	Primary Education	Secondary Education	Total
Teachers	37.232	58.847	96.079
School Directors	3.286	3.458	6.744
Heads of bureaus	140	281	421
Heads of Regional Directions	57	58	115
School Counsellors	257	196	453
Source: Statistical Department of the Ministry of Education			

We will indicate below some characteristic bad practices in the Greek school, which seriously limit efforts of improving teacher training as well as school functioning.

Characteristic structural defects of the Greek Education System, which highly affect the training procedures and outputs

1. Lack of dedicated science classrooms. Pupils of a certain grade are divided into groups of 25-30 persons (classes) and share throughout the school year the same classroom where the teachers move in order the make their courses. Specially-organised subject classrooms (e.g., in science, literature, etc.) do not exist in Greece, at least in the public schools. So, the willing teacher has no chance to create a purposeful teaching environment. In particular the science teacher, who needs a laboratory environment, is restricted to "chalk and talk" teaching methods. In this way, teachers lack the necessary vital space for creative teaching.

2. Lack of teacher evaluation.There is no in-service evaluation of the teachers. Neither the school directors nor any other officers of the educational system evaluate the teachers at school. The typical school personnel structure (i.e., teacher, senior teacher, departmental head efficient school director), common in other European education systems, does not exist in Greece.

3. Lack of extra-classroom teacher work.The teachers deliver about 18 courses a week, as it is usual in Europe, however they do not stay at school any longer after the completion of their obligatory time-table so as to have the chance to contact their pupils outside the classroom, to share the so called "school life" or, in the case of training, to get trained by their senior, more experienced, colleagues.

4. The use of quotas in student acceptance to university science departments. There is a system of entrance examinations in the Greek universities as in many other European countries. However, since the number of students being admitted to tertiary education every year is about equal to the number of the secondary education graduates, one might expect that they are distributed to the disciplines (although not the universities) of their choice. This is not the case.

Every discipline and department accepts a predetermined number of students so that many students are obliged to follow disciplines they are not interested in. This system has the following consequences: a) About all the pupils, during the last two years of their secondary studies, attend either private courses (frontistiria) or private tuition, in order to maximise their possibility of getting admitted to the discipline and department of their preference. b) At least the 80% of the science teachers deliver unofficial well-paid private lessons. b) There are an extremely large number of Greek emigrant students in the other European states. c) Many Greek students in the science departments find themselves studying a discipline far from being their first choice, which influences negatively their motivation.

Due to all these peculiarities, the ultimate educational objective of instructing pupils is diverted. It is not the purpose of the present report to analyse the reasons for the situation described here, but rather to present the resulting consequences on teachers' training and the quality of science courses in Greece.

1.2 Characteristic features of science education

Special demands of Science education

The common empirical knowledge of nature cannot confront the demands of the technological devices of our days. Besides, the friendly interface of all these devices is not enough to make them familiar to the common user. That's why basic scientific knowledge should be taught already in the stage of lower secondary education, since it seems to be the only way for enabling people to understand and use effectively the future advanced instruments. But this is not always possible because of the well-known Piaget stages. In the Bloom taxonomy the objectives of the science courses are not only cognitive. They are also psychomotor type, meaning that observation, experimentation and collaboration among the students are also needed. This component differentiates science courses from all the other school courses. Science (physics, chemistry and biology) courses need special classrooms with all the necessary equipment and instruments, where the pupils could come in contact with the fundamental physical phenomena which lie behind all the everyday sophisticated devices. Unfortunately such special classrooms (laboratories) are scarcely used in Greek education.

The recent efforts to increase the science in-class experimentations have failed

In Greece, all school buildings are constructed with laboratories. But in practice, the majority of these laboratories are turned into normal classrooms. In the context of the European programme Community Support Framework II (CSF II, 1996-2000), more than 1000 science laboratories have been developed and equipped in upper secondary education. Even more laboratories are planned in the context of CSF III. Besides, the central objective of science teachers' training, which will be described below in detail, was to familiarise them with experiment-based teaching. Nevertheless lab-centred teaching is not systematically carried out in the Greek schools, due to the following reasons:

- Science teachers are unwilling to carry out the time-consuming lab work (especially the preparation phase) as long as they are not additionally paid for it. Recall that the teachers of the other subjects do not stay at school any longer after their three/four course hours per day.

- There is no auxiliary personnel for the laboratory works.

- The equipment and the materials for the laboratory are provided by a central service in the Ministry of Education. The consequence is that they are not always compatible and even with the slightest shortage of some material, cannot be efficiently supplemented. The school budget cannot cover everyday lab expenses.

- As far as the science subjects are concerned, the General University Entrance Examinations are based on pencil-and-paper problem solving. Pupils are not encouraged to be interested and spend time in experiments! They merely want to be trained regarding what will be on the exams.

Therefore the training institutions and approaches, which will be described below, have to be viewed in the context of the Greek "reality".

1.3 Plan of the present report

Section 2

In Section 2 all the institutions involved in teachers' in-service training are presented and their administrative structure is described. These training institutions generally deal with all the teachers, providing different training programs for teachers of different subjects. In this context science teachers attend training courses in their subjects and/or pedagogical issues. Only the Science Laboratory Centres (EKFE) are special for science teachers' in-service training.

Section 3

In Section 3 all the training procedures, which have been applied the last years in Greece, are presented. We merely focus on the teacher approaching procedure with some reference on the pedagogical training methods. We mention the procedures used for all the teachers, making the necessary references to the science teachers' training. The main difference between the science and the other teachers is the use of the school laboratory.

Section 4

Greek teachers were not regularly trained. There was only occasional training or in the context of postgraduate studies and after special examinations. It was after 1990 and in the context of the Community Support Framework programs that a regular in-service training has been performed. In Section 4 we survey the actions of these programs, which were devoted to the teachers in-service training and the way all this funding was used.

2. INSTITUTIONS INVOLVED IN TEACHER IN-SERVICE TRAINING

The quality of education depends on the quality of the teaching process and especially the quality of the teacher himself. In Greece, future science teachers receive their initial education, specialised in one discipline (Physics, Chemistry, Biology, etc), studying for four years in the university. There is no specialization year (major) in science education. Neither do they generally receive compulsory courses in science pedagogical methods, though they may take them voluntarily. According to a recent law (ΠΔ 45/99), the owner of a science (Physics, Chemistry, Biology and Geology) degree has to sit in specific national examinations in order to be appointed as a science teacher in the secondary education. The candidate takes a test in two of the following scientific domains: Physics, Chemistry, Biology and Geology and another test in science didactics. An analogous procedure is followed for the appointment of all the teachers in public schools.

The teachers are appointed after a successful examination on scientific and pedagogical subjects

It is widely-accepted that teacher training is a matter of strategic importance for the professional progress of the teachers and for the progress of the education system in general. This importance is implied by:

- Changes concerning the role of the teacher
- Changes in the social, technological and cultural context
- The interjection of a long time period between the teachers' basic university studies and their in- school work, due to unemployment.

Teachers' in-service training is necessary

Up to the present, the training activities have been coordinated by the Teachers Training Department of the Pedagogical Institute, which is a public law organization, dependent directly on the Minister of Education. Recently, a central private law institution has been established. This institution could organise all the teachers' training activities and could use the EU funds more effectively for this purpose. To what extent this new institution can reverse the existing (and disappointing) picture concerning teachers' training in Greece remains to be seen.

The name of the new private law institution is Teachers Training Organization (in Greek Οργανισμός Επιμόρφωσης Εκπαιδευτικών [O.EP.EK]). It was established with the law N.2986/8-2-2002, and its governing board is appointed by the Minister of Education. The activities of this new institution will cover the following dimensions:

A special Teachers Training Organization [O.EP.EK.] has been recently founded

- The planning of training policy of the Ministry of Education.
- The certification of the training institutions.
- The coordination and management of all forms of teachers' training.
- The development of training programs which will be undertaken by the training institutions.

We should point out once more that the Greek education system is completely centralised and the approval of the Minister of Education is needed for the implementation of any training activity. So in practice the role of the O.EP.EK will be restricted to the distribution of training activities to the training institutions.

2.1 Regional Training Centres [PEK]

There are 16 regional training centres (PEK)

The first attempt to bring the training centres closer to schools was through the development (N.1566/85, N.1824/88, N.2009/92, ΠΔ.250/92) of 16 Regional Training Centres (Περιφερειακά Επιμορφωτικά Κέντρα [PEK]) in the existing 13 administrative regions of Greece. These centres are located in Attiki 4 PEK, in Central Macedonia 2 PEK, in Eastern Macedonia and Thrace 2 PEK and from 1 PEK in the remaining regions (West Macedonia, Sterea Ellada, West Greece, Thessalia, Eperus, Peloponese, Crete, South Egean Islands, North Egean Islands and Ionian Islands).

Every PEK is locally administered by a scientific board appointed by the Minister of Education. The director and the vice director of PEK are usually university professors and/or school counsellors. The administration is locally carried out by special appointees and/or detached teachers. All the PEK are administered by a special bureau (directorate) in the Greek Ministry of Education.

PEK are simple training centres where external trainers deliver the courses to the teachers of the region.

PEK is a simple training centre with no permanent personnel. For the trainees' convenience, every PEK may occasionally provide training courses in other locations within its region, if a sufficient number of trainees register to a concrete training program. The location of PEK is usually a school building. The courses take place in the PEK school building and/or in other schools during the afternoon.

The most common procedure followed by a PEK for implementing a training program is the issue of a proclamation by the PEK scientific board on certain training subjects. Any public or private organization can propose an explicit training curriculum which may last 40 hours and must be completed in a period of about three months. In April these programs are released to the teachers of the PEK range. The chosen training programs take place during the next academic year and the trainees receive an economic aid of €5 per hour. Other training procedures are also followed and they will be described below. Generally speaking PEKs simply "dispatch training seminars" following a system of supply (by the state) and demand by the trainees (teachers) who finally choose the training course.

2.2 Science Laboratory Centres (EKFE)

The science laboratory centres were organized in order to support science teachers carry out experiments and keep running a laboratory in school. In every Educational Regional Directorate there is at least one EKFE under the scientific supervision of the science counsellor of the region. Responsible of the EKFE is a detached science teacher, who has been chosen on the basis of his interest in promoting lab based teaching. EKFEs are usually located in a school building in the capital of the region and are equipped with all necessary instruments and materials for carrying out the experiments proposed in the national curriculum. The main objectives of EKFEs are:

- To receive the instruments and materials from the Ministry of Education and distribute them in the school laboratories of their region.
- To carry out regular training courses for the science teachers on matters related to the science experiments and the teachers' effectiveness in teaching process.
- To visit on a regular basis the school laboratories and provide any requested help to the science teachers.
- Students of certain classes may visit their regional EKFE for demonstation experiments or, moreover, to carry out experiments which cannot be done in the school laboratory.

The science laboratory centres (EKFE) are fully equipped to promote lab based teaching

It has already been mentioned that a significant effort to develop and equip school laboratories has been undertaken in the context of CSF II and it is continuing in the context of CSF III. Science Laboratories Centres are playing a key role in this process, providing the necessary know-how and undertaking the supervision of all in-field efforts at the regional level. Without their involvement, these large programs could not be implemented.

EKFE supervises the development of science laboratories in the secondary education

On the other hand, any science teachers training program to be carried out needs equipment and materials. On the regional level, EKFE are the only fully-equipped places where such training programs can take place and therefore are used by training groups of different training programs.

EKFE are the training centres concerning lab-based teaching

2.3 Pedagogical Institute [PI]

The Pedagogical Institute (PI) is a state institution, which is the official advisor of the Ministry of Education on matters of primary and secondary education and is directed by a Board appointed directly by the Minister. It is divided into 5 departments. The Department of Teachers Training and Evaluation is the official advisor of the Minister of Education on anything related to the teachers training. Until the establishment of O.EP.EK., all training initiatives were proposed and supervised by this department. This department has also coordinated the teachers training action of the CSF II as well as the first actions of the CSF III programs.

The Department of Teachers Training and Evaluation is part of the PI and the official advisor of the Minister of Education on training matters

Any explicit training report submitted by PI has to be approved by the Minister of Education; in fact, the political environment often introduces persons of uncertain scientific competence. Besides, there are cases when even a simple replacement of the Minister in the same government changes the educational policy. New curricula and books are introduced and -- as a consequence -- new teachers training programs are needed. These frequent changes of policy and objectives hamper any training planning. It is doubtful whether the new organization O.EP.EK. will reach expectations, since it will certainly face the same problems that PI did (e.g., its board will change in any Minister replacement).

The irregular changes of policy hamper any training plan

2.4 Teachers' in-service training in universities

Science teachers receive their degree after having studying for 8 semesters in one of the university departments of Physics, Chemistry, Biology and Geology. During his initial studies, a science student may select some subjects in science didactics and pedagogy (held in the science departments), but these courses are not compulsory and they are not directly considered as a prerequisite for his appointment as a secondary education teacher, though they are part of the subject matter he will be tested in for entering the profession.

The universities can participate in the in-service training of the in-service teachers through the following channels:

Through concrete programs and regular post- graduate studies universities provide in-service training too

- Any university professor or a group of professors can submit a two- or three-months training programs in one or more PEKs. If this program is chosen by a sufficient number (at least 15) of teachers of the PEK region, then it can be implemented.
- University professors can be trainers in the training programs of the PI.
- Any university professor or a group of professors in collaboration with some schools can submit training programs in the framework of SOCRATES training actions.
- After five years of continuous employment any teacher may sit in a special examination and get admittance for a post-graduate diploma (Master or PhD) in a university. This may be done either in an education department or in a science department.

3. TRAINING PROCEDURES

A variety of training procedures have to be realized in order to anticipate the teachers' varying needs, interests, convenient time, etc. All training procedures that have been realized in the Greek education system are listed below.

3.1 Training of new appointed teachers

This training procedure concerns the newly appointed teachers. Due to long-term unemployment, they have been away from their scientific domain for a long time after their university studies. Besides, the fact that science students do not take compulsory pedagogical courses during their studies makes introductory training necessary. Therefore the new teachers need:

- To be informed about changes and development in education (new legislations, new curricula, new school books) and the role of school in the modern society.
- To renew and supplement the subject knowledge they received at the university.
- To harmonize their knowledge and their teaching methods with the Greek school reality.

Because of the long period between initial training and employment, teachers need additional training

This training is compulsory (Presidential Act: 45/1999) for all Greek teachers employed in primary and secondary education and ends up with a certification of attendance. The training lasts at least 100 hours, takes place out of school time and is structured in three phases. In the first phase teachers attend special courses for two weeks before the beginning of their teaching obligations. The subjects of this course are related to school matters, the new legislation and the teaching process. The second phase training includes practice and attendance of exemplary teaching presented by the school canceller of the region or other senior teachers of the school. The third phase takes place mostly in the middle of the school year. Teachers discuss the problems they faced and the possible ways of solving or generally dealing with them.

Beginners' training is compulsory and covers matters on school legislation and new pedagogical procedures

3.2 In-school training

This training takes place inside school during school time. It may refer to general pedagogical issues, which interest all teachers, is usually curried out in the context of a program and the trainers are university professors. In-school training can also be carried out by school cancellers who train teachers on subjects of their specialty. It may also be part of a self-training program inside school, where senior teachers train the younger ones.

In-school training is curried out during the school time by external trainers

3.3 Occasional training

Short-term training programs which aim at supporting teachers in their scientific and pedagogical work accompany occasional changes of school programs, new courses, new school books or new teaching aids and methods as well as innovative educational techniques. They last at most one day and common in Greece, especially after 1994 when the European program EPEAEK started.

Occasional training takes place after an educational or curriculum reform

3.4 Long term training

After a successful examination, a teacher may attend post graduate courses in a university

This training is addressed to a relatively small number of teachers who succeed in a certain examination test. It takes place in the universities where the trainees attend post-graduate courses either in their subject or in a pedagogical specialisation. This training has as effect the dissemination of new knowledge and modern ideas at school. It also enhances the self-esteem of the school community. Such training programs are also planned in the context of EPEAEK II.

3.5 Special laboratory training

This training is addressed to teachers of physical sciences aiming at providing them with lab-based teaching skills. Training takes place in the Regional Laboratory Centres (EKFE) for the majority of the teachers of the region. This training is needed in Greece for two reasons:

Science teachers are specially trained regarding science experiments

- The school laboratory supplies (equipment, instruments, etc.) are distributed by the central administration. They are not standard. They may not have any relation with the book in use and are usually incomplete.
- Teachers are not obliged to carry out scientific experiments; therefore the science course is done on the blackboard. The majority of pupils finish high school without having seen any measuring device.

In order to bypass these problems, many acts in the EPEAEK program have been directed to this special training. The results are not encouraging, because there is no indication that more science teachers have been engaged in lab based teaching.

3.6 Training of educational staff

The new school and regional directors are regularly trained regarding administration matters

The improvement of school administration and management is essential. On the other hand, the school directors and the directors of the regional educational bureaus are usually former senior teachers without managerial and administrative knowledge or experience. Therefore they are trained in the beginning of their employment. In the context of the EPEAEK program many training initiatives had this objective giving the possibility to other teachers to attend the courses.

3.7 Training of trainers

This training has been implemented to facilitate the dissemination of the objectives of educational reforms and new curricula. Selected senior teachers and all the school cancellors are gathered in one or two places where they attend an intensive short training on the new ideas of the educational reform or curricula. In their turn they train teachers in compulsory short term training programs held in their region.

3.8 Open Distance Learning (ODL) training

The Greek Open University provides special programs for teachers

Open Distance Learning (ODL) is used for the training of teachers. The Greek Open University delivers general pedagogical, thematic and administrative courses. This training approach is highly adequate to the teacher profession and a large number of teachers attend different courses. On the other hand they are not expensive for the government because the trainees do not stop their work and/or are not additionally paid for the attendance of the training courses, instead they pay fees. The information and communication technologies are expected to enhance the ODL training. The development of an interactive virtual classroom in the internet, where exemplary teaching of different topics could be presented, would provide an innovating useful approach for new teaching ideas and techniques.

4. TEACHERS TRAINING PROGRAMS

A quite large part of the European fund is devoted to teachers' training. During the first Community Support Framework (CSF I) the corresponding action was administered by the Ministry of Labour. In the context of the other two programs (CSF II and CSF III) there were independent subprograms for education and training (EPEAEK I and EPEAEK II) administered directly by the Ministry of Education.

A large number of teachers have also been directly or indirectly trained through other European programs (like COMENIUS) managed directly by the Commission.

4.1 EPEAEK I in CSF II program

In the context of the second CSF program and the subprogram EPEAEK there was the measure 1.3 "Teachers Training and other Sustaining Actions" and specifically the action 1.3a "Teachers Training", which was used for a systematic training of teachers. The initial budget of the action was €103.000.000 (35x109 drachmas), but finally it only absorbed about 80.000.000€.

According to the Technical Report, the objectives of the action were:

- The continuation and the upgrade of PEK in the reformation, the evaluation, the coordination and the spreading of training in collaboration with other specialised institutions.
- The renovation, improvement and development of the infrastructure of PEK, related to the development of training laboratories for special courses.
- The development of other training institutions more flexible and effective.
- Planning and development of a training observatory for researching and recording teachers training needs.
- Planning and development of a long distance training system on the open university basis

The objectives of the training action of CSF II program

It may be interesting to point out that none of these objectives has been fulfilled due to a government reshuffling.

This 1.3 action was partly realized in the period 1996-2000 and had the following acts: 1.3a(1).

"Training as a pivot supporting educational reforms". It moved towards three directions: i) long employed teachers: About 2500 training programs took place in the PEKs. Each program held 40 hours and was attended on average by 25 teachers. ii) new appointed teachers: About 1500 programs took place, each one held 40 hours and was attended on average by 20 new teachers. iii) educational officers: About 330 programs took place, each one held 40 hours and was attended by 25 educational officers.

The teacher training acts are planned and partly fulfilled in the context of the CSF II program

1.3a(2).

"Upgrading and support of multiple training institutions through planning and development of voluntary training programs". It was addressed to i) the teachers of secondary education. About 35 programs took place in universities after issuing the appropriate proclamation. These programs were medium term and held a semester (195 hours) each. 60 teachers attended each program. ii) The teachers of primary education. These programs took place in the education departments of the universities and were attended by 35000 teachers who followed one semester courses on pedagogics. iii) The teachers who wanted to attend short term training programs. About 2000 programs took place in the universities and about 25 teachers attended each program. iv) School networks for in school training. About 700 training programs took place and about 25 teachers attended each program.

1.3a(3).

"Innovative training programs through long distance learning methods". They were one and two years training programs.

1.3a(4).

"Planning and gradual development of a unified framework of certification and a system of viable structures in continuous teachers training". This act was dealing with the "Teachers Training Laboratory" and the "Teachers Portofolio".

1.3a(5).

"Evaluation and dissemination of the act 1.3(a)". The evaluation of this large-scale teachers training was restricted to the opinion of teachers and it did not accoblish the final objective, which was the impact of training in pupils' achievement.

All these actions have not been finally realized. According to preliminary data (Proposal for EPEAEK II) the following teachers training acts have been accomplished:

The finally trained teachers in numbers, subjects and training procedure

- 74.475 teachers participated in occasional compulsory training for the implementation new reforms.
- 27.000 teachers participated in occasional voluntary training in the 16 PEK.
- 5.740 new teachers participated in initial training programs.
- 480 teachers participated in 18 one-year university programs.
- 6.606 teachers from 470 schools participated in "in school" training programs.
- 2.443 teachers of secondary Technical Education participated in training programs on technological and pedagogical subjects.

The change of Minister changed the objectives of the educational reform and the subsequent training stopped

According to a short range independent research17 the 80% of the teachers attended training seminars.
During the CSF II program (1994-1999) large amounts of money were spent for teachers training and the support of the educational reform then undertaken by the Minister of Education of those times. After the change of the Minister, the undertaken reform was partly withdrawn. The training programmes stopped or oriented into other directions, presented as primary objectives of the new Minister of Education.

The main objective of the reform in science education was the introduction of the lab-based teaching. This objective was explicitly described in the new science curriculum and all the new book-packets were supplemented with a laboratory guide, where all the science experiments of the curriculum are described. A special act of the CSF II program had to do with the development of new laboratories in all schools of secondary education. Besides, the central direction of the training courses was to support the laboratory exercises. During the period 1997-1999 about the 8% of all the voluntary training programs18 were directed to physical sciences teachers. Despite all this systematic effort and the large amount of money spent, the result is disappointing. The school laboratories generally remain closed and the teachers do not use them.

The established science school laboratories are not used by the teachers

4.2 EPEAEK II in CSF III program

In the context of CSF III, the teachers training actions are part of its educational branch, EPEAEK II, managed by the Ministry of Education. The action 2.1.1 "Teachers Training" of EPEAEK II has a budget of €7,976,000. According to the Technical Report of EPEAEK II, the training aims focus at enabling the teachers to encourage renovation of the educational approaches and the educational officers more effective in administrative and economic management. The number of teachers who will be trained in the context of EPEAEK II, as well as the training procedure are presented in the following TABLE 3. The number "BASE VALUE" refers to the trained teachers in the context of EPEAEK I and the other two values to the program targets for 2003 and the end (2006).

TABLE 3

TRAINING INDICATORS	BASE VALUE	TARGET 2003	TARGET 2006
Number of teachers who will participate in the initial training	5.740	7.100	15.000
Number of teachers who will participate in the occasional training	101.000	165.000	250.000
Number of schools which will participate in the in-school training	450	850	1.300
Number of teachers who will participate in long-term training	480	1.500	2.800
Number of primary education teachers who will participate in equivalence training	17.000	21.000	28.000
Number of educational staff who will participate in school administration training	640	1.440	4.440
Number of teachers of Technical Education who will participate in the pedagogical training	1.500	5.600	8.000

SOURCE: Proposal of EPEAEK II

In the first three years of EPEAEK II, all the teachers training acts focused on the "diathematic approach" and the implementation of the "flexible zone", which seem to be the new Minister's priorities, and new curricula and books were written. A new circle of teachers' training on these directions has already started.

In the context of CSF III, another large scale training action is the program of "Information and Communication Society". This program has also an educational branch, managed by the Ministry of Education, with primary objective the training of teachers in information technology. The training is performed in certified public and private laboratories in informatics (KSE). There are three training levels: On the basic level teachers are trained in the Operating System, on the medium level they are trained in specific applications and on the advanced level a small number of teachers are trained in multimedia applications. The program is going to train 150.000 teachers until the end of 2004. Its target is to train all Greek teachers at least up to the second-training stage. The trained teachers receive substantial economic aid in order to buy their own PC. Unfortunately, the money is not enough for a notebook with Wi-Fi facilities which could be better used in the classroom.

Table 2.1 *Comparison of National Science Teacher Education Programs*

Belgium (frenchspeaking Community)	**France**	**Germany** Baden-Wuerttemberg State[1]	**Greece**	**Italy**	**Romania**
Diploma requested to teach in secondary schools					
- lower secondary school: 3 years Higher Education - upper secondary school: 4 years university degree + 300h (about ½ academic year) university degree specialized in science teacher education	- 3 years science university degree - 2 years specialization in science teaching (in IUFM)	3,5 years University degree divided in "Fundamentum" and "Main study"	4 years university degree	3 years university degree + 2 years university degree specialized in teacher education	4 years university degree + pedagogical module which can be chosen during the 4 years
Aims					
To educate future teachers to - observe and analyze teaching and learning practices; - understand the school system and its environment; - integrate him/herself into a process of didactic research; - communicate scientific knowledge and, therefore, master the discipline being taught;	After the science university degree, the aims are to require to teacher-to-be to : - Enhance their disciplinary knowledge, master the discipline they teach and develop interdisciplinarity - Communicate scientific knowledge - Understand the school system and its environment; - Observe and analyse teaching and learning practices;	Provide basic knowledge, skills and experiences, field work To educate future teachers to ICT use + (future) interdisciplinarity knowledge.	Provide basic content knowledge	- to require the teachers-to-be to - actively participate in the construction of knowledge; - elicit possible lacks in disciplinary knowledge, pointing to remedial procedures; - be aware of common teaching/learning difficulties - be competent to manage students' learning difficulties, offering innovative ways to address and overcome them;	- to assure both the informative and the formative side of education of the students - to develop their personality

- design and organize science teaching and learning activities with a "science in context perspective", which integrates science, technology and society and in which the student is required to participate in the construction of his/her knowledge; - evaluate and regulate teaching and learning practices; - understand adolescents in their school context and to manage groups of adolescents; - prepare science teaching units which enable students to understand the world around them;	- Elaborate and implement science courses based on activities which enable learners to understand the world around them (real phenomena, experimentation, conceptualisation and modelling approaches) - Be aware of common teaching/learning difficulties - Be competent to manage students' learning difficulties, offering innovative ways to address and overcome them; - Take into account, whenever possible, the common sense knowledge; - Evaluate and regulate teaching and learning practices; - Integrate him/herself into a continuous process of didactic and pedagogical research and training;			- take into account, whenever possible, the common sense knowledge; - be trained to use ITC - combine expertise in Science Education with the one in Disciplinary Didactics[2] - be helped by experienced in-service teachers through experience in ordinary classes - use meta-reflection in order to point out learning difficulties and disciplinary knotty problems.	
Belgium	**France**	**Germany**	**Greece**	**Italy**	**Romania**
Channel					
(For upper secondary schools) - Natural sciences for teachers in Biology, Chemistry; - Physics for teachers in Physics; - Mathematics for teachers in Mathematics - Geography for teachers in Geography	- Physics and chemistry for teachers in these disciplines united in one discipline, - Natural Sciences: Biology and Biology (called Life and Earth Sciences: in this one discipline SVT) for SVT teachers. - Mathematics for teachers in mathematics		- Natural sciences for teachers in Biology, Chemistry; - Physics, Geography or Biology for teachers in Physics; - Mathematics for teachers in Mathematics	- Physics-Informatics_Mathematics is designed for teachers-to-be in Physics and Mathematics - Natural Science for teachers- to-be in Biology, Botany, Earth science, Chemistry.	

Belgium	France	Germany	Greece	Italy	Romania
Local Curriculum					
For upper secondary schools - School system and its actors (15h) - School system and its context (22h30) - General didactics (22h30h) - Adolescent in school situation (22h30) - Education to interrelation and group management (22h30) - Science epistemology (22h30) - Science education (Biology or Chemistry) (45h) (+ another discipline 22h30) - Information and Communication Technology (ICT) in education (15h) - Seminar to integrate practices (30h) - Teaching in secondary schools (with a tutor) (60h)	For First year IUFM : 1. Modules in each of the previous disciplines respectively (theoretical and practical work (the last is a training (simulation) to teach experimental approach of the disciplines)) (500h) 2. Elaboration and Simulation of disciplinary courses (72h). 3. Module in school system, its history, its actors, comparison across Europe (12h) 4. Module in "know oneself and communicate with others" (12h) 5. Stage in secondary schools (to observe and analyse teaching and learning practices) (18h) For second year IUFM : 6. General and applied didactic (including ITC) (132h) 7. Pedagogical, psychological and sociological approaches for teaching and the school system (54h) 8. Stages in secondary schools (361h) 9. Professional (applied) research (ending in a written report and a viva) (31h).	Fundamentum : pedagogical, psychological field (8 credits), Language or Math or French (8 credits) first further subject (6 credits), second further subject (6 credits) Sociology, Politics, Philosophy or Theology (2 credits) Modules in Biology (24-44 credits) - Main subject (44 credits) - Leading subjects (24 credits) - Connecting subject (24 credits)		a) Apprenticeship and school training (including stages in secondary schools) (300h) b) general pedagogy, sociology and psychology (no less than 20%); c) disciplinary didactics, history, epistemology (no less than 20%); d) labs, mainly focused on professional disciplinary teaching training and use of ICT, (no less than 20%); e) school based-work (apprenticeship, school training) under the supervision of expert teachers (no less than 20%). (700 h)	- Psychology of education (5 credits, 56h) - Pedagogy; theory of curriculum (4 credits, 42h) - Theory and methodology of instruction and evaluation (4 credits, 42h) - Science didactics (A) (4 credits, 42 h) - Science didactics (B) (4 credits, 42h) - Practice (4 credits, 56h) - Information and communication Technology (3.5 credits, 42h) - Pedagogical practice (A) (4credits, 56h) - Pedagogical practice (B) (4credits, 56h) - Optional discipline (3.5 credits, 42h)
Total : 300h	Total : 1168h	Total: around 170 credits		Total : 1000 h	Total : 40 credits, 476h

Belgium	France	Germany	Greece	Italy	Romania
Problems					
- lack of self study - not enough focus on those processes which characterize the discipline and on connections with the real phenomena.	- Lack of Interdisciplinarity - Systematic application of the teaching styles/models presented by textbooks - Lack of reflective practice especially epistemological reflection about how science is constructed - Lack ok knowledge in didactics, especially teaching and learning difficulties.	- Hauptschule & Realschule : appropriate knowledge of the discipline and the teaching methods used in university teaching. - Gymnasium: relationship between pedagogy and disciplinary didactics - lack of interdisciplinarity	- insufficient up to date knowledge of the discipline which are supposed to be addressed in the teaching process. - not enough focus on scientific processes (modeling) - lack of experience in running interdisciplinary projects - insufficient experience in using Information Educational Technology in the lab	- lack or insufficient knowledge of the discipline(s) which are supposed to be addressed in the teaching process. - not enough focus on those processes which characterise the discipline and on connections with the real phenomena. - Application of the teaching styles/ models presented by textbooks - Lack of experiential training	- lack or insufficient knowledge - link with everyday life

Belgium	France	Germany	Greece	Italy	Romania
SPECIFIC EXAMPLES of Good Practices which address such problems in local situations					
- Portfolio as a tool to enhance self-study	How to introduce some concepts of Didactics of Science from an example: the digestion	"Life in Winter": Interdisciplinary project integrating Biology, Physics, Math and Computer Sciences	- Simulations of metaClassical and Classical Models of microCosmos -Atoms and Molecules - Environmental / Ecological project(s) based on the Scientific Method and enhanced by Systemic Analysis – Science and Interdisciplinarity - Experimentation in Science Laboratory – Measurements with Sensors / Actuators – Physics, Chemistry, Biology	- Use of Real-Time Experiments and Images to address a) the Inversions of motion and impulsive forces and b) oscillations - Modeling Physical Reality: from observations to descriptive models to interpretative models	- Electric circuits - Students'naïve ideas

1 this is the case of the Baden-Wuerttemberg State. Different rules are applied in the individual states.

2 It includes both to reflect on how to optimise the presentation of the addressed disciplinary content (which is supposed to be known by the teachers to-be) and to experience the usable different viewpoints, techniques, tools, materials, …)

2.2 Towards an Effective Science Teacher's Profile

Defining an Effective Science Teacher's Profile represents a crucial step in the effort to confront the serious shortage of interest in scientific careers among young people across Europe. Building a consensus regarding what makes an effective science teacher will help us join forces to create strategies and programs that will produce effective science teachers across Europe. The work presented in this section represents an attempt to start such "consensus-building."

In this section, we first design an Effective Science Teacher Profile and then compare it the Desired Competencies generated earlier in WP1. We conclude this section with a brief summary and a transition to the next two reports (WP3 and WP4).

2.2.1 Design of the Profile

The design of the Effective Science Teacher's Profile is based on:

- the surveys made by the partners (WP1: The Sciences Teachers' Competencies),
- the problems in science teacher education identified by the different partners (from a comparison of the 6 different science teacher training systems, as presented in section 1.5 and the Appendices of this report) and
- the science education research literature (basically Barnett J., Hodson D., "Pedagogical Context Knowledge: Toward a Fuller Understanding of What Good Science Teachers Know ").

We have chosen to synthesize all these data by the following fictitious "job advertisement," which has been constructed in three paragraphs. The first paragraph introduces the advertisement by generalities linked with the science teacher's job. The second paragraph, titled "requirements", is dedicated to the essential personal abilities required for a science teacher. The third paragraph, called "duties," focuses on the competences to be developed by the science teacher within the classroom.

The choice of each "requirement" or "duty" is motivated by at least one source of data which is referred by one or more footnotes. Each "requirement" or "duty" has been formulated in order to address the problems identified in section 2.1.5 above. Each Roman number refers to one general problem, i.e.:

I. Lack or insufficient knowledge of the discipline(s)

II. Lack of reflective practice

III. Knowledge of the discipline focused more on contents (laws, theories and models), not focusing as much on those processes which characterize the discipline and on connections with the real phenomena.

IV. Problem of compartmentalization of the disciplines (Biology, Chemistry and Physics)

V. Problem of teaching approach essentially based on a lecture format classes

The content of this "job advertisement" will be used as an analysis grid for choosing the "Examples of Good Practices" (EGPs) which will be presented in detail in the next sesion. This EGPs were implemented by the partner institutions in different countries and assesed during the implementation of the project. The description of the implementation and the assesment process is described in detail in the report on WP3, "Exemplary Models of Science Teachers Preparation Programmes".

Effective European Science Teachers

In order to enhance interest for science and scientific careers among pupils, European Secondary Schools are looking for:

Effective Science Teachers

They are interested in hiring dynamic and reliable **Science Teachers keen to "plan, organize and evaluate lessons so that all pupils are successful"**.

He/she enjoys teaching and his/her students, demonstrates a willingness to know his/her students (Barnett & Hodson, 2001)[1], adapts and changes to meet their needs (Monck, 2001)[2], tolerates ambiguity and is comfortable with not knowing. He/she is a leader within the classroom and with colleagues (Sergiovanni & Starratt, 1998)[3] (Dimmock & Lee, 2000 in Ritchie & Rigano, 2003)[4].

Requirements

- Degree in one scientific discipline, including a strong introduction to the others and a specialization in science teaching (included or separated from the science degree) (Fishler, 2002)[5], (Barnett & Hodson, 2001)[6]. **I**
- Ability to use a large range of teaching/ learning strategies, and organizational and management strategies in order to create environments favorable to pupils motivation and success (Macrae & Quintrell, 2001)[7] (Monck, 2001)[8] (HLG, EC, 2004)[9] (Barnett & Hodson, 2001)[10]. **V**
- Expertise and interest in contemporary science and the history and philosophy of science. (Borghi, et al, 2000)[11] (Barnett & Hodson, 2001)[12]. **I** **III**
- Ability to use the results of research in science education (HLG, EC, 2004)[13] (Borghi, et al, 2000)[14] (Barnett & Hodson, 2001)[15]. **V**
- Ability to reflect on his/her work (Hasset, 2000) (Barnett & Hodson, 2001)[16], and to self-study (Monck, 2001)[17] (Borghi, et al, 2000)[18] (Bass et al., 2002)[19]. **II**
- Being aware of the sense of purpose of what he/she teaches (Hassett , 2000) [20]. **I**
- Ability to face innovation (Noss & Hoyles., 1993) [21]. **V**
- Ability to work both individually and in a team (Monck, 2001)[22] (Borghi et al, 2000)[23] (Bass et al., 2002)[24] (Barnett & Hodson, 2001)[25]. **V**

Duties

The candidate will

- Organize student centered teaching/learning approaches, based on student's conceptions and needs (Hassett , 2000)[26] (Hoban, 2003)[27] (HLG, EC, 2004)[28] and on a variety of learning strategies (HLG, EC, 2004)[29] (Abell & Jacks, 2000)[30] (Borghi et al., 2000)[31]. **III V**
- Design teaching units addressing student learning difficulties by using among other elements the results of current research in Science Education (Hoban, 2003)[27]. **III V**
- Design interdisciplinary teaching/learning units linking science, technologies and society (HLG, EC, 2004)[32] (Barnett & Hodson, 2001)[33]. **IV**
- Design teaching units enhancing student self-directed learning (e.g., competence in finding, analyzing and presenting information) (HLG, EC, 2004)[34]. **V**
- Integrate ICT in teaching/learning units (Borghi et al., 2000)[35]. **V**
- Organize "hands-on" experiments, enhancing learning by doing instead of learning by observing, and informal learning science in social and technological context, such as field trips, arranged visits to museums or to industries and institutions that engage in scientific or technological research (HLG, EC, 2004)[36] (Barnett & Hodson, 2001)[37]. **IV V**
- Design teaching/learning units that help pupils experiment in different areas regarding the passage from their everyday experience to representations of formal science (Borghi et al., 2000)[38] (Vander Borght, 2003)[39], (HLG, EC, 2004)[40] . **IV V**
- Design teaching/learning units leading pupils to become aware of the sense of purpose of what they learn (situated learning to making science more relevant to students) (HLG, EC, 2004)[41]. **I**
- Share and talk about his/her practice with their peers and pupils. (Loughran, 2003)[42] (Borghi, et al, 2000)[43] (Macrae & Quintrell, 2001)[44] (Van Driel and Beijaard, 2003)[45] (Dimmock & Lee, 2000 in Ritchie & Rigano, 2003)[46]. **II**

The request is supported by all National Instruction Institutions across Europe. Candidates may join the effective team at the following academic year. **For further information, please contact effectivescience teachers@europe**. Please send a complete application (with a full CV, copies of degrees/marks, letter of motivation) before **30th May 2005** at the same address short-listing and interviews will take place in June 2005.

1 Barnett and Hodson, (2001), p. 444: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. 400. Classroom Knowledge. 410"Psychological" Knowledge of Students(…) 420. "Sociological" Knowledge of Students(…) 440. Knowledge of Individual Sudents (…) 450. Behavioral Feedback from Students (Reflection-in-Action)"

2 Monck, (2001), p. 144: "pupils are motivated –in a sense that they have needs and drives. Those needs and drives may not aligns with yours. The chances are that the principal reason they do not align with yours is because the pupils have not enjoyed success in their learning experiences before you taught them."…"[teachers] may have tried one way of teaching. If it worked they tried again. If not they modified the strategy and tried the modification"

3 Sergiovanni & Starratt, (1998), p. 149: "Teacher leadership involves the experimentation and examination of more powerful learning activities with and for students, in the service of enhanced student productions and performances of knowledge and understanding. Based on this leadership with and for students, teacher leaders invite other teachers to similar engagements with students in the learning process."

4 Dimmock & Lee, (2000) in Ritchie & Rigano, (2003), p. 49 : "Teachers leaders (…) are committed to improving their practice by engaging in classroom trials of activities and approaches designed to enhance student learning outcomes. Not only do teacher leaders commit themselves to personal professional learning but also they are likely to model their orientation to learning and practice for their colleagues."

5 Fischler, (2002), p. 106: "The answer stresses the significance of extensive knowledge (…) meaning that the more extensive the teacher's subject knowledge the better his or her capability to teach."

6 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. 100. Academic and Research Knowledge. (…) 120. Scientific Knowledge "

7 Macrae & Quintrell, (2001), p. 156: "the management of lessons includes their organization and presentation, witch requires the ability to analyze the various phases and elements of a lesson, select and deliver appropriate material and reduce source of friction." (..) "… [Teachers] need to be encouraged to understand and develop different styles of management and organizations according to the work being undertaken as well as the age and ability of the students."

8 Monck, (2001), p. 144: "…the [teacher's]professional responsibility for the lesson will be with [his] planning, organizing and managing. Pupil motivation can only be a scapegoat."

9 HLG, EC (2004), p 136 "Another neglected aspect in teacher education is the classroom climate factor and the teacher-student relationship which appears to be extremely important for the enhancement of interest and the assessment of a classroom situation by students." and p 117 : "some important factors can be mentioned that have been shown to influence motivation in empirical studies. These are the students' perception of autonomy (…), of their own competence (…) and of their being socially embedded within a (peer) group of people (…)The importance of the perception of competence and the learner's self-concept are pointed out in particular in different studies. In addition, motivation depends on more school-related factors, such as the perceived relevance of the topic, the quality of instruction or the interest of the teacher."

10 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. 200. Pedagogical Content Knowledge. 210. Use of Strategies for Teaching Science(…)400. Classroom Knowledge. (…) 430 Facilitation of Learning. 431. Crea&ting a "Learning Environment ". 432. Influencing Student Motivation. "

11 Borghi, L. et al. (2000), p 40 : "…future [science] teachers should be provided with opportunities to (…)frame in an historic dimension, the elaboration of physical theories and significant case studies, analyze the debate which accompanied their development."

12 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. . 100. Academic and Research Knowledge. (…) 120. Scientific Knowledge . (…) 123. Knowing History and Philosophy of Science"

13 HLG, EC (2004), p 135 : "…[Science's teachers] should make teaching material for science courses more authentic through the co-operation of teachers and researchers."

14 Borghi, L. et al. (2000), p 40 : "…future [science] teachers should be provided with opportunities to (…)know the results of research in physics education."

15 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. . 100. Academic and Research Knowledge. 110 Knowledge of Educational Research"

16 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. . 100. Academic and Research Knowledge. (…) 130 Reflection-on-Action 131. Personal Teaching Strategies, tactics and Styles. 132. On Student Success. 133. Intuition (…) 200. Pedagogical Content Knowledge. 220 Use of Strategies for Assessing Science Learning. (…) 222. Alterantive Practices (portfolio, peer, self-assessment) "

17 Monck, (2001), p. 147: " If sharing experiences and talking about them is the quickest way for you [future teacher] to develop yours skills as a teacher then it is doubtlessly going to be the case that the same activity will anhance the learning of your pupils."

18 Borghi, L. et al. (2000), p 40 : "…future [science] teachers should be provided with opportunities to (…)appreciate working in groups and reflecting on their action in classrooms."

19 Bass, L et al.(2002), p 59: "A self-study cycle. We learned that small shifts of awareness were made visible through the self-study process. These shifts had significant, though subtle, impacts on how w taught. Throughout this process, we noted how working with critical friends helped make visible these shifts and pushed reflection to reflexivity. This current re-analysis has deepened our conception of self-study as a creative and personally meaningful method. Our research collaborative concludes that self-study is an emergent and creative process, that change in practice necessarily integrates change in self, that self-study requires a collective, and that self-study's version of professional growth challenges the developmental model that implies that teachers improve simply with experience

20 Hassett M. (2000): "Good teachers have the sense of purpose. You can't be good in a generic sense; you have to be good for something. As a teacher, this means that you know what your students expect, and you make plan to meet those expectations. You too have expectations about what happens in your classroom, based on the goals you're trying to achieve."

21 Noss, R and Hoyles, C. (1993), p. 214 " The challenge for teachers faced with innovation is to work to clarify a new set of ideas and practices whose interactions with existing practice are not at all evident from the outset, but emerge in the course of innovation."

22 Monck, (2001), p. 145: "…the [teacher's]professional responsibility for the lesson will be with [his] planning, organizing and managing. Pupil motivation can only be a scapegoat."

23 Borghi, L. (2000), p 40 : ibid. footnote 10.

24 Bass, L et al.(2002), p 59: ibid. footnote 13

25 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. 100. Academic and Research Knowledge. (…) 140. Other Teachers' experience (through Networking)"

26 Hassett M. (2000): ibid. footnote 8.

27 Hoban, G.F. (2003), p 31: "…it is interesting to note that each of the teachers involved in the project sated that the catalyst for change in their teaching was listening to the interview tapes of their own students. (…) the student tapes provided the teachers with 'conceptual inputs' as triggers for reflection and challenged the way that the teachers thought about their practice."

28 HLG, EC (2004), p 116 : "There is a broad consensus today that all learning processes have to start with the preconcepts, attitudes and interests of the learner, and that learning cannot be arranged and organised for every student in the same way at the same time. This constructivist idea of learning has led to many research studies and developmental work, aiming at the production of material and methods which look at student preconceptions and at different interests and competencies, and which allow a more successful handling of diversity, as guidance can be given to weaker students and more demanding tasks can be carried out by high achievers.(…) Adaptation to the learner does not only refer to cognitive understanding. Different types of motivation or different cultural views about science are also very important for the stimulation and support of learning processes."

29 HLG, EC (2004), p 116 : "…various tasks take the diversity of interests into consideration: not all students have to do the same things, but instead can learn to work in teams even in school science classes, which can be one aspect of social embedding.", and p 136 "It is a very old wisdom that a variety of teaching and learning methods is important for a successful learning process."

30 Abell S. K., Jacks A. M. (2000), p. 146: "Thinking about Learning. Despite Amy's novice status, she showed evidence of thinking deeply about student learning. (…) I (…) realize the importance of asking a student how they got an answer to understand their thinking."

31 Borghi, L. et al. (2000), p 40 : "…future [science] teachers should be provided with opportunities to (…)learn how to explore the ideas of their students and design instructional strategies to help students overcome difficulties, analyse and discuss teaching strategies and new approaches, (…) learn how to provide alternative ways of thinking about a concept and pauses for interpretation and reflection (…), learn to integrate into their teaching activity different tools and approaches, discussion of everyday experience, use of simple experiments with easily available material and more complex equipment, together with multimedia tools "

32 HLG, EC (2004), p 115 : " movements towards improving science education do at least try to integrate interdisciplinary topics and approaches into new curricula, showing the interaction between different disciplines, different fields of careers, and between research, technology and society."

33 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. 100. Academic and Research Knowledge. (…) 120. Scientific Knowledge. (…) 124. Knowing Relationships among Science, Tech-

nology, Society and environment (STSE). (…) 200. Pedagogical Content Knowledge. 220 Use of Strategies for Teaching Science. 214. teaching STSE. (…) 260. Use of Strategies for Integration Science with Other Subjects. "

34 HLG, EC (2004), p 116 : "New approaches give greater possibilities for self-directed learning and for the application of many different competencies, not just the formulation of formulae and abstract laws. For example, competence in finding, analysing and presenting information – i.e. communication – becomes more and more important, not only for school science, but also for scientific and other careers.."

35 Borghi L. et al (2000), p 40: "…future [science] teachers should be provided with opportunities to (…) use new technologies which in the near future will be available in the schools."

36 HLG, EC (2004), p 116: "Problem-based or inquiry-oriented approaches. By combining different activities and focusing on open-ended tasks and self-directed learning, students are enabled to integrate and to develop different competencies and modes of creativity. To do so, students will have to be given the opportunity to undertake 'research activities' instead of just carrying out routine 'cook-book experiments', for example. This includes the development of questions, the formulation and testing of hypotheses based on existing knowledge and theories, and the analysis and presentation of results and conclusions – it means to prepare 'minds-on' and 'hands-on' activities." and p 136 "For some students and some situations, a clear teacher-centred way of teaching with a highly organised structure can be the most effective way of teaching. On the other hand, active engagement ('minds-on') is necessary for a successful learning process."

37 Barnett and Hodson, (2001), p. 443: "Table 1. The components of Science Teachers' Knowledge on the Knowledge landscape. (…) 200. Pedagogical Content Knowledge. 250 Use of Community Resources 251. Museums. 252. Business/Industry. 253. College/University. 254. Individuals."

38 Borghi L. et al (2000), p 40: "…future [science] teachers should be provided with opportunities to design instructional strategies that help pupils experiment in different areas the passage from their everyday experience to representations of formal physics."

39 Vander Borght C (2003), p. 180: "…[Teachers] should be educated in how to implement active teaching strategies and to relate events from everyday life with scientific contents."

40 HLG, EC (2004), p 115: "Context-based learning. The goal of enabling students to apply their concepts and competencies requires the highlighting of the connection between concept and context or situation. In some situations, daily-life concepts and terms are useful; in other contexts, only the scientific concept will be helpful in understanding or solving a problem. Misunderstanding the correct application of a concept or term cannot only cause mistakes and wrong answers – it also produces a feeling of incompetence in science in general. Therefore, contextualisation and decontextualisation become important for a successful learning process..."

41 HLG, EC (2004), p 117-118 :" if scientific and technological education is to meet the needs of the learners and be seen by them as relevant and meaningful, perhaps we should consider what the learners themselves find interesting and challenging.(...) But the concern about making S&T more relevant by concentrating on what is 'concrete, near and familiar' is not necessarily meeting the interests of the children. It seems that both boys and girls are more interested in learning about the possibility of life in the universe, extinct dinosaurs, planets, earthquakes and volcanoes than about food processing or soaps and detergents!"

42 Loughran J. (2003), p.243 : "Communication the personal learning of individual science teachers requires consideration of approaches to the sharing of ideas and information. (…). It is crucial that (…) an audience is able to access ideas in ways that help them to identify with the situation as well as being encouraged to respond appropriately to the situation, particularly in light of their own professional knowledge and actions."

43 Borghi, L. et al. (2000), p 40 : ibid. footnote 12

44 Macrae & Quintrell, (2001), p. 151: "It is essential for (…) teachers to have a forum in which they feel safe to discuss issues without fear of ridicule."

45 Van Driel and Beijaard, (2003), p. 108: "… the network appeared to have contributed substantially to the enhancement of the participants' PCK. In particular, the opportunity the participants had to discuss their experiences (…) with each other (…) was an important element that help the participants to understand student learning (…) added to the participants' awareness of strengths and weakness of various teaching strategies (…)."; p 110 "The impact of collegial interaction on the development of the participants' PCK was most evident in the final workshops. (…) In these discussions, each participant discussed his or her experiences in terms of an analysis of student learning difficulties they had noticed. These individual analyses were often recognized by other participants, who would then present their own analyses, which often led to in-depth discussions."

46 Dimmock & Lee, (2000) in Ritchie & Rigano, (2003), p. 49 : "Teachers leaders (…) are likely to help build a collaborative culture among staff so that resources, including ideas, can be shared for the benefit of all students."

2.2.2 Comparison with the Desired Competencies

As discussed earlier, the main effort of the project team was the development of a common set of Desired Teacher Competencies and their use as a baseline, both in characterizing Examples of Good Practices (EGPs) as well as in the design of an Effective Teacher's Profile. How do the attributes of this Profile relate to these Desired Competencies?

Tables 2.2 and 2.3 are presenting data relating to this issue. Table 2.2 shows those attributes of the proposed profile of the effective science teacher which are matched to the various competencies. Table 2.3 shows those attributes of the profile of the effecive science teacher which are unmatched to these competencies.

Table 2.2 *Comparison of the "Effective Science Teacher Profile" with the "Desired Competencies of a Science Teacher": Matched Attributes. The following attributes from the profile match the Desired Competencies, as shown.*

Attributes of an "Effective Science Teacher Profile" Matched to the Desired Competencies	Desired Teacher Competencies
"Degree in one scientific discipline, including a strong introduction to the others and a specialization in science teaching (included or separated from the science degree)."	**SMK 1**: Subject Matter Knowledge
"Expertise and interest in … the history and philosophy of science."	**SMK 2**: Nature of Science and Inquiry Knowledge/Skills
"Design interdisciplinary teaching/learning units linking science, technologies and society."	**SMK 3**: Multi- and Interdisciplinary Framing
"Expertise and interest in contemporary science."	**SMK 4**: Contemporary Science
"Organize student centered teaching/learning approaches, based on student's conceptions and needs and on a variety of learning strategies." "Design teaching units enhancing student self-directed learning." " keen to plan, organize and evaluate lessons so that all pupils are successful."	**PK 5**: Student-Centered Approach
"Ability to reflect on his/her work and to self-study." "Ability to use the results of research in science education." "Ability to work both individually and in a team."	**PK 6**: Independent and Life-Long Learning
"Being aware of the sense of purpose of what he/she teaches." " Share and talk about his/her practice with their peers and pupils."	**PK 7**: Self-Reflection and Meta-cognition
"Ability to use a large range of teaching/ learning strategies, and organizational and management strategies in order to create environments favorable to pupils motivation and success." "Design teaching/learning units leading pupils to become aware of the sense of purpose of what they learn (situated learning to making science more relevant to students)." "Design teaching/learning units that help pupils experiment in different areas regarding the passage from their everyday experience to representations of formal science."	**PCK 8**: Teaching/learning processes
"Organize "hands-on" experiments, enhancing learning by doing instead of learning by observing, and informal learning science in social and technological context, such as field trips, arranged visits to museums or to industries and institutions that engage in scientific or technological research."	**PCK 9**: Inquiry, Modeling, Guided Practice
"Design teaching units addressing student learning difficulties by using among other elements the results of current research in science education."	**PCK 10**: Student Learning Difficulties
"Integrate ICT in teaching/learning units."	**PCK 11**: Use of ICTs
	PCK 12: Knowledge and Use of Curricular Materials

Table 2.3: *Comparison of the "Effective Science Teacher Profile" with the "Desired Competencies of a Science Teacher": Unmatched Attributes. The following attributes from the Profile have not been located thoughout the project's survey as Desired Competencies.*

A. Personal Qualities:	B. Requirements and Duties
"dynamic and reliable"	"Ability to face innovation."
"enjoys teaching and his/her students"	
"demonstrates a willingness to know his/her students"	
"adapts and changes to meet their needs"	
"tolerates ambiguity"	
""is comfortable with not knowing	
"is a leader within the classroom and with colleagues"	

The implications of this data are discussed in detail in session 2.4 (Summary and Conclusions).

2.3 Examples of Good Practices in Science Teacher Training

In this section, we present a series of **examples of "Good Practices" in science teacher training** shaped into "pattern cards". Each participating institution was asked to experiment at least one out of these "Good Practices" in the framework of the project's implementation. Indeed, in a project devoted to harmonize science teacher education activities across Europe, it is of great importance to test them in diverse contexts and in differnt cultures. These pattern cards have been constructed in order to enable partners to select and fully implement the "Good Practices" in the different institutions. It has to be noted that all activities were implemented in the framework of the normal curriculum of the science teachers preparation programmes.

Each pattern card has been shaped as following:

- Title of the proposed activity
- Justification of the purpose
- Competence(s) to be developed by pre/in-service science teachers
- Didactical aims :what concepts of didactics are involved?
- Timing (each partner is planning to experiment their "Good Practice" in the normal curriculum)
- Materials (equipment, lesson plan, textbook, website,…)
- Assignments for the prospective students
- Organization of the class (group, Individual,…)
- Academic staff involved
- Guide to the tutor (how to manage the implementation of the proposed activities.)
- Bibliography needed for the realization of the implementation.

The portfolio (Evrard, Vander Borght, 1998) assesement method was adopted for the evaluation of the proposed case studies. Portfolio is a very powerful tool for preparing future teachers to develop their skills in self-study and reflection and to assess their performances.

Todoroff and Vander Borght (2002) have defined the portfolio as follows. A portfolio is

- a collection of structured documents that teacher can use
- a tool focused on learning issues
- a teacher assessment tool
- a dossier built by the student teacher
- a communication tool student teacher – secondary school teacher – teacher trainers (it can be read by teachers and/or teacher trainers)

"Portfolios can portray both the "what" and "why" of instruction. They can provide a forum for sharing examples of our teaching and for understanding about one's teaching… They should tell a story or paint a picture about one's performance, results and values as a teacher." (Tucker and al., 2002). Two kinds of portfolio were used:

- Learning portfolio that accompanies the student teachers during their teacher education. Students are asked to build progressively this portfolio during their teacher education curriculum. This tool will be used during the whole learning process and therefore will be developed and enriched with the improvement of the science teacher students. The students use the portfolio at each meeting with the mentor and the educators and during seminars devoted to integration of didactics contents and practice (lessons taught)
- Presentation portfolio in order to show the results of the learning issues and to conduct them to use more and more their competencies and to manage their lack. This one results from a personal selection of documents coming from the learning portfolio and from a personal synthesis

established by the student – teacher him/herself.

If the structure of the two portfolios remains similar, the function of those are different. Indeed, the "presentation portfolio" is used to assess in a certificative perspective while the "learning portfolio" provides a formative assessment tool.

In the following session the proposed case studies are presented in detail.

Table 2.4 displays an "at a glance" overview of the Examples of Good Practices (EGPs) to be implemented. Each partner institution chosed, implemented and assesed one or more EGP during the life-cycle of the project's run, using a cross-experimentation methodology, as described in the report of WP3.

In Table 2.4, the following columns have been set up:

- Title
- Desired Competencies Associated with the EGP,
- Subject
- Action/ Strategy
- Duration of EGP (number of hours)

How to introduce concepts of Didactics of Science: The case study of Digestion

Justification of the purpose

Science Education is taught to trainee teachers, as well as to in-service teachers. It should be paradoxical to introduce concepts of socio-constructivism by the way of a classical behaviorist / transmissive lecture.

During **the proposed sequence (3 hours)**, trainee (or in-service) teachers (coming from any scientific field) will practice successive steps from a single example, as an introduction to start to acquire some precise competencies (see below). This single sequence will probably not be sufficient to learn enough these competencies to know how to use them in any ulterior science teaching / learning sequence. Nevertheless, it will be a first step: to understand some didactical concepts (see below) and to start to acquire the related competencies.

Competence(s) to be developed by pre/in-service science teachers

The specific case study supports SMK1, PK5, PK6, PK7 and PCK8 from the desired competencies. A science teacher has to know how to identify the conceptions of their students, related to a precise scientific topics, and then how to use them. That means :

- What kind of question to ask to students ?
- How to categorize and analyze the students' answers ?
- How to identify the students' conceptions?
- How to analyze the origins of these conceptions?
- How to identify, from these conceptions, the different types of obstacles to learn a precise scientific topic?
- How to define, from the identification of these obstacles, possible didactical strategies, taking them into account?

Didactical aims: what concepts of didactics are involved?

This proposed sequence is a possible introduction of some concepts of Science Education ("Didactics of Sciences") :

- Situated conceptions
- Conceptions
- Epistemological obstacles
- Didactical obstacles
- Goals-obstacles
- Metacognition
- Pedagogical / didactical strategy ; didactical situation
- Conceptual changes

Timing: organization of the class and guide to the tutor (how to manage)

3 hours

General context:

- A teaching / learning sequence of 3 hours
- Number of students : if possible < 30 (nevertheless, it can success with more students, and it is also possible with few students, as 10 to 15 students)
- Students = in-service science teachers, or trainee teachers, or trainee researchers in Science Education (any field of Science).
- Context : Starting a course on Science Education

Precise timing and management :

- Short introduction : 5 minutes. Then each student answers to 2 successive questions on the same sheet1 : < 15 minutes

- The students organize themselves in groups (3 - 5 students), each around a table: 10 minutes. During this time, the teacher (or somebody else) numbers each sheet, and then photocopies all the sheets for each students' group. Then the teacher explains the goals of the students' work2 (<5 minutes)
- Each students' group works from the photocopies, categorizing the drawings (only the answers to question 1) and then writing their results on the blackboard (or on some collective transparencies): 40 - 60 minutes. A 10 minutes pause is possible at this moment (each group is ending at its own rhythm).
- Each group shortly explains its results to the others (2 minutes by group) : 10-15 minutes
- General discussion about the criteria of categorization3; consensus for some main criteria: with or without blood; % of "continuous tubing" (conception A). The teacher shows the results obtained from other comparable samples : the high % of continuous tubing is not specific of this group : 10-20 minutes
- General discussion about the origin of the continuous tubing conception. Comparison of answers to questions 1 & 2. The teacher organises the discussion, and introduces, when it is appropriate, the concepts of "situated conceptions", "conceptions", "epistemological obstacles" 4 : 15-20 minutes
- The teacher shows examples of pages of textbooks (for 7 – 8 years old children) and introduces the concept of "didactical obstacles"5. And then the concept of "psychological obstacles"6. The teacher makes a clear synthesis of all the concepts of Science Education introduced from this example of digestion / excretion, and discusses with students to suggest other examples which can illustrate theses concepts: 15-20 minutes
- Discussion on the pedagogical / didactical consequences of the identification of the different types of obstacles (pedagogical / didactical situ-

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1 *The teacher: "You will answer to two successive questions, on the same sheet. Briefly but as precisely as possible. The answer is anonymous (only precise is you are male or female; and, if there are different scientific disciplines, precise if you are biologist or other sciences). That is not a control of your knowledge, with a notation. It is only to try to understand what you have in your head about the 2 questions. Do not copy to your neighbour: express your own individual ideas!"*

Question 1. "You are running, it is warm, you are thirsty: you drink a litre of water. You know that, some minutes after, you will want to go to urinate! What happens to the water in your body after you drank it, before you go to urinate ? Draw its path in your body, and label your drawing."

N.B. : Do not accept any question ! Because any comment will influence the answers.

Then the teacher is waiting during some minutes, just asking the students to hurry up. When all the students have finished their drawings, the teacher asks the students to answer to a second question on the same sheet (and to add no change to their answer to the question 1)

Question 2 : "Your sister had lost her precious ring in a plum jam. You just realised that after you swallowed it ! You decide to wait one day to take it at the exit … Draw the path of the ring in your body after you swallowed it and before it goes out. Label your drawing."

Then the teacher gathers the sheets.

2 *Here, the teachers briefly explains (if possible from a drawing) that all the absorbed water is going to blood and the in all the body. Only a part of the blood (and not necessarily the absorbed water) is then going outside by the way of the kidneys then the bladder.*

3 *Generally, students use several criteria for their categorisations. It is allowed. The only orders were to explicit each kind of used criteria. From the general discussion, the usefulness of each kind of criteria can be discussed. For example, the goal was not to judge the drawings, to put notation (as a teacher is generally doing), but to try to understand them (as a researcher does). The categories "with schema vs with only text" are possible, but not very useful in a didactics perspective. In this perspective, the presence or absence of blood is more interesting, as is the eventual direct continuity between the digestive tract and the excretory apparatus (continuous tubing, as intestine going directly into the bladder).*

ations and strategies, syllabus, …), with eventually the introduction of the notion of metacognition: 10-15 minutes

- Evaluation of the sequence: learning as a conceptual change: what learning about digestion / excretion ? What learning about the concepts of Science Education ? 10-15 minutes N.B.

- The indicated times are approximate and can be adapted.
- If there is more than 20 students, each students' group can work only from a part of the drawings (15 to 20 drawings by group)
- 4 hours are sometimes better than 3 hours.

Materiel (equipment, lesson plan, textbook, website,…)

1) Possibility to do fast photocopies of the students' drawings
2) Over head transparencies (or power point) to show other images (from bibliographic references : see below, or from your own previous results)
3) Eventually, scholar textbooks of Primary School to identify didactical obstacles

Theoretical background :

- General references : most of the science education works are concerning the conceptions and the conceptual changes (for some synthesis : e.g. in French : Astolfi et al 1993, 1997a; in English : Pfundt & Duits 1994, and the IPN site in Kiel).
- References concerning conceptions on digestion / excretion : Clément 1981, 1991, 2001a, b & c, 2003a & b, and also Carey 1985, Giordan & de Vecchi 1987, Sauvageot-Skibine 1993, Astolfi et al 1997b, Teixera 2000, Psarros & Stavridou, 2001, Kammoum et al 2002, Carvalho et al 2004.

The most useful references (in English):

- A more precise description of this teaching / learning sequence can be consulted on the STEDE website : final report of the micronetwork 6a :

  Clément P., (2003) - An interactive teaching / learning sequence to introduce the concepts of conceptions, obstacles and conceptual changes (from the example of digestion / excretion). In http://www.biol.ucl.ac.be/STEDE/

  www.biol.ucl.ac.be/STEDE/levels/archives/Final_report_02_03/ micro_product_0203pdf/6a_ESERA_poster.pdf

  Included in this text are some students' drawings, a scholar textbook figure, and short definitions of the main concepts of Science Education introduced by this sequence. The precise references of the just above cited works are also in this work

- A survey of the main results obtained from different students samples (biologists, and not biologists, first and second years of the University, trainee teachers, …) is published in :

  Clément P., (2003) Situated conceptions and obstacles. The example of digestion / excretion. In D. Psilos ed., Proceedinds of 3th ESERA Meeting : Science Education Research in the Knowledge-Based Society, August 2001, Thessaloniki, Kluwer Academic Publishers, pp.89-98.

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4 *Here, the epistemological obstacle is the permeability of the wall of the intestine and of the capillaries : the wall of the every day tubes are not permeable!*

5 *Generally, the blood, and the circulatory apparatus, are not drawn near the digestive tract when there is the first figure of the digestive tract and digestion.*

6 *The question of the permeability of a "wall" is very general : our own skin, a room, our house, our car, our garden, borders of a country and also Shoengen Space, etc.*

- Results coming from Primary School pupils are in press (2004):

Carvalho G., Rui S., Lima N., Coquet E. & Clément P. - Portuguese primary school children's conceptions about digestion: Identification of learning obstacles. International Journal of Science Education. (in press)

In French, you can also read :

Clément, P., (2003) Didactique de la Biologie : les obstacles aux apprentissages. In G.S. Carvalho et al., Saberes e Praticas na Formação de Professores e Educadores. Braga, Univ do Minho, pp 139-154.

Clément P., (1994) Représentations, conceptions, connaissances. In A.Giordan, Y.Girault, & P.Clément, Conceptions et connaissances. Berne: Peter Lang, pp.15-45.

Clément P., (1991) - Sur la persistance d'une conception : la tuyauterie continue digestion-excrétion. Aster, 13, p.133-155.

"Life in Winter": Interdisciplinary project integrating Biology, Physics, Math and Computer Sciences

Justification of the proposition

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 a thirteen year experience of 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 goal. For in-service and pre-service teacher as well, any understanding of natural phenomena within every day life and the environment requires an interdisciplinary methodology. Any didactical reduction of most complex biological systems calls for an integrated application of contents of the different subjects within different disciplines of science at least. Modern approaches, therefore, try to overcome the century-long division in the three separate subjects Biology, Chemistry and Physics without falling back into the natural history tradition of the 19th century. This subdivision of Natural Sciences has a long history within the education sector. Even within every subject further subsubjects are established such as molecular biology or genetics. Additionally, we can include the returns of computer sciences (for instance, for modeling relationships or documentation purposes) without neglecting the advantages of hands-on-science. Integration of such a subject-integrative approach with an ICT focus should be obvious to the science teacher training in order to make them competent to the section of needs.

Competence

General competencies include all the teacher personal attitudes / beliefs / values with regard to the general subject matter knowledge as well as the beliefs and attitudes about teaching and learning

Specific competencies

- SMK1: Competencies related to subject matter / content knowledge
- SMK2: Competencies in framing a discipline in a multidisciplinary scenario
- SMK4: Competencies in disciplinary knowledge of contemporary science
- PK5: Competencies in mastering and implementing a variety of (especially student-centered) instructional strategies and assessments attending to individual differences
- PK6: Competencies in sustaining self -learning
- PK7: Competencies in sustaining autonomous life-long learning
- PCK8: Competencies related to the area of teaching/learning processes within the domain
- PCK11. Competencies in the use of ICTs

Programme

The unit "Life in Winter" provides a specific example of interdisciplinarity. It is a 6-lesson hour unit and due to its self explaining structure it could be introduced to every secondary school class (9th grade). Specifically it was designed for the Medium Stratification [Realschule] but is also suitable for a freshman course at university. The participants are working in tandem groups or alone on a computer.

The overall structure of the unit is displayed in Table 1. Both subjects, Biology and Physics, are integral part of the programme and are always linked to each other, i.e. the unit is suitable for Physics and Biology classes as well. The central unit builds upon a animal which has to survive harsh winter conditions. Students learn about the biological and physical details and they have to use this knowledge to “design” an artificial animal called “Nigno” (providing sufficient insulation, considering the body size, allowing for nutrients etc.). The students have to take into account the potential loss of body energy due to convection, energy transfer, radiation and evaporation, as well as simultaneously the given opportunities to avoid energy losses. Knowledge from both subjects, Biology and Physics, has to be integrated in order to reach optimal conclusions.

Although few static diagrams cannot show the design of the interactive programme, for a short illustration, five different scenes are detailed below. Additionally a mapping plan gives an imagination of the integrative design.**Theoretical background**

Science education is not taught as a subject in German universities. We even do not have a single word for “science” in the specific term as it is used in the English language. In German schools there is a “Physics Education”, a “Biology Education” and/or a “Chemistry Education”. Consequently, teachers generally emphasize the individual disciplines, their differences and distinct domains rather than the coordinating and complementary aspects when they mean science education. However, new introduced curricula demand science education although teacher were not being trained in this context (see below).

Many significant concepts in science (not just in biology or chemistry or physics) cross our arbitrary disciplines continuously while discipline-centred teaching builds upon the philosophers of science. Nevertheless, universities around the world house their science teacher preparation programs in individual science departments, leading to separate programs for biology education, chemistry education, and confining them in separate compartments. This department fragmentation escort numerous problems, especially since few teachers have the time or opportunity to study the pedagogy as offered in each of the science departments and in most countries few teachers have the luxury of teaching only one subject. Therefore, the question arises whether trainee teachers should not be offered an opportunity to study with teachers with strong backgrounds in other subjects rather than in disparate discipline-centred programs? This would be even more important due to the lack of any evidence that chemistry teaching relies on different underlying research related to how students learn, how excellent teachers teach, or that classroom climate in chemistry must be distinctly different than the classroom climate in biology or physics.

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. Furthermore, overcoming the compartmentising of the different subjects is increasingly requested. This approach is accompanied by the belief that most students learn best working with meaningful problems and issues in real-world, and in collaborative groups where communication is of the essence. Additionally, most problems in science are closely linked to each other, for instance, studying photosynthesis is difficult to perform without studying the physics of light, the chemistry of light reactions, and energy flow and use in the cell. Consequently, as in the real world where successful people integrate their knowledge as they resolve the problems they face, children in our schools should learn to integrate all of their knowledge, bringing all of their resources to bear on whatever problem they are facing. Similarly, science topics could feature problems and issues that require the use of specific science concepts and skills from various science disciplines where students are expected to use this same combined language in their responses.

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). Furthermore problem solving is seen as a means for learning, not just as a goal. Students should learn a range of topics from all the major disciplines, emphasizing active learning and the simple use of tools such as, for instance, computers. Therefore the described approach follows an object-oriented and conservation-related approach (c.f., bird migration) as well as a process-oriented rationale (c.f., visual process). A selection of those contents facilitates a subject-integrative approach by highlighting a practice-related access, a content-relatedness of factual knowledge, an access to different methods of work and a problem- and hands-on-related access as well. Many students (and teachers as well) complain a lack of skills of teaching integrated science due a lack of knowledge to teach all three subjects simultaneously and of and confidence of science. Consequently, appropriate opportunities to learn in integrated settings are required which enables students to match current standards by being inquiry-oriented, activity-centred, and overtly constructivist in approach. Students should be given sufficient opportunity to develop more maturity, communication, and laboratory and reasoning skills in the context of learning science in an active learning environment. This also belongs to the consequences derived from his studies. An inquiry-centred, integrated curriculum provides students with numerous problems and activities in science to gaining a concrete experience with materials, a systematic development of science concepts from direct experiences, leading to appropriate applications. Many of the activities should include true experimentation. As a result, studying fewer topics with more depth, will lead to better understanding and retention of concepts rather than attempting to cover more material in the same period of time.

Consequently, for the training process of pre-service teacher, the training contents focus on

(i) the use of pictures and illustrations for different purposes in science education (Levin, 1981, Issing, 1983, 1990, Kircher et al., 2001, Girwidz, 2002) and offer multiple codings. We combine this with an introduction of modern techniques in order to visualize selected contents: Students learn about basic principles of digital photography as well as document adjustment to websites; this includes a designing of real websites as well as its didactical appliance with a science educational framework.

(ii) material development which favour a "situated learning" (Brown et al., 1989, Cognition & Technology Group at Vanderbilt, 1993, Lave, 1988, Lave & Wenger, 1990, McLellan, 1995), providing a visual access to daily-life situations (including those which in general may not be available within classroom situations). Subsequently contents and problems may easier be detailed in a natural context (which by itself is generally seen as a precondition of a situative learning environment).

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Simulations of metaClassical and Classical Models of microCosmos– Atoms and Molecules

Justification of the proposition

In order to enhance students' comprehension of contemporary physics, simplified versions of scientific and historical models should

- be transformed to curricular / educational models (Gilbert, Justi and Aksela, 2003),
- be applied following an appropriate method and accompanied with special supporting material (software) –including simulations and dynamic visualization– (Kalkanis et al, 2003).

A. Competences

SMK.1 Competencies related to subject matter / content knowledge

- communicate scientific content knowledge
- Epistemological competence on models building, and on the functions and limits of each model

SMK.4 Competencies in disciplinary knowledge of contemporary science

PCK. 8 Competencies related to the area of teaching/learning processes within the domain

- transform scientific content representations into ones suitable for teaching

PCK. 11. Competencies in the use of ICTs

- design and organise science teaching and learning activities including simulation and modeling packages.

B. Practices

- epistemology (i.e. Epistemological competence on models building, on processes of the students' modelisation, and on the functions and limits of each model)
- Science Education (i.e. Competence on analysis of learners' conceptions on a scientific topic, before teaching this topic, and after this teaching to evaluate the eventual conceptual changes and the didactic transposition of the contents)
- didactical transposition and use of language (i.e. Competence on adaptation of the scientific language in a language adapted to children)
- Use of Instructional Technology (i.e. simulations / visualizations)

Didactical aims (what concepts of didactics are involved?)

- to help students understand that macrocosm is a synthesis of probabilistic processes of microcosmos
- to familiarize students with simulations processes
- to help students comprehend meta–classical principles by an educational / curricular meta–classical model (produced by a meta–classical scientific model)

Methodology

Parallel introduction of the scientific models of the meta-classical and classical physics (Kalkanis et al, 2003)

Timing

7 hours

Technology and Material (equipment, lesson plan, textbook, website,…)

Simulation educational software

Student worksheets

Assignments for the prospective students

Search the Internet for relevant models and applets

Organization of the class (group? Individual,…)

Groups of three persons

each group working on a PC

Academic staff involved

Two persons (instructor and an assistant person)

Guide to the tutor (how to manage)

Written instructions

Bibliography – Existing experience

Dimopoulos V., Kalkanis G., (2003) An introduction of microcosmos quantum model to students of limited mathematics and science background supported by computer simulations / visualizations, 4th ESERA Conference Proceedings, Noordwijkerhout, The Netherlands

Gilbert J., Justi R., Aksela M., (2003) Visualization: A metacognitive competence in the learning of science, 4th ESERA Conference Proceedings, Noordwijkerhout, The Netherlands

Kalkanis G., Hadzidaki P., Stavrou D., (2003) An Instructional Model for a Radical Conceptual ChangeTowards Quantum Mechanics Concepts, Science Education 87: p. 257 – 280

Good Practice Pattern Card

Environmental / Ecological project(s) based on the Scientific Method and enhanced by Systemic Analysis – Science and Interdisciplinarity

Justification of the proposition

Science, interest, awareness, practice/experimentation, Knowledge, decision, action, is all components of environmental educations' process and environmental protection and policy

A. Competences

- **SMK1. Competencies related to subject matter / content knowledge**

  Communicate scientific content knowledge

- **SMK3. Competencies in framing a discipline in a multidisciplinary scenario**

  Awareness of multidisciplinary supports

- **PCK8. Competencies related to the area of teaching/learning processes within the domain**

  Transform scientific content representations into ones suitable for teaching

- **PK5. Competencies in mastering and implementing different teaching styles and methods**

  Mastering of procedures involved in teaching/learning activities

B. Practices

- Methodology (i.e. Competence on imagining processes of analysis and validation of the students works, of their hypotheses and conjectures)
- Inquiry (i.e. Competence on reflecting on, and constructing, knowledge from data)
- Evaluation – Assessment (i.e. Competence on measuring and evaluating of students learning in a variety of dimensions)

Didactical aims

- To familiarize students with the complexity of environment
- To make loud and clear the relations and interactions of the parameters of environmental systems
- To be able to study the elements of each environmental parameter by several/different means
- To be able to design, apply and evaluate an environmental project
- To familiarize students with the scientific method: trigger of interest, making hypothesis, experimentation, conclusions, generalization

Materiel (equipment, lesson plan, textbook, website,…)

Easy found material for the experiments

Student worksheet

Sensors and actuators

Timing

6 hours

Assignments for the prospective students

Proposing experiments and models in order to describe environmental phenomena

Bibliography – Existing Experience

Regarding the above statements and referring to the background to each category, we recommend the following:

1. Concerning the title of example, Scientific methodology/Systemic analysis, science and interdisciplinarity:

Straga, S., Kalkanis, G. (1999) The scientific method enhanced by systemic analysis –fieldwork - educational material - information technologies, as a sequence of supportive approaches in present and future Environmental Education, Workshop on Environmental Education for Sustainable Future, Indian Environmental Society, New Delhi, India, 1999

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FIREES (1995-1997) European project (Formation Interdisciplinaire aux Relation Energies – Environment – Société), carried out by five Universities from five countries/members of the E.U., aiming the development of the methodology and the educational means for promoting the interdisciplinary subject of Energy-Environment-Society 1995-1997

2. Concerning the actions and strategies we recommend the following:

National Program (E.U fund): Teachers Education on the Environmental Education, five seminars to 250 Greek teachers of primary and secondary education, Greece, 1999-2000

Concerning the precise examples we recommend the following:

FIREES (1995-1997) European project (Formation Interdisciplinaire aux Relation Energies – Environment – Société), carried out by five Universities from five countries/members of the E.U., aiming the development of the methodology and the educational means for promoting the interdisciplinary subject of Energy-Environment-Society 1995-1997

FIREES, Athens' (sub) project (1996-97), Environmental Education (micro-) projects on the World Wide Web Project/subject title: "Energy Equilibrium at Buildings - School and energy"

Kalkanis G., (1997), Energy and its Sources – What, How, Why? A book for students and teacher, Greek center of Renewable Energy Sources (CERES), Athens.

Patrinopoulos, M., Imvrioti, D., Dimopoulos, V., Sotiropoulos, D., Tsagogeorga, A., Papatsimba, L., Dimitriadis, P., Kalkanis, G., (2001) Visualizing and measuring by the computer the operation of hands-on educational devices – The case of solarheater, Sixth Workshop on Multimedia in Physics Teaching and Learning of the European Physics Society, Ghent 2001

Good Practice Pattern Card

Experimentation in Science Laboratory – Measurements with Sensors / Actuators – Physics, Chemistry, Biology

Proposition

A combination of laboratory practice with multiple but flexible polymorphic experimental devices, based on sensors and actuators connected to the PC, supported by appropriate educational software and designed according to the scientific/educational method.

Justification of the proposition

Embodying laboratory practice at educational practice seems to be important as regarding the effectiveness of science education.

Linking science education with technology applications and common devices.

Easy and timesaving way of data logging leaving time for commenting on data

A. Competences

- PCK11 Competencies in the use of ICT

  Using sensors and actuators in Computer Based Laboratory

  Design and organise science teaching and learning activities based on ICT

  (Computer Based Laboratory)

- PCK9 Competencies in the use of laboratories and experiments

  Design and organise science teaching and learning activities based on ICT

  (Computer Based Laboratory)

- PK7. Competencies related to self-reflection and meta-cognition

  Imagining processes of analysis and validation of the students works, of their hypotheses and conjectures

B. Practices

- Methodology

  (i.e. Competence on imagining processes of analysis and validation of the students works, of their hypotheses and conjectures)

- Use of Instructional Technology

  (i.e. competence on using sensors and actuators in Computer Based Laboratory)

Didactical aims

- To familiarize students with using ICT in physics, chemistry and biology
- To familiarize students withautomatization
- To familiarize students with the scientific method: trigger of interest, making hypothesis, experimentation, conclusions, generalization
- To facilitate data acquisition and processing
- To trigger students' interest

Methodology

Application of the scientific method: trigger of interest, making hypothesis, experimentation, conclusions, generalization

Timing

8 ½ hours

Materiel (equipment, lesson plan, textbook, website,…)

- Sensors and actuators
- User Interface
- Everyday material for the experiments
- Educational Software
- Paper worksheets

Assignments for the prospective students

Proposing and conducting experiments using sensors / actuators

Organization of the class

Groups of three persons

Each group working on a PC

Academic staff involved

2 persons (instructor and assistant)

Guide to the tutor

Electronic guide incorporated in the educational software

Bibliography – Existing Experience

Kalkanis, G., (2001), Which (and how) science and technology education for future citizens? (invited talk), 1st IOSTE Symposium in Southern Europe, Science and Technology Education: Preparing Future Citizens, Paralimni, Cyprus.

Patrinopoulos, M., Imvrioti, D., Dimopoulos, V., Sotiropoulos, D., Tsagogeorga, A., Papatsimba, L., Dimitriadis, P., Kalkanis, G., (2001), Visualizing and measuring by the computer the operation of hands-on educational devices – The case of solar heater, Sixth Workshop on Multimedia in Physics Teaching and Learning of the European Physics Society, Ghent, Belgium

Cees Mulder, Ellermeijer T., (2001) Is there a place in investigations for computer based modeling?, Third International Conference of the ESERA, Greece

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Kalkanis, G. (1996), "The Monte Carlo Techniques as a tool in Physics Education - Applications to microcosmos processes" (invited workshop), 1996 GIREP-ICPE Conference: "New ways of teaching Physics", Ljubliana, Slovenia

Niedderer, H., Schecher, H., (1996), Laboratory tasks with MBL and MBS in introductory physics classes for prospective high school teachers, International Conference on Undergraduate Physics Education (ICUPE), University of Maryland, USA

Use of Real-Time Experiments and Images to address the Inversions of motion and impulsive forces

Justification of the proposition

- Motion inversions are frequently encountered in the study of one dimensional motion, as well as in many common situations as e.g. in collisions, bounces of a ball on the floor.
- In the case of collisions the study of motion inversions involves understanding the role of impulsive forces, which is a very difficult subject.
- RTEI makes it possible to address impulsive forces and accelerations and focus on the related learning difficulties.
- Addressing many learning difficulties one encounters in the study of impulsive forces makes it possible to better understand the role of initial conditions, of Newtons' Second Principle etc
- This kind of presentation allows to introduce at the same time kinematics and dynamics aspects of the impulsive forces

Competences

PCK 11. Competencies in the use of ICTs

- To be able to use/exploit Real Time Experiments mainly as cognitive tools and not only as technological ones.
- To be able to read/interpret Images obtained in Real-Time Experiments and to be aware of students' iconic difficulties.
- To be aware of RTEI role in addressing key disciplinary issues.

PCK 10. Competencies in addressing students' common sense knowledge and learning difficulties

- To be aware of research results on disciplinary nodes related to inversions of motion, impulsive accelerations and forces

PCK 8. Competencies related to the area of pedagogical content knowledge versus disciplinary / subject matter knowledge

- To value students' naïve ideas and reasoning strategies in order to transform them in disciplinary knowledge and address possible cognitive conflicts about impulsive forces

Didactical aims

- To address the main issues about impulsive forces and accelerations and to focus on learning difficulties, both eliciting and addressing them
- To focus on those iconic aspects of collisions which allow to distinguish between inversion in air and on the floor
- To focus on the forces responsible of the type of motion in different time intervals
- To have the students familiarize with the use of ITC, sensors and software of data acquisition
- To have the students focus on the richness of information provided by the experimental real-time graphs, and the links with possible abstract models

Methodology

- To start from student' common sense knowledge, as a cognitive resource.
- To relate perceptive observations of the studied phenomenon with abstract representations of Real-Time graphs
- To implement the Rationale "from Real to Ideal": exploration of real/familiar phenomena, identification of phenomenological regularities which are then transformed in rules, modeling these rules with simple mathematical functions and abstraction toward the ideal case/model.
- To implement the learning cycle: Prediction,

Experiment Comparison (PEC) which is greatly facilitated by RTEI approaches

- To integrate Real-Time experiments with traditional lab-work activities
- To integrate kinematics and dynamics aspects addressing both impulsive accelerations and forces

Timing

8 hours

Material (equipment, lesson plan, textbook, website,…)

- Sensors and software data acquisition (for instance Logger Pro, MBL…)
- Material for the experiments (masses, springs, balls)
- Paper worksheets

Assignments for the prospective students

Proposing and conducting experiments using sensors

Filling Lab Worksheets during experiments

Assigning reflections about the addressed theme as homework

Organization of the class

Groups of two/three persons

Each group working on a PC with real-time software

Academic staff involved

2 persons (instructor and assistant)

Bibliography – Existing Experience

Monroy G., Sassi E., Testa I., Lombardi S. (2001). Teachers' adoption of Real-Time approaches: transforming trends and research-based training materials. In Proceedings of Third International ESERA Conference on Science Education Research in the Knowledge Based Society, Thessaloniki, August 2001

Monroy G., Testa I, Sassi E (2000) Teachers' interpretation of students' difficulties when reading images: the case of real- time kinematic graphs", In R. Pintò & S. Surinach (ed.) Proceedings of the International Conference Physics Teacher Education Beyond 2000. CD Production Calidos,Barcelona

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Thornton, R. K. and Sokoloff, D. R., (1997). Real-Time Physics: Active Learning Laboratory. In The changing role of Physics Departments in Modern Universities, Proceedings of the ICUPE, ed. by E.F. Redish and J.S. Rigden, AIP, Woodbury, NY, pp. 1101- 1118 : http://ase.tufts.edu/csmt/html/papers.html

Viennot.L., et al. (1996) Raisonner en physique: la part du sens commun, Louvain-la-Neuve: De Boeck.

Use of Real-Time Experiments and Images (RTEI) to address the Oscillations of mass-spring systems

Justification of the proposition

- The theme of the oscillations of a mass-spring system is addressed in all physics curricula and the students encounter frequently many learning difficulties related to e.g. the understanding of the role of the initial conditions, the relations amongst mass, elastic constant, period.
- The approximation of "small oscillations" where the force can be treated as "elastic" is very frequent in many physical situations.
- This kind of presentation allows to introduce at the same time kinematics and dynamics aspects of the oscillatory motion

Competences

PCK 11. Competencies in the use of ICTs

- To be able to use/exploit Real Time Experiments mainly as cognitive tools and not only as technological ones.
- To be able to read/interpret Images obtained in Real-Time Experiments and to be aware of students' iconic difficulties.
- To be aware of RTEI role in addressing key disciplinary issues.

PCK 10. Competencies in addressing students' common sense knowledge and learning difficulties

- To be aware of research results on disciplinary nodes related to inversions of motion, impulsive accelerations and forces

PCK 8. Competencies related to the area of teaching/learning processes within the domain. To value students' naïve ideas and reasoning strategies in order to transform them in disciplinary knowledge and address possible cognitive conflicts about impulsive forces

Didactical aims

- To address the main issues about oscillatory motions and to focus on learning difficulties, both eliciting and addressing them
- To make plausible the model of free mass spring oscillations
- To understand the role of elastic-type forces in the small oscillations approximation
- To have the students familiarize with the of ITC, sensors and software of data acquisition
- To have the students focus on the richness of information provided by the experimental real-time graphs, and the links with possible abstract models

Methodology

- To start from students' common sense knowledge, as a cognitive resource.
- To relate perceptive observations of the studied phenomenon with abstract representations of Real-Time graphs
- To implement the Rationale "from Real to Ideal": exploration of real/familiar phenomena, identification of phenomenological regularities which are then transformed in rules, modeling these rules with simple mathematical functions and abstraction toward the ideal case/model.
- To implement the learning cycle: Prediction, Experiment Comparison (PEC) which is greatly facilitated by RTEI approaches
- To integrate real time experiments with traditional lab-work activities
- To integrate kinematics and dynamics aspects of the oscillatory motion

Timing

8 hours

Material (equipment, lesson plan, textbook, website,…)

- Sensors and software data acquisition (for instance Logger Pro, MBL…)
- Material for the experiments (masses, springs,)
- Paper worksheets

Assignments for the prospective students

Proposing and conducting experiments using sensors

Filling Lab Worksheets during experiments

Assigning reflections about the addressed theme as homework

Organization of the class

Groups of two/three persons

Each group working on a PC with real-time software

Academic staff involved

2 persons (instructor and assistant)

Bibliography – Existing Experience

Monroy G., Sassi E., Testa I., Lombardi S. (2001). Teachers' adoption of Real-Time approaches: transforming trends and research-based training materials. In Proceedings of Third International ESERA Conference on Science Education Research in the Knowledge Based Society, Thessaloniki, August 2001

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Viennot.L., et al. (1996) Raisonner en physique: la part du sens commun, Louvain-la-Neuve: De Boeck.

Modeling Physical Reality: from observations to descriptive models to interpretative models

Justification of the proposition

To provide student-teachers with learning environments and computational tools that will help them to express and reflect on their concepts and ideas about phenomena and support their activities concerning exploration, experimenting and modelling

To implement teaching methods aimed to make the trainee teachers aware of the strategies to put into action in filling the gap between the physics content to be taught and the pupils' knowledge relevant to find explanations for the involved natural phenomena.

Areas of competences explored (according to WP1categorisation)

A. Content Knowledge

Knowledge about the disciplines

- Understanding of methods and processes of science;
- Understanding of the unifying role of models and modelling procedures;
- To be aware of students' learning difficulties in sketching microscopic behaviors
- To be aware of students' previous ideas and reasoning strategies about microscopic properties of gasses
- To be able to connect the observation of phenomena to their representations and models acknowledged in the disciplinary structure;

B. Pedagogical content Knowledge.

Teaching/learning processes

- Transform content knowledge in a appropriate knowledge for teaching;
- Perform a reconstruct of subject knowledge appropriate for teaching.
- Use various models and representations in order to fit student reasoning;

Pedagogical methods and tools scaffolding learning

- Use Information Technologies as cognitive tools;
- Use Computers as laboratory tools;
- Use Computers for different representations (verbal, iconic, mathematical,..) of the same data;

Awareness of relevant characteristics of students' common-sense knowledge.

- Identify students' mental models of reasoning;
- Search for students' naïve ideas
- Identify learning/teaching difficulties;

Didactical aims

- To modify the high school physics teaching approach by a procedure of transmission of consolidated knowledge to the implementation of teaching/learning environments where teachers manage and support the pupil's processes of knowledge construction, involves a deep modification of the structure of the teacher training courses. The proposal, from a didactical point of view , is aimed:
- to make TTs experience the same teaching/learning environments we think they have to provide to their pupils;
- to apply teaching methods based on learning by doing and metareflection.

Timing and Assignments for trainee teachers

The Trainee Teachers work is organised according to the following five phases:

I. TTs analyse worksheets and pictures describing/representing phenomena involving behaviours of gases (mainly air) and describe/explain them describe phenomena by identifying relevant variables and infer their relationships.(~1 h).

II. TTs analyse the answer sheets of some questionnaires and/or recorded interviews, previously administered to high school pupils in order to draw their common conceptions and reasoning (mainly, questionnaires and interviews, reported in literature (~1 h).

III. TTs program appropriate experiments (using equipment at disposal) perform them and verify the validity of the previously inferred relationships among the variables analised (~3 h).

IV. TTs research for appropriate explicative models by inferring microscopic properties of gases and experimenting their behaviors using simulations (~3 h).

V. As final step simulation results are compared with experimental results (~1 h).

Materials (equipment, lesson plan, textbook, website,…)

- Sensors and Interfaces
- Material for the experiments
- Modelling Software
- Paper worksheets
- http://griaf.dft.unipa.it/TermoMod/Default.htm

Assessment

- Analysis of TTs worksheets
- Final report prepared by TTs (defining in detail small teaching-learning sequences for high school classroom activities).

Organization of the class

Groups of three/four persons (each group working on a PC)

Academic staff involved

2 persons (instructor and assistant)

Bibliography about our experience and results

Aiello-Nicosia, M.L. and Sperandeo-Mineo, R.M. (2000): Educational reconstruction of the physics content to be taught and pre-service teacher training: A Case Study, International Journal of Science Education, 22, pp 1085-1097

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Involving the Pre-Service Science Teachers in Action Researches. Application at the Theme "Electric Circuits - d.c." - Students' Naive Ideas

Justification of proposition

The theme "Electric Circuits - d.c." is studied in secondary school, of course at different levels, depending of the students' age: 11-12 years, 13-14 years, 15-16 years. The theme is also studied in the frame of the "Babes-Bolyai" University at the Faculty of Physics.

In the teaching/learning process of this theme it is absolutely necessary to combine, in a very good "well-balanced" way, the modelling (iconic and symbolic) and the experimental activities.

The literature describes an ensemble of students' naïve ideas (conceptions/misconceptions) and some mental models of reasoning (natural reasoning) referring to the mentioned theme. Some of these conceptions could be found in the didactic transpositions from the physics' schoolbooks.

Generally speaking our pre-service and in-service science teachers are not initiated in the achievement of action researches.

Competences: The pre-service science teachers must have:

Didactical competencies

- Appreciate difficulties of subjects in learning subject matter content (Physics, "Electric Circuits- d.c.").
- Help subjects to understand the scientific process and to use science knowledge in learning subject matter content.
- Identify subjects' mental models of reasoning.
- Search for subjects' naïve ideas (conceptions).
- Project the teaching/learning activities centered on overcoming subjects' naive ideas (conceptions).
- Realize or try to realize the established project.

Note: Subjects means: trainee science teachers or students belonging of the secondary school. For example, a student teacher can search the naïve ideas of his/her colleagues or the naïve ideas of pre-university students.

Pedagogical competencies

- Observe and analyze teaching and learning practices.
- Design and organize science teaching and learning activities.
- Evaluate and regulate teaching and learning process (and take into consideration the "backwash effect").
- Teaching through interaction with his/her students in all activities.
- Integrate him/her self into a process of didactic research.

Atitude

- Awareness about subject's own conceptions.
- Known oneself and be able to change oneself.
- Critical attitude of one's own activity.

Communicate scientific knowledge

- Set of students' naive ideas concerning "Electric Circuits- d.c." scientific content.
- Knowledge of methodology, procedures and activities involved on action research.

Didactical aims

To support and train pre-service science teachers regarding methodology, procedures and activities involved on action research;

To involve the pre-service science teachers in action researches centered on investigation and overcoming of students' naïve ideas concerning "Electric Circuits- d.c." content.

To apply teaching strategies based on socio-constructivism and metacognition.

Methodology

Teaching and learning strategies based on understanding of methods and process of science.

Designing tools, collecting and processing data, analyzing and interpreting the results, and finally applying the findings in the science classroom;

Timing:

15 hours

Material:

Bibliography concerning existing experience (naive ideas concerning "Electric Circuits- d.c." content.)

Material for experiments.

Paper worksheets.

Assignments for the pre-service science teachers

- The study of the recommended bibliography.
- The projection of the questionnaires for the investigation of some conceptions, selected from the literature (see the bibliography).
- The application of the questionnaires. The subjects of the investigation can be pre-service teachers or students.
- The processing of data and the interpretation of the obtained results.
- The projection of the conception's overcoming strategy. Each team of pre-service science teachers select a conception from those which had been discovered.
- The application in the classroom of the established strategy, by the each team of the pre-service science teachers.
- The evaluation of the efficiency of each strategy.
- The communication/dissemination of the findings.

Assessment

Analysis of the pre-service science teacher's worksheets;

Analysis of the pre-service science teacher's learning portfolio.

Organization of the pre-service science teachers group: ten (10) micro-groups of three people.

Academic staff involved: 2 people (instructor and assistant)

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"Electrolysis and its applications", Simulation on experimental theme based on the scientific method (enhanced by systemic analysis and interdisciplinarity)

Justification of proposition

"Electrolysis" is a theme integrated into the electrochemistry's domain/ field, which study the phenomenon and the modifications that occur at the interface of two mediums, among one has free electrons and the other contains ions, when this interface is traversed by electrically charged particles.

We can say that the study of electrochemistry involves two large parts: one of them studies the ionic equilibrium in solution and the other the traversing of the interface metal-electrolyte (kinetics of electrode). Electrochemistry is an interdisciplinary science, which uses knowledge belonging to some physics-chemistry disciplines (thermodynamics, statistical mechanics, kinetics, electrostatics and the surfaces' physics), but in the same time, contributes at the development of the other sciences.

Electrolysis is the phenomenon of electrolyte's transformation, as a consequence of electrode's reactions, by traversing electrical current (oxidation at the anode and reduction at the cathode) and of secondary reactions.

We have chosen the theme "Electrolysis", having in view its exceptional practical applications and the necessity that the pupils understand the links existing between chemical and electrical energy. Getting in sight the fact that pupils have studied the "Redox reactions" and the "Cell", it is absolutely necessary that pupils realize the reciprocal transformations of the two types of energy - chemical and electrical. Otherwise, pupils must realize the difference between processes which occur in the cell and in the electrolysis cell.

This theme is studied at different levels in secondary school, depending of pupils' age: at 11-12 years and 15-16 years. The first level is studied in the frame of Physics and the second in the frame of Chemistry.

The theme will be performed by our trainee science teachers belonging to the Faculty of Chemistry and Chemical Engineering. We have to consider that the official/ formal structure of the activities in the frame of subject matter "The didactic of chemistry" is: 2 hours courses, 1 hour seminar and 4 hours pedagogical practice (from which 2 with theoretical character - seminar in the faculty - and 2 destined for teaching in school). Our survey will be performed in the frame of the four hours of pedagogical practice: seminars and active practice at secondary schools.

The effective modality of work that we apply as academic staff at the subject matter "The didactic of chemistry" is as follows:

- In the frame of seminar and of the two hours with theoretical character, the students, under our coordination (or under a mentor coordination), realize simulations for activities in the study of chemistry (one of them is the teacher and the others form the class of pupils).
- To achieve these simulations, the student analyses the national programmes, the alternative manuals and elaborates the lesson projects; by simulation, they are testing the quality of the contents processing and the quality of the didactic transposition, in such educational conditions which try to reproduce the real conditions.
- After that, in the second part of the pedagogical practice (the practical one), the students organize effective didactic activities in schools, in the educational reality, therefore validating/ invalidating the didactic transposition realized.

Our trainee science teacher has a very important task: to "transform" the content/ text from the National Curricula to a given theme in a way to make the concept phenomena to be accessible in the teaching-learning process.

The role of a science teacher in our days is to be moderator and not a transmitter of knowledge, because only in this way, out youth can develop his personality, can be integrated in the social and economic life of each country.

Don't forget that our trainee science teachers will become the tomorrow society, a knowledge-based society, who will be put in the situation to take the important decisions in the social/economical field.

Competencies aimed:

The competence to assure the formative character of the chemical laboratory experiment, to organize learning experiences of pupils, thus their experimental activity being doubled by the intellectual activity, necessary in order to:

- interpret chemical phenomenons and processes which are studied
- infer conclusions
- analyze and compare experimental data obtained
- generalize some particular cases or some theoretical and practical conclusions
- transfer new knowledge in other theoretical and practical contexts
- realize the interrelations between theoretical and practical domains.

Competences: The pre-service science teachers must have:

A. COMMUNICATION OF KNOWLEDGE

A.1. Subject matter knowledge (SMK)

- SMK1. Competencies related to subject matter/content knowledge (identify the scientific concepts belonging to the theme and the relationships between them and the other related concepts)
- SMK 2. Competencies related to the nature of science (NOS) including inquiry knowledge and skills (identify methods and processes of science; study the steps which have been developed in science in order to develop different epistemologies; communicate scientific content knowledge
- SMK 3. Competencies in framing a discipline in a multidisciplinary scenario including STSP (Science, Technology, Society in a Personal context) and mathematics (a teacher should be able to make the interrelations between the concepts belonging to different disciplines and to form a holistic vision about the phenomena).

A.2 Pedagogical content knowledge

PCK 8. Competencies related to the area of teaching/learning processes within the domain

- transform content knowledge from the National Curricula in a appropriate knowledge for teaching
- mastering of strategies involved in teaching-learning activities, using activate methods and strategies able to help the subjects to build her/his own knowledge
- correlate the observations of phenomena to their representations and models agreed upon in the disciplinary knowledge
- to organize efficiently socio-constructiviste conflicts in order to support students in their learning processes and to obtain a scientific knowledge
- to be able to know oneself and to change oneself
- to be able to make a pertinent analyze of a lesson after the well known criteria

PCK 8. Competencies related to the area of teaching/learning processes within the domain

- guide students in building and organizing their knowledge
- stimulate students in using different representations (verbal, iconic, mathematical etc.) of the same phenomenon

PCK 9. Competencies in using laboratories, experiments, inquiry, projects, modeling and outdoor activities to build understanding and skills of students.

- to integrate lab-work with theory

- to use conceptual maps
- to use different ways to formalize a definition/ conclusion: verbal, iconic, mathematical, models etc.

  PCK 10. Competencies in addressing students' common sense knowledge and learning difficulties

- to be aware of students' learning difficulties, confusions, lacks in the knowledge etc.
- to consider/ use empirical knowledge of students, their preconceptions, their naïve ideas and their reasoning strategies in order to obtain an scientific knowledge
- to organize efficient socio-constructivist conflicts in order to support students in their learning process and to obtain an scientific knowledge.
- to be aware of students' learning difficulties, confusions, lacks in the knowledge etc.
- to be able to know oneself and to change oneself

A.3 Pedagogical knowledge

  PK 5. Competencies in mastering and implementing a variety of (especially student-centered) instructional strategies and assessments attending to individual differences

- appreciate difficulties students in teaching-learning process
- adapt teaching methods (heuristic strategies) to the specific contents to be addressed
- project a lesson according to the psychological resources of the classes
- select teaching-learning strategies to meet specific learning outcomes: to organize group work; to define specific goals; to speak clearly; to address at an adequate language level
- integrate lab works and simulations in the teaching process
- organize evaluation of his/ her teaching in terms of student learning
- manage class life
- favor group-work
- monitor learning/ teaching process
- perform clear evaluation strategies, e.g. continuous evaluation centered on the operational objectives.

Didactical aims

referring to the content of the theme

To differentiate the phenomenon which take place in electrochemical cells and in electrolysis cells.

To focus on the chemical interpretation of phenomena and on the modeling of chemical processes by the equations of chemical reactions.

To form some necessary techniques of intellectual and practical activities and, also, the thinking manner specific to the discipline "Chemistry".

referring to the methodical side:

To make the concept, phenomenon accessible to the pupils, developing their personality.

To change the structure of the theme in concordance with the results obtained by the continuous assessment.

To familiarize the students with the idea that they must use multimedia resources and must project and realize educational software (possible in team with other teachers, specialists etc.).

The didactic concepts involved are: to join the intellectual and practical skills of the Trainee Science Teachers.

Methodology

- To start from the potential (re)sources of students' learning and of cognitive processes:
  - common knowledge

- empirical knowledge of students
- comparison between the phenomenon in the electrochemical cells and in the electrolysis cells.

- To analyze by comparison the phenomenon in electrochemical cells and in electrolysis cells.
- To realize electrolysis experimentation of different electrolytes and to analyze, on the basis of experimental observations and data, different aspects:
  - processes at electrodes
  - discover the first law of electrolysis
  - verify law II of electrolysis
  - the comportment at electrodes
  - the chemical elements and the substances which can be obtained by electrolysis, the working conditions and the most important applications.
- To model the chemical processes which take place by writing chemical equations.
- To analyze realize electrolysis installations, to solve exercises and problems.
- To concept educational software which can be used in the study of electrolysis and its applications.

Timing:

8 hours

Material:

- electrolysis cells with their components
- material for the experiments: electrolytes, laboratory tools, electrochemical kit, voltmeter Hoffmann, source of current, conductors, transparencies for projectors, projectors
- paper worksheets
- computer and educational software
- video-camera

Assignments for the pre-service science teachers

The Trainee Science Teachers inquiry will be organized according to the following:

- Trainee Science Teacher (TST) contact with the content of the National Curricular, with the curricular area "Mathematics and Sciences".
- TST will analyze by systemic approach the chosen theme: subsystems, interrelations between subsystem and the finalities of the system.
- To fill in paper worksheets.
- Valorize their empirical knowledge, their preconceptions, their reflections about this phenomenon.
- TST elaborate the project based on an appropriate up-to-date didactic conceptions, working in group (3-4 students) with a leader of each team. Interchange the results between the teams.
- Final adjustment of the results.
- Simulation of the project: the TST become the pupils and some TST become teacher (each TST for a lesson).
- Analyze the results during simulation by auto-evaluation of the teacher student, then the all group of TST and the conclusions of the observers (Adrienne, Musata and the mentor from the secondary school).
- Train to apply the results from the simulation in a secondary school.

Assessment

Analysis of the pre-service science teacher's worksheets;

Analysis of the pre-service science teacher's learning portfolio.

Organization of the pre-service science teachers group: - frontal, in groups formed by 3-4 students, individual, combined

Academic staff involved: 2 people (instructor and assistant) and the invited mentor

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Table 2.4 *Overview of the Examples of Good Practices (EGPs)*

a. How to introduce some concepts of Didactics of Science from an example : Digestion			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, PK 5, PK 6, PK 7, PCK 8	Biology	• A teaching / learning sequence of 3 hours • Number of students : if possible < 30 (nevertheless, it can success with more students, and it is also possible with few students, as 10 to 15 students) • Students = in-service science teachers, or trainee teachers, or trainee researchers in Science Education (any field of Science). • Context : Starting a course on Science Education	3h
b. "Life in Winter": Interdisciplinary project integrating Biology, Physics, Math and Computer Sciences			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, SMK 2, SMK 4, PK 5, PK 6, PK 7, PCK 8, PCK 11	Interdisciplinary project integrating Biology, Physics, Math and Computer Sciences	The unit "Life in Winter" provides a specific example of interdisciplinarity. It is a 6-lesson hour unit and due to its self explaining structure it could be introduced to every secondary school class (9th grade). Specifically it was designed for the Medium Stratification [Realschule] but is also suitable for a freshman course at university. The participants are working in tandem groups or alone on a computer.	6h
c. Simulations of meta–classical and classical models of micro-cosmos / Atoms – Molecules			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, SMK 4 , PCK 8, PCK. 11	Physics	Parallel introduction of the scientific models of the meta-classical and classical physics Introducing: 1. the Rutherford' s model 2. the Bohr' Model and 3. the radial probability distributions of an electron for the 1S, 2S and 2P states in hydrogen Introducing classical model for molecules motion Simulation / visualization program of the atom of Hydrogen. Simulation of Solids, Liquids, Gasses	6h

d. Environmental/ecological project(s) based on the Scientific method (enhanced by systemic analysis), Science and Interdisciplinarity			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, SMK 3, PCK 8, PK 5	Energy equilibrium (and consumption) at a school building (heating, cooling, lighting, water supply,………, building materials) Energy sources over-consumption - Green house effect-CO_2 tax CO_2 production experiments and measurements Renewable energy sources - Solar Energy Heater	Application of the scientific method: trigger of interest, making hypothesis, experimentation, conclusions, generalization. Data and information collection: "from the field" and "in the field". Design and application of experiments in order to inquire and test environmental/ecological phenomena Modeling and use simple, science based constructions. Use of Technology for: - measurements - testing - web site creation	6h

e. Experimentation in Science Laboratory – Measurements with Sensors / Actuators			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
PCK 11, PCK 9, PK 7, PCK 11	Physics, Technology, Chemistry, Biology	Application of the scientific method: trigger of interest, making hypothesis, experimentation, conclusions, generalization Demonstration and practice on: 1. the technology of sensors and actuators 2. using the software (receiving data, drawing diagrams,…) Questionnaire and discussion aiming at the elicitation of students' hypotheses Laboratories in which prospective teachers experiment using sensors and actuators: Thermal equilibrium Laboratories in which prospective teachers experiment using sensors and actuators: • Production and detection of CO_2) Measuring pH during neutralisation reaction Laboratories in which prospective teachers experiment using sensors and actuators: • Measuring CO_2 being emmited by a plant • Greenhouse effect and CO_2	8½ h

f. Use of Real-Time Experiments and Images (RTEI) to address the inversions of motion and impulsive forces			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
PCK 11, PCK 10, PCK 8	Inversion of motion and impulsive forces	- exploration/observation of a persons' inversion of motion and of a cart moving on a horizontal track with little friction - regularities and rules inferred from analysis of s(t), v(t), a(t) graphs - analysis of similarities/ differences in the two motions; focus on iconic aspects - eliciting students' ideas about impulsive forces and duration of motion inversions - comparing experimental results with students' predictions - addressing cognitive conflicts amongst predictions previous ideas and experimental results [Small group work in peer learning/sharing]	8h

g. Use of Real-Time Experiments and Images (RTEI) to address the oscillations of mass-spring systems			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
PCK 11, PCK 10, PCK 8	Oscillations of mass-spring systems	- exploration/observation of rhythmic oscillations of a person on its feet - regularities and rules inferred from analysis of s(t), v(t), a(t) graphs - exploration/observation of mass-spring system oscillations; analysis of s(t), v(t), a(t) graphs - analysis of similarities/ differences in the two motions; focus on iconic aspects - modeling of motion under the action of elastic force - eliciting students' ideas about relations amongst mass, elastic constant, period, amplitude. - comparing experimental results with students' predictions - addressing cognitive conflicts amongst predictions previous ideas and experimental results [Small group work in peer learning/sharing]	8h

h. Modelling Physical Reality: from observations to descriptive models to interpretative models			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, PCK 8, PCK 9, PCK 10, PCK 11	Behaviors and properties of gasses Simulating microscopic models of gasses	To recall and describe phenomena by using verbal language [Image analysis (group work) and class discussion] To identify relevant variables and infer their relationships [group work and class discussion] To foster Lab-work in groups and peer learning [group work] To analyse pupils' conceptions about microscopic structure of matter (research results) [group work and class discussion] To infer microscopic building blocks and their properties [Teacher presentation and class discussion To use a simulation to analyze model behaviors. [group work] To compare Experiment and Model results [Whole class discussion]	9h

i. Involving the Pre-Service Science Teachers in Action Researches. Application at the Theme “Electric Circuits			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
PK 5, PCK 10, SMK 1	Pre-service teachers’ training regarding conceptions and action research. The investigation of a set of conceptions, which had been mentioned in the literature referring to the theme “Electric Circuits - d.c.” Application in the classroom by each pre-service science teacher group of the strategies centred on the overcoming of a selected conception.	Learning knowledge about conception: its characteristics, associate models of reasoning, investigation techniques, overcoming strategies. Getting familiar with the action research: its methodology, procedures and activities. Analysing the conceptions mentioned on the literature regarding the theme “Electric Circuits - d.c.” (and own conceptions also). Projecting and planning the activities realised by pre-service teachers (organised on group and micro-group). Projecting the questionnaires regarding the conceptions’ investigation by each group of pre-service teachers. Application of the questionnaires by each group of pre-service teachers on the classroom. Processing and interpretation of the obtained results. Projecting the overcoming strategies referring of a selected conception, by each group of pre-service science teachers. Application of the projected strategies by each group of pre-service science teachers. Analyzing the results to realize if a conception is overcome or not. Communicating/ Disseminating the findings.	15h

j."Electrolysis and its applications" Simulation on experimental theme based on scientific method (enhanced by systemic analysis and interdisciplinarity)			
Competencies	**Subject**	**Action/ Strategy**	**Hours**
SMK 1, PK 5, PK 7, PCK 9	Electrolysis and its applications: Electrolysis / the chemical effect of the electrical current The electrolysis laws. Efficiency of current The obtainment of metals and non-metals by electrolysis. The obtainment of compound substances by electrolysis. Electrolysis - method for the purification of metals. Electrolysis and its applications.	Trainee Science Teacher must be able to: - study the National Curricula - make the didactic transposition i.e. the projects of chosen theme - elaborate the systemic approach schema in order to reveal the interdisciplinarity and intradisciplinarity between different concepts and phenomena - elaborate the operational objectives, the heuristic strategies and the continuous assessment - elaborate the scenario, on the basis on didactic strategy - simulate the lessons in the frame of our academic institution - apply the scenario in the frame of a secondary school - compare the results obtained by simulations with those from the secondary school - to be able to know oneself and be able to study oneself	8h

2.4 Summary and Conclusions

The main product of WP1 realated work was a common list of Desired Competencies for science teachers. The goals of this report (WP2) were twofold: first, to generate a common profile of the effective science teacher across Europe and second, to generate Examples of Good Practices (EGPs) based on these competencies. We believe that these two outcomes of WP2 can serve as important steps towards creating strategies and programs that will produce effective science teachers across Europe.

We began this report by comparing the secondary school science teacher training systems from the partner countries (See Table 2.1). This comparison revealed that there are significant differences regarding (a) the diploma required to teach in secondary schools (3 different approaches), (b) the grouping of science majors to be studied, and (c) the amount of time devoted to didactics and pedagogy. However, what emerged were common goals of science teacher education as well as some common problems faced by the partner countries.

The common problems were: (1) lack or insufficient knowledge of the discipline(s), (2) lack of reflective practice, (3) lack of focus on the processes which characterize the discipline and on connections with the real phenomena of the discipline, (4) compartmentalization of the disciplines and (5) a teaching approach based on a lecture (as opposed to a "hands-on") format. (It is important to note that unique and particular problems regarding the Greek and Romanian teacher training systems were also presented.)

In this report, Examples of Good Practices in Science Teachers Training were designed and presented (in Table 2.4) by each participating insitution to counteract these common problems as well as to embody the Desired Competencies. In addition, an Effective Science Teacher's Profile was designed, based on the Desired Competencies, the abovementioned common problems of science teacher education in Europe, and the science education research literature.

A comparison of this Profile with the Desired Competencies clearly shows that these competencies are necessary but not sufficient attributes of an effective science teacher. Also necessary are personal qualities such as being dynamic and reliable, enjoying teaching, adapting and changing to meet student needs, tolerating ambiguity, being a leader within the classroom and with colleagues, and having the ability to face innovation.

How might science teacher training programs develop these personal qualities in pre-service science teachers? This is a crucial but open question. As a result of this situation, perhaps teacher preparation programs will have to focus on developing the Desired Competencies, with the hope that the desired personal qualities in the Effective Science Teachers Profile will develop over time. This issue is reconsidered in WP4.

As presented in this report (WP2), one way to develop the Desired Competencies in pre-service teachers is through the EGPs. The next report (WP3) describes the results of a cross-experimentation approach, in which EGPs designed by one country were implemented by another. The final report (WP4) discusses the implications of the three prior reports and suggests how the Desired Competencies might be developed into common standards for pre-service, in-service and lifelong learning programs for science teachers across Europe.

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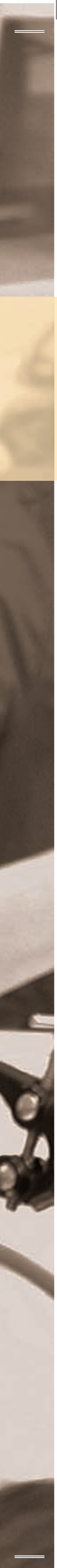

Report of Work Package 3

3 Exemplary Models of Science Teachers Preparation Programmes

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Introduction

A principal exertion in any science education research contains a critical reflection upon domains of various major problems: (i) to overcome boundaries of "pure science" in the subject; (ii) to extract the subject's substantial core information for providing age-appropriate units for the pupils, (iii) to trespass boundaries of the specific science subjects in a collaborative process by justifying a curriculum across the subjects and integrating science teaching in a discursive process, and last but not least (iv) to meet the challenge of collaboration and team working. Consequently, any teacher education scenario has to include teaching and learning frameworks as well as a scientific analysis of teaching. We may label this as a "scholarship of teaching" since the power of scientific thinking and the analysis of teaching was integrated due to empirical data in order to improve individual teaching performance. In combination with the existing science skills of every science teacher, the knowledge of research outcomes has already improved and will further improve the professionalism of teacher. In turn, the rationale of teaching often leads to new and exciting professional opportunities.

A suitable approach of developing such an integrated science education scenario may be provided by following a narrative framework of implementing "good examples" or "best practices" selected by an expert rating. Although this modus operandi may be judged as a very subjective approach, it may present a suitable foot-in-the-door-effect. Previous science curricula increasingly criticized various insufficiencies by culminating, for instance, in failures of targeting student interests, of gaining sufficient competencies in scientific literacy, of addressing professional teaching practices, or of perceiving sufficient relevance in science learning at all. This overall and general critic often includes also a challenge of teacher knowledge bases across discipline boundaries and a call for reorganization of the within the different subjects' knowledge which often is portrayed as a dramatic overload by matter specialists. One potential way to overcome these challenges may lie in a principal shift from the traditional teaching of canonical science contents towards a more everyday relevance and student centred view. Ordinary textbook knowledge often fails to meet the real world which commonly does not follow the compartmenting of the traditional science subjects.

Collaborative (curriculum) projects within the interdisciplinary field of science education often mount a marked contrast with a "hard science" approach and accept science disciplines as separate sections for school science subjects. An appropriate notion of curriculum integration may be portrayed by STSE approaches (Science Technology Society Education) which very often follow the inbuilt need of cross-disciplinary knowledge and skills.

The STTAE project efforts can be framed in this changing teacher education scenario, aiming at improve teachers' professional competencies in order to match the above considered challenges. The effectiveness of "best practice" approach is one of the main assumptions made by the STTAE community and the implementation of such an approach is the subject of the Work Package 3 of the project.

This report describes the cross-experimentation of Examples of Good Practice (from now on, EGP), selected within the set that emerged as outcome of the correlation survey carried out in Work Package 2, the aim being that of providing, on the basis of national acknowledged experiences, suggestion for a common framework for teacher education programs across European countries.

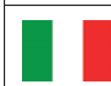
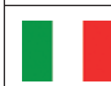
A major goal of modern science education consists of attempts to harmonize science teacher education activities across Europe. Generally, a cross-experimentation stage has been valued as an important step to provide and to test good examples of practice in different contexts. Thus, within the STTAE community, for each proposed EGP, originally framed within National teacher education programs or educational interventions in a partner country, a specific pattern card has been constructed in order to facilitate partners' selection of one EGP to be cross-experimented. The final selection was driven by a set of variable which included the availability of necessary resources, the general fit into an existing course system as well as the disciplinary background of the pre-service teachers.

This WP3 report describes the implementation procedure of the selected EGPs with special regard to the used methodology, the data collection as well as common trends which emerge from the cross-checking. National reports, for which a common structure was agreed, have been used as resources and are reported for the sake of completeness as Annexes to this report.

3.1 The Cross-Experimented "Example of Good Practices"

In Table 3.1, the EGP selected for the cross-experimentation in different countries are shown. The country that has already implement the proposed case study is presented on the first column. The complete set of proposed EGP ia presented in detail in WP2 report, session 2.3. It has to be noted that only the EGPs that finally selected from the participating institutions are presented here. For the sake of brevity, the EGPs have been labelled with a key word [in bold].

Table 3.1: *The EGP Selected for the Cross-Experimentation in the framework of the project. The country of origin of each EGP (the country where the specific case study has been already implemented and tested) is presented in each column.*

Origin	Title of EGP
	Simulations of metaClassical and Classical Models of microCosmos– Atoms and Molecules; The Atom of Hydrogen [**Atom**]
	Involving the Pre-Service Science Teachers in Action Research. Application at the Theme "Electric Circuits - d.c." - Students' Naive Ideas [**Circuits**]
	Concepts of Didactics of Science from an example: Digestion [**Digestion**]
	Use of Real-Time Experiments and Images to address the Oscillations of mass-spring systems [**RTEI**]
	Modelling Physical Reality: from observations to descriptive models to interpretative models [**Modelling**]
	"Life in Winter": Interdisciplinary project integrating Biology, Physics, Math and Computer Sciences [**life in winter**]
	Environmental / Ecological project based on the Scientific Method and enhanced by System Analysis – Science and Interdisciplinary approach [**Greenhouse**]

The cross-pattern of the implemented EGPs is described in Table 3.2. Here both the countries or origing and the countries of hosting of the proposed EGPs are presenetd.

As it can be seen from the Table 3.2 (view by rows), each participating group has experimented at least one EGP and (view by columns) had at least one of its proposed EGP been experimented. This circumstance supports the validity of the cross-experimentation methodology, which was adopted in the framework of the project..

Table 3.2: *The Cross-Pattern of the Implemented EGPs*

Origin / Host	 [Atom]	 [Circuits]	 [Digestion]	 [RTEI]	 [Modelling]	 [Life in Winter]	 [Greenhouse]
						●	●
			●				
		●				●	
				●	●		
							●
	●						
	●						

3.2 Description of the Implementation Procedures

3.2.1 Methodology

In this section we give an outlook to the methodology agreed within STTAE project in order to tackle the following general research questions:

1. **Do the proposed EGPs trigger the acquisition of competencies? If so, which ones?**

2. **Do the competencies indicated by the learners match or not with those declared by the designers of the EGPs?**

3. **What plausible factors may have influenced the success/ failure, and the matches/ mismatches of the EGPs?**

Questions within this context generally address a comparison of results coming from very different education contexts. Nevertheless, a major challenge of any cross-country experimentation within Europe has to take into account the existence of various national curricula within a specific (and often diverse) tradition. Generally, European curricula are not linked to each other and, thus, transferring an exemplary example from one system to another very often means more than just a simple transfer process. Similarly, adopting an example into another language frame never is just a simple literally translation into another language but it also has to deal with appropriate environments of the host country. In the STTAE framework of cross-experimentation, the principle content of an example never was changed in translating. To indetify succesful approaches and expand the pool of exemplary case studies and well prepared new teachers, rigorous criteria are needed beyond those already used by credentialing and accrediting bodies (Better targeted performance criteria are indicated for teacher preparation institutions if for no other reason than the less-than-succesful teaching generated by many of their graduates. Designation as an exemplary case study or programme must be highly selective, a mark of prestige; nonetheless, there should be no artificial limit on the number of the proposed case studies. Once identified, researches and faculty at institutions with exemplary programmes will need to collaborate with colleagues in other higher education institutions across Europe to increase the number of programmes that can meet the the exemplary criteria (e.g. meeting the teachers needs and the identified competencies).

Finally, any implementation approach has been influenced by the pre-selection of courses of an academic university year within a specific limited time slot. This seemingly has been the case with the implementation in Italy and Germany. Nevertheless, such a situation is not unique within case study frameworks.

Taking into account all of these cross-national constraints and different contexts, the implementations of the EGPS have been made according to the designers' indications. In some cases, some adaptation was needed in order to match the context of the experimentation; in case of major adaptations, the participating group that implemented an EGP has agreed with the research group that designed it what modifications were needed for the implementation. The structures of the intervention are summarized in Table 3.3. In almost all the cases, minor adaptations have been made; each case in which major adaptations have been made is briefly described in the relative footnotes.

The overall methodology of analysis of the cross-experimentation of EGPs is qualitative, since in almost all the cross-experimentation contexts the sample size of student teachers (from now on "learners") is limited and not appropriate for qualitative analysis (see Table 3.4).

Table 3.3: *The Structure of the Intervention in Each Country*

Cross-Experimentation context	Structure of interventions	
 UoA	[**Modelling**]; 3 sessions; 9 hours [pre test; discussion; simulation activity; RT experiment activity; discussion and post-test]	[**RTEI**]; 2 sessions[1]; 8 hours [pre-test named; RT experiments activities; discussion; homework]
 UBT	[**Digestion**]; 1 session[2]; 2 hours [introduction; individual work; group work; discussion]	
 UBB	[**Atom**] 2 sessions[3]; 14 hours [pre-test, simulation activities, post-test,frontal lessons with software, worksheets; questionnaires]	
 UCL	[**Greenhouse**]; 3 sessions, 6 hours [introduction; group presentation; discussion]	
 UoL	[**Circuits**]; 1 session; 9 hours [introduction; group work; discussion]	
 UoN	[**Greenhouse**]; 3 sessions; 10 hours [introduction; RT experiment activity; discussion]	
 UoP	[**Hydrogen**]; 3 sessions; 9 hours [pre-test; recalling of contents; simulation activity; post-test]	

Table 3.4: *Number of Learners in the Implementation Context in each Country*

Host University	No. of Learners
UoA	15 [**Modelling**]; 12 [**RTEI**]
UBT	11
UBB	15 pre-service (and 42 pupils)
UCL	62
UoL	36
UoN	12
UoP	25

1 *Sessions were reduced to two.*
2 *For the implementation the provided time was shortened to 120 minutes, which was the maximal available time slot.*
3 *The simulation activity was performed with pre-service students, in the frame of a workshop. The didactic transposition was performed by the students (pre-service science teachers).*

3.2.2 Data collection

The portfolio assesment method was used for the data collection and the evaluation of the proposed EGPs in each of the participating countries. The tools used include:

- a collection of structured documents that teacher can use
- a tool focused on learning issues
- a teacher assessment tool
- a dossier built by the student teacher
- a communication tool student teacher – secondary school teacher – teacher trainers (it can be read by teachers and/or teacher trainers)

Two kinds of portfolio were used:

- Learning portfolio that accompanies the student teachers during their teacher education. Students are asked to build progressively this portfolio during their teacher education curriculum. This tool will be used during the whole learning process and therefore will be developed and enriched with the improvement of the science teacher students. The students use the portfolio at each meeting with the mentor and the educators and during seminars devoted to integration of didactics contents and practice (lessons taught)
- Presentation portfolio in order to show the results of the learning issues and to conduct them to use more and more their competencies and to manage their lack. This one results from a personal selection of documents coming from the learning portfolio and from a personal synthesis established by the student – teacher him/herself.

If the structure of the two portfolios remains similar, the function of those are different. Indeed, the "presentation portfolio" is used to assess in a certificative perspective while the "learning portfolio" provides a formative assessment tool.

The specific tools that were used for the collection of the data are presented in Table 3.5.

Table 3.5: *Data Sources for the EGPs*

Host University	EGP	comments/ reflections	answers to question-naire	lab worksheets	trainers notes	drawings	exp. results
UoA	[**Modelling**]	●	●		●		
	[**RTEI**]	●	●	●	●		
UBT	[**Digestion**]					●	
UBB	[**Atom**]	●	●	●	●		
UCL	[**Greenhouse**]		●		●	●	
UoL	[**Circuits**]		●				
UoN	[**Greenhouse**]	●	●		●		●
UoP	[**Hydrogen**]	●	●		●		

3.3 Main results

The research questions outlined above have been addressed by comparing the collected the data collected for each EGP. In the theoretical framework agreed within STTAE community, implementation of the EGPs is assumed to trigger awareness and acquisition of competencies for pre-service teachers. In order to test this hypothesis, the list of declared competencies was compared with that of the actual acquired competencies for each of the EGPs, based on observations by researchers or perceptions by learners. This procedure may provide an answer to the first two research questions. Afterwards, to answer the third research question, we extracted a set of potential and plausible factors which may have influenced the degree of competence achievement by the pre-service teacher.. A precise analysis of such factors may lead us to emerging common trends, as well as suggestions for future improvements of the selected EGPs.

3.3.1 Competencies triggered

The analysis presented here is based on analytical reports from the participating institutions. Data from the implementation of the case studies are analysed in the framework of the research questions. We present also as an example the report from the [Greenhouse] EGP implemented in UCL, Belgium.

Research question: Do the proposed EGPs trigger the acquisition of competencies? If so, which ones?

In Table 3.6 we address the first research question. We summarize the desired competencies (competencies that were triggered in the institution of origin) versus tha triggered ones (competencies that were triggered in the host institution during the project's implementation) in each implemented EGP done in the participating universities.

Some common trends can be inferred, in terms of the broad areas of competencies according to the categorization described in the transversal WP1 report on the science teachers competencies.

Table 3.6 indicates that:

- Each EGP triggered several competencies.
- The distribution of the triggered competencies between the three main categories (namely SMK, PK and PCK) is not even.
- In general, the most frequent triggered competencies (about 50%) belong to the category of pedagogical content knowledge (PCK)

Subject Matter Knowledge (SMK):

The dominant competency in this category is SMK1, "Competencies related to subject matter/content knowledge". The other SMKs are mentioned only in very few cases. These findings imply that the areas of the nature of science (SMK2), inter and multi-disciplinary approach (SMK3) and contemporary science (SMK4) were hardly met.

Competencies of framing a discipline within an interdisciplinary scenario were focused on during the EGPs cross-experimentation. Actually, the two Greenhouse EGPs addressed the importance of framing the discipline in a wider teaching scenario that calls mainly for an active interaction with colleagues, with the aim at accessing different disciplenary domains of knowledge. These EGPs have been received positively (e.g. those dealing with environmental issues and greenhouse effect). The learners valued the following aspects: presenting to students different perspectives on the same phenomenon can motivate them to study the sciences; The focus on abilities linked to inter-disciplinary and intra-disciplinary teaching approaches imply that a skilled science teacher should have, other than a sound knowledge in the subject matter area a sufficient acquaintance with basic concepts in different and related content areas. Moreover, it emerges that modules focusing on interdisciplinary approaches can be useful in order to lead students to distinguish between (and practice) an approach based on one scientific discipline and a multi-disciplinary approach.

Pedagogical Knowledge (PK)

Competencies in this category were mentioned in half of the EGPs. The competencies that were found related mainly to self reflection and meta-cognition (PK7) and instructional and assessment strategies (PK5).

Pedagogical Content Knowledge (PCK)

Competencies in this category were found in each of the implemented EGPs. In particular,the competency related to the area of teaching/learning processes within the domain (PCK8) was reported by each of the eight EGPs. This category includes all the competencies related to using modelling activities as an instructional strategy to improve students learning and as a way to reflect on teaching actions. The following PCK components have been recognised as triggered:

a. Modelling (PCK9)

Modelling has been observed in 5 EGPs (Atom in the two implementation case, Greenhouse, Modelling, RTEI). The data also indicate that the EPGs' focus on modelling activities has been well accepted by learners; they valued it and claimed, in all cases, their desire to use models in their future teaching. More specifically, the following capabilities were triggered:

- design and organize science teaching and learning activities including simulation and modelling packages;
- reflect on model building and on processes of understanding the functions and limits of each model;
- be aware of the importance of modelling activities in the teaching/learning process; - connect the observation of phenomena to their representations and models; - understanding the unifying role of models and modelling procedures; - use various models and representations in order to fit the students' reasonings.

b. Laboratories and experiments (PCK9)

Laboratory competencies have been triggered mainly by 4 EGPs (Atom, RTEI and Modelling) and have been valued by learners, specially when addressing complex disciplinary areas (e.g. environmental issues, quantum mechanics). This refers mainly to the effective use of experimental activities and ICT learning-oriented environments, with particular emphasis on cognitive goals and disciplinary areas and includes the following capabilities:

- address a disciplinary content by means of an appropriately designed experiment;
- use computers as laboratory tools and to have different representations (verbal, iconic, mathematical etc.) of the same data;
- use ICT tools/environments as cognitive tools.

c. Addressing students' learning difficulties (PCK10)

Apparently, dealing with students' naïve ideas and learning difficulties was a main objective in all EGPs. However, the results do not always explicitly indicate that this competency was triggered. In 3 EGPs (Modelling, RTEI and Electric ciruits) this competency was one of the main objectives of the activities in the following aspects:

- eliciting students' naïve ideas and reasoning strategy
- knowing pupils' conceptions about precise scientific topics and using these conceptions in the teaching-learning process

The competency dealing with the knowledge, planning and use of curricular materials (PCK12), which was identified in WP1 relative work based on experts comments and additoions, was rarely mentioned as triggered in the implemented EGPs. Please note that this compentency was not initialy analayzed in the framework of the development of the EGPs cards for the project's implementation and for this reason is not mentioned in none of the proposed EGPs. Still the project team decide to included in the integrated analysis as there is always the possibility to be triggered during the implemenmtation.

Table 3.6: Desired *Competencies* (•) *and triggered competencies* (√) *for the implemented EGPs in the different countries. The comparison is possible only for the case studies where the portfolio assesment method was adopted. The importance of SMK1 and PCK8 competencies is clearly demonstarted. Additionally the significant increase of the triggered cases of PCK9 (taking into account the high relevance with PCK10) demonstrate the importance for this competency in the framework of the project's implementation.*

EGPs	Hosting Country	SMK1		SMK2		SMK3		SMK4		PK5		PK6		PK7		PCK8		PCK9		PCK10		PCK11		PCK12	
Modeling	U.A (Greece)	•	√													•	√	•	√	•	√	•	√		
RTEI	U.A (Greece)															•	√		√	•	√	•	√		
Digestion	UBT (Germany)	•	√							•	√	•	√	•	√	•	√								
Atom	UBB (Romania)	•	√					•	√		√				√	•	√		√			•	√		
Greenhouse	UCL (Belgium)	•	√			•	√			•	√				√	•	√								
Electric Circuits	UL (France)	•			√					•					√		√			•	√				
Greenhouse	U.N (Italy)	•	√			•	√		√	•						•	√		√						
Atom	U.P (Italy)	•	√					•								•	√		√			•	√		√
Total		**7/8**	**6/8**	**0/8**	**1/8**	**2/8**	**2/8**	**2/8**	**2/8**	**4/8**	**3/8**	**1/8**	**1/8**	**1/8**	**4/8**	**7/8**	**8/8**	**1/8**	**5/8**	**3/8**	**3/8**	**4/8**	**4/8**	**0/8**	**1/8**
		11/11								**6/8**						**15/21**									

Full Title:

"Modeling Physical Reality: from observations to descriptive models to interpretative models"

Proposed by:

University of Palermo, Italy

Implemented by:

University of Athens, Greece

Introduction:

General Description of the Exemplary Model

The model is proposed by the University of Palermo and implemented and assessed by the University of Athens. The content refers to the gas laws, and especially the Boyle's law. It is designed so as to provide student-teachers with learning environments and computational tools that will help them express and reflect on their concepts and ideas about phenomena and support their activities concerning exploration, experimenting and modelling. Moreover emphasis is put to implement teaching methods aimed to make the student-teachers aware of the strategies to put into action in filling the gap between the physics content to be taught and the pupils' knowledge relevant to find explanations for the involved natural phenomena. The didactical aims are: a) to make student-teachers experience the same teaching/learning environments we think they have to provide to their pupils; and b) to apply teaching methods based on learning by doing and metareflection.

The student-teachers work is organised according to the following five phases:

1. student-teachers analyse worksheets and pictures describing/representing phenomena involving behaviours of gases (mainly air) and describe/explain them describe phenomena by identifying relevant features and infer their relationships.(~1 h).
2. student-teachers analyse the answer sheets of some questionnaires and/or recorded interviews, previously administered to high school pupils in order to draw their common conceptions and reasoning (mainly, questionnaires and interviews, reported in literature (~1 h).
3. student-teachers program appropriate experiments (using equipment at disposal) perform them and verify the validity of the previously inferred relationships among the features analised (~3 h).
4. student-teachers research for appropriate explicative models by inferring microscopic properties of gases and experimenting their behaviors using simulations (~3 h).
5. As final step simulation results are compared with experimental results (~1 h).

Implementation:

Areas of competences explored (according to WP1categorisation)

1) Content Knowledge

Knowledge about the disciplines

- Understanding of methods and processes of science;
- Understanding of the unifying role of models and modelling procedures;
- To be aware of students' learning difficulties in sketching microscopic behaviours
- To be aware of students' previous ideas and reasoning strategies about microscopic properties of gasses
- To be able to connect the observation of phenomena to their representations and models acknowledged in the disciplinary structure;

2) Pedagogical content Knowledge.

a) Teaching/learning processes

- Transform content knowledge in a appropriate knowledge for teaching;
- Perform a reconstruct of subject knowledge appropriate for teaching.
- Use various models and representations in

order to fit student reasoning;

b) Pedagogical methods and tools scaffolding learning

- Use Information Technologies as cognitive tools;
- Use Computers as laboratory tools;
- Use Computers for different representations (verbal, iconic, mathematical,..) of the same data;

c) Awareness of relevant characteristics of students' common-sense knowledge.

- Identify students' mental models of reasoning;
- Search for students' naïve ideas
- Identify learning/teaching difficulties;

Context of Implementation:

The exemplary model was tested in the Science, Technology and Environment Laboratory of the University of Athens.

Sample:

A group of 15 (2nd academic year) students of the Physics Department of the University of Athens. The exemplary model was organised as a laboratory practice in the frame of their winter class on "Physics Didactical Methods". At the second semester of their studies, the students of the Physics Department have been taught Thermodynamics, where the gas laws are examined by mathematical equations as well as by the microscopic model. The same subject is included in the curriculum of the second class of the upper high school. The didactical process in both the secondary and university level are traditional and are not supported by simulation software or real time experiments.

Class Organization:

The students were divided into 5 groups of three persons. Each group was working on a PC. The instructors were two members of the UoA team.

Didactical Materials:

The instruction was based on the worksheets supplied by the UoP team and translated into Greek by the UoA team. There were three main worksheets per student: the observation worksheet, the real time experiment worksheet and the simulation one. The didactical material also included simple material for the observation experiments. The instruction was supported by the simulation software provided by the designers of the exemplary model as well as by software and hardware (sensors) for the real time experiment.

Time schedule

The exemplary model course was organized in five meetings which the students participated in during two weeks time.

Adaptations of the exemplary model

The adaptations of the exemplary model by the UoA team in order to apply and test it were performed regarding the phases and timing as well as the organization of the micro-portfolio material, as presented below:

The phases of the exemplary model were organized as following:

First meeting: pre test (1 hour)
Second meeting: observations (2 hours)
Third meeting: simulation activity (1,5 hour)
Forth meeting: real time experiment (2 hours)
Fifth meeting: discussion and post (2 hours)

The students were asked to answer a pre test (provided by the UoP team) on the content knowledge about the Boyle's law. After the intervention a discussion took place on the role of models in science and science education instead of article reading on the same subject. In addition during the instruction, the members of the UoA team made comments from the didactical point of view to the students. Finally the students worked on a post test that included questions on content knowledge, on the nature of science and modeling and on didactics. In the post test provided by the UoP team the UoA team added a group of questions that were agreed by all the members of the project as micro-portfolio activity. This group of questions referred to the specific items of competence, to advantages and disadvantages on the process the students participated in, on the transferability of the pedagogical content knowledge with the same or another subject as well as on the relevance of the activity with practice in school in science teaching.

Results:

Difficulties and success encountered by the learners

During the intervention a member of the UoA team acted as an observer and noted the difficulties and success encountered by the learners. According to the observer the students had no difficulty to deal with content knowledge activities either on the observation phase or on the modelling one (simulation and real time experiment with sensors). The main difficulties were encountered by the learners on the didactical activities. In particular, they were rather unable to answer questions like "How would you guide your class to the observation of the phenomenon" and "How would you explain its interpretation to your class".

From the analysis of the data the students seem to answer most of the question at the macroscopic level and include in their answers mathematical equations. However, in some cases they use the microscopic model and in a correct way, not in a very detailed level though.

Worksheets

Concerning the data obtained from the worksheets, the answers to the content knowledge questions are rather of no special interest, as they are almost always correct and satisfactory and remain unchanged during the process. Baring this in mind, we focus on the pedagogical content questions and we analyze the answers the students gave at the three observations and the simulation worksheet.

First observation

Most of the students proposed to repeat the hands on experiment in order to guide their class to the observation. Fewer stated that they would provide verbal guidance.

Regarding the way they would explain the interpretation of the observation to their class most of the students prefered verbal explanation, few of them verbal simplified explanation or role play analogy. Some of them mentioned the simulation of microscopic process.

Second observation

Most of the students wrote down that they would emphasize on the change of macroscopic parameters in order to guide their class to the observation. Fewer stated that they would repeat the hands on experiment while some other would use analogy.

Regarding the way they would explain the interpretation of the observation to their class most of the students prefered verbal explanation, few of them mathematical formulas or role play analogy. Some – more than in the first observation – of them mentioned the simulation of microscopic process.

Third observation

Most of the students wrote down that they would emphasize on the change of macroscopic parameters in order to guide their class to the observation. Fewer stated that they would repeat the hands on experiment.

Regarding the way they would explain the interpretation of the observation to their class most of the students prefered analogy, few of them verbal explanation or schematic explanation.

Simulation

The students when answering the question "How would you use the simulation in the classroom" wrote down that they would organize their class in groups, they would use the simulation to support the qualitative explanation of the phenomena.

When students were asked whether this simulation could help the class to better understand the model and the modelling process, they all answered positively since the model of the phenomenon is visualized. In every case the role of the teacher is mentioned to be of great importance.

Post test

Concerning the question "How the microscopic model of matter can be explained to a student that doesn't understand it" most of the students mentioned simulation and sensors. Those who proposed simulation stated that they would draw the attention of their class to the conventions (color, dimensions of atoms,…) made at the visualization of the atoms. Fewer of them would use simulation emphasizing on the macroscopic parameters.

Portfolio Methodology

Questions on the competence

Most of the students can use Ms Office and state that they didn't have any difficulties concerning ICT although they feel that they need to spend some time in order to learn the software for the real time measurements with the sensors.

Some of them who claim that they are not competent on ICT, believe that if they learn how to use ICT the possible difficulty in the future will be the effort to design an experiment.

Almost all of them claim that a possible difficulty in the future could be the time needed by their pupils on learning how to use the software concerning real time measurements.

Advantages and on the process

Most of the students commented that through the intervention: "I saw that phenomena can be explained in an easier way".

They also said that they learned how to use "software concerning sensors and models of explanation".

Some other said that: "I saw through a didactical intervention how to use sensors and simulations".

Some other focused on the "Simulation of microcosmos".

Fewer spotted that an intervention which includes ICT is a "more stimulating process in comparison to traditional process".

One of them said that he liked the fact that "we came up with the same results (concerning the diagram of P-V) through simulation and sensors"

Disadvantages on the process

Most of the students spotted no disadvantages concerning the intervention. Few of them –some of those who in the first questions stated that they don't feel competent in ICT– said that someone in order to use sensors should be competent in ICT.

One of the students said that a disadvantage is the fact that there was no "reference to theory before the intervention".

One of them said that although she liked the intervention, she believes that "Greek educators are not ready for the introduction of ICT in schools".

Finally one of them didn't recognize the role of the simulation as an appropriate didactic tool.

Transferability with the same or another subject

The subjects chosen from our students were:

Subject	Number of students
Charles law	7
Friction	4
Resistance of the air in the free fall	1
Conservation of Momentum – 3rd law of Newton	1
Acceleration	1
Cells	1

Activity relevance for practice in school

Most of the students said that they could use sensors and simulation as didactical tools (Charles law, Resistance of the air in the free fall, Friction).

Some of them chose only the sensors (i.e. for the subjects of Conservation of Momentum – 3rd law of Newton, Acceleration).

The student who chose the subject "cells" said that he would use a microscope.

Almost all of them described an intervention with the same methodology that we followed for the thematic of the Boyle.

Matches or Mismatches with declared competences

Following the presentation of the qualitative results of the tests, we came at the following conclusions on the success of the exemplary model on the declared competences.

The exemplary model seems to contribute to the acquisition of the following competences:

1) Content Knowledge

Knowledge about the disciplines

- Understanding of methods and processes of science;
- Understanding of the unifying role of models and modelling procedures;
- To be able to connect the observation of phenomena to their representations and models acknowledged in the disciplinary structure;

2) Pedagogical content Knowledge.

Teaching/learning processes

- Transform content knowledge in a appropriate knowledge for teaching;
- Use various models and representations in order to fit student reasoning;

Pedagogical methods and tools scaffolding learning

- Use Information Technologies as cognitive tools;
- Use Computers as laboratory tools;
- Use Computers for different representations (verbal, iconic, mathematical,..) of the same data;

Finally, it is important to mention that all the students agreed with the comment of one of them that following the course they participated, they should perform lessons in a class in order to practice themselves in a real secondary school environment.

Useful tools for triggering competences

The tools included in this exemplary model that are considered to be useful for triggering the above mentioned competences are mainly:

- the certain methodology according to which students first observe a phenomenon through a simple experiment, then study the model that explains it and then comment on the whole process from a didactical point of view.
- the simulation software that supports the visualization of the model
- the real time measurements with sensors, which in combination with the simulation software serve as a bridge between the model and the real world.

Plausible features influencing success or not success related to the local training plan

Baring in mind the comment of a student that "Greek educators are not ready for the introduction of ICT in schools", we consider the methodology of the exemplary model to be of great importance for its success to the Greek training plan. The comment of the student seems to be incoherent to the reality. The policy of the ministry of Education in Greece is to equip – and in most of the cases this aim has almost been fulfilled – school laboratories with ICT, but greek educators seem to be reluctant to use them. The reason for this behavior is supposed to be the fact that they never experienced lessons supported by ICT as explained below. In particular, teachers are supposed to use in their classes didactical tools similar – in most of the cases – to the ones they experienced at their university classes. In Greece most of these classes at the Physics department might be characterized as traditional ones. As a result most of the physics teachers, graduated from the above department, are expected to perform traditional instructions. Hence, as students in this exemplary model participate in a learning environment supported by ICT they are expected to be more eager and competent to act in such an environment as teachers in future.

Points that will lead to the guidelines for the teacher's training profile, as a link to WP4

- modeling process
- microscopic model
- simulation that supports modeling process
- real time experiments that provide a link between real world and models
- learning environment for the student teachers similar to the one they are expected to be competent to act in.

Full Title:

"Interdisciplinary approach and Green House effect"

Proposed by:

University of Athens, Greece

Implemented by:

Université catholique de Louvain, Belgium

Introduction

According to the agreed list of competence, entering a problem with an interdisciplinary point of view was recognized to be acquired by future teachers.

From this perspective, two teams proposed Good examples about interdisciplinary approach. The German team's one was based on temperature gradient, using computer simulations, and the UoA's one was based on experiences.

As such, these propositions, while very interesting, could not be implemented by UCL. The German's proposition did not fit the syllabi of the Belgian secondary schools. Furthermore, at UCL, we were not able to implement computer simulation for the 62 student teachers we worked with. Nor was it possible to ask students to realize experiences about green house effect. We decided to adapt both propositions in order to take the idea of interdisciplinary approach from the German team and the greenhouse effect from UoA team.

Indeed, interdisciplinary approach is one important theme prescribed by upper secondary school science syllabi[1]. Science teachers ask for ideas to be implemented.

Competencies Triggered

The aim of the proposed activity was to develop the following competencies:

- related to greenhouse effect (SMK : related to subject matter knowledge)
- related to self-reflection and metacognition to make student teachers aware of the "a priori" of their own discipline when facing scientific problem (PK)
- in framing a discipline in a interdisciplinary scenario (SMK)
- related to the area of pedagogical content knowledge : translating subject matter knowledge into science teaching unit.

Theoretical framework

For this exemple, three kinds of references were used:

1. About interdisciplinary approach. It has been borrowed from Fourez (2002)[2] and Clément & Cheikho (2001)[3]. Interdisciplinary approach occurs when the disciplinary approaches are interconnected, with retroactions between them, when giving a representation of a situation, we use different disciplines.
2. About Environmental Education : the publications of Sauvé (1999), Clément (1999) and Clément & al. (2001)[4] were used.
3. About the Green House Effect.

Desription of the Activity

Context of implementation

As it was analysed in detail in WP1 report on European training systems and programmes, in Belgium, to become an upper secondary school science teacher, student teachers are asked to get a degree in sciences (Biology or Chemistry, or…) and to perform a programme especially devoted to teacher training 300 h (30 ECTS). 15 out of these 300 hours are devoted to help student to integrate practice (namely stages in secondary schools) and theory (other activities at the university). The EGP has been experimented during this seminar. The seminar went off during three times two-hours sessions.

Sample

62 Teacher Trainees (TTs) attended the seminar : 21 biologits, 10 chemists, 5 Physicists, 17 mathematicians and 9 geographs.

Academic Staff

The seminar had been prepared by a team composed by biologist, physicist, agronom, mathematician, geography. We all participated to the seminar in order to observe, analyse, what happened.

Data collection

What are the conceptions of the future science teachers about greenhouse effect?

Activity :

Brainstorming. Student teachers work in disciplinary team in order to reply to the question : With the point of view brought by your disciplinary education (chemist, physicist,…) answer to the following question : What is the greenhouse effect? What causes has it? What are the consequences? Write down a model.

Data :

Each group constructs an A4 document which will be distributed to all the participants.

Are student teachers aware of the "a priori" of their own discipline when facing scientific problem (PK)?

Activity :

Students are asked to reply to the following questions :

1. Compare the various productions prepared by the interdisciplinary groups from the point of view of
   - contents approached,
   - language used,
   - causes of the effect of greenhouse,
   - consequences of the effect of greenhouse,
   - models suggested
2. Are the productions coherent with the scientific theories on the effect of greenhouse?
3. In what can you use these productions to build your sequence of teaching?

Data

One written page by group.

Are student teachers able to frame a teaching unit in a interdisciplinary scenario (SMK)? How do they translate their reflection and metacognition into science teaching unit?

Activity :

Student teachers are asked to prepare a teaching unit (2X50 min.) by using the groundwork of preparation proposed of teaching

- Quote the scientific concepts which you choose to develop
- In order to have an interdisciplinary point f view in relation to your production, clarify the points which you wish to approach
  - which are the actors concerned with the effect of greenhouse (the human ones, the producers of energy, the ecologists, oil producers...);
  - Which are the standards in Belgium? In Europe? Elsewhere? (p. E on the levels pollution, safety, health...);
  - Identify stakes and tensions (p. E comfort, environment, quality of life, policy...);
  - Which are the black boxes (mechanisms, theories, unexpected factors...) = the concepts which you will not approach?
- describe, in terms of competencies, what students are asked to at the end of the teaching unit (at the end of the sequence, the pupils will have...);
- describe the strategy to arrive there (unfolding)
  - How you will collect the designs of the pupils?
  - How will you use these designs?
  - Which situation-problem will you set up?
  - How will you contextualize learning?
  - What activities of formative and sommative assessment will you propose?
  - Show in what this strategy is coherent or not compared to announced competencies;
  - Stress the way in which the pupils are brought to build their knowledge
  - Describe didactical tools which you will use and in what they are relevant

The third period is devoted to the presentation and discussion about their productions.

Data Analysis

What are the conceptions of the future science teachers about greenhouse effect?

In order to find it out, we have analysed the replies to the questions they were asked to reply.

How student teachers define the green house effect? :

The following elements were given in their definition:

- 6 mention the green house effect as a "natural phenomenon". Ex :Natural and essential phenomenon with the life on earth, which makes possible to maintain the temperature average of the Earth's atmosphere with approximately 15°C."
- 6 mention the physical phenomenon :"phenomena by which some gaz, called with green "house effect" absorb electromagnetic rays" .
- 2 groups do not define the green house effect. For them, the scheme they drew was a definition.

It is very interesting to notice that only two groups out of thirteen mention that natural phenomenon and human and economics activities cause greenhouse effect. Nine groups out of thirteen mention economics or human activities as the only causes of green house effect. It seems that these students do not have the notion of "threshold" which is a very important notion in Biology. Even if it is a "natural" phenomenon, the green house effect has a rather bad connotation.

As for the consequences they unanimously speak about the raising of the mean temperature, climate modification.

As for the schema of the green house effect, there were relatively standardized but coloured with disciplinary touch. Schemas 1 and 2 illustrate the point of view of physicist and biologists.

Are student teachers aware of the "a priori" of their own discipline when facing scientific problem (PK)?

As the productions were not very differentiated, student teachers were not able to compare their a priori very deeply. Nevertheless, they underline that the physician insist more on the absorption of a electromagnetic ray and the emission of a part of this radiation in I.R., whereas the chemists insist more on the capacity of some molecules to absorb IR light and the biologist, more on the equilibrium/desequilibrium changed by the human activities.

Their comparison join ours about the conceptions concerning the green house effect.

Are student teachers able to frame a teaching unit in a interdisciplinary scenario (SMK)? How do they translate their reflection and metacognition into science teaching unit?

Student teachers reply with obedience to the questions there were asked in particular to those related to an interdisciplinary point of view . But, reading their teaching unit, we are obliged to recognize that they are not able to use the replies in the design of the teaching unit. So the different productions were rather classical and content oriented, with, at the end, some remarks about the link between science and environment.

Conclusion

This activity was implemented for the first time. From this perspective, this implementation of good practice can only be seen as a "exploratory". In this section, we would like to draw up some features which should be taken into account for implementing this activity next year or for comparing with the other activities implemented in other countries.

Here are some remarks concerning the implementation.

1. The period of the implementation occurs very early in the science teacher education programme. We think that, at the beginning, student teacher are more interested in "how to build a teaching unit" than in thinking of interdisciplinary approach.

2. Timing: we think that three two hours period is not enough for such a work.

3. After each activity, we should more discuss with the students

References

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4. Sauvé, Lucie, Pour une éducation relative à l'environnement - Éléments de design pédagogique, Guide de développement professionnel à l'intention des éducateurs. 2e édition. Montréal : Guérin - Eska, 361 p. (première édition 1994), 1997

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6. Clément P., 1999 - Les sciences naturelles et l'éducation à quel environnement ? L'éducateur, Revue scientifique et pédagogique (E.N.S. Tétouan, Maroc), 9, p. 3-15.

3.3.2 Matches and mismatches

Research question: **Do the competencies indicated by the learners match or not with those declared by the designers of the EGPs?**

Another aspect of this cross-experimentation deals with matches and mismatches between the triggered competencies that were identified by the designers of the EGPs and those identified by the learners. Table 3.6 shows a combined presentation of the above as taken from and the data on EGP competencies from WP2 report (desired competencies) and the competencies that were triggered in the hosting institutions (triggered competencies).

The data shows that learners' perceptions of the triggered competencies of the EGPs mostly matched those of the EGPs' designers. Mismatches appeared only in few cases. In three cases there was a full match (Modelling, Digestion, Atom) and in two there was a good match (RTEI, Greenhouse). Only in one case the matching was poor (Electric Circuits). Please note the full match means that all the desired competencies (as proposed from the institution of origin of the EGP) are triggered. In many cases more competencies were trigerred (see Table 3.6).

In most cases, the implementation results indicated additional competencies which did not exist in the designers' original list. Overall, 32 competencies were mentioned by the designers while 40 triggered competencies were indicated by the learners.

More specifically, the designers emphasized almost equally SMK and PCK competencies, and hardly mentioned PK competencies. The picture is slightly different in the list of the triggered competencies, where the PCK becomes dominant. Apparently, throughout their experience, the learners revealed competencies that the designers did not anticipate.

3.3.3 Plausible Factors influencing success / failure of the cross-experimentation of the EPGs

Research question: What plausible factors may have influenced the success/ failure, and the matches/ mismatches of the EGPs?

The factors influencing the cross-experimentation of the EGPs may be described as favouring or hindering features. Favouring factors are those who may help a pre-service teacher in his/her acquiring the stated competencies, while hindering factors may have caused mismatches and thus a discrepancy between the expected and actual outcome.

The conclusions drawn by each participating group are summarised in Table 3.7.

Table 3.7: *Factors Favouring/Hindering the Triggered Copmetencies*

EGPs	Hosting Country	Factors that have been Favouring/Hindering the Triggered Competencies
Modeling	U.A (Greece)	Favouring factors: • methodology (simple experiment to model); • use of simulation; • real time measurements with sensors
RTEI	U.A (Greece)	Favouring factors: • methodology (PEC cycle); • real time measurements with sensors; • create a bridge between the model the students had for a certain type of motions and the real world Hindering factors: • type of experiment chosen; lack of knowledge about the use of software

Digestion	UBT (Germany)	Hindering factors: • time schedules
Atom	UBB (Romania)	Favouring factors: • use of an appropriate simulation software
Greenhouse	UCL (Belgium)	Favouring factors: • bringing the students of different subjects together Hindering factors: • time schedule (translating into teaching units consumed too much time and undertaking) • insufficient number of computer prevented to reintroduce the unchanged approach of UBT • chosen age-group of students: interdisciplinary approach needs a solid subject knowledge (which could not yet been expected by "science education freshmen")
Electric Circuits	UL (France)	Hindering factors: • Need for major changes in the proposed scheme to be implemented in the hosting institution • The proposed approach was based on literature review, a process in which French students are not used in.
Greenhouse	U.N (Italy)	Favouring factors: • disciplinary content addressed; • perform the experiment in small groups; • integration of questionnaires/worksheets with (micro)portfolios; • use of Information/Communication technologies (Internet resources, search facilities, transparencies). Hindering factors: • simplification of the physical contents involved; • non-quantitative aspects of experiments; • difficulties in keeping under control the physical parameters involved in the experiment; • difficulties to implement an actual assessment of their future students' work; • concepts no more familiar to trainees.
Atom	U.P (Italy)	Favouring factors: • use of simulation

In summary, the following common favouring and hindering factors can be inferred:

Favouring factors:

a. Methodology:

The methodology suggested is very important in determining the success of experimented activity. For example, clear instructions which lead from simple experiments to a physical model.

b. Modelling:

Familiarity with the pedagogical/instructional tools appropriate for modelling procedures is important for conceptualization of the underlined scientific ideas.

c. Use of ICT:

The activities performed, using computer modelling facilities, stimulated pre-service teacher to play an active role in the modelling process and in appreciating its role in developing ideas and explanations. An accurate use of modelling tools shows the same pedagogical/instructional validity of strategies based on laboratory work.

Finally the use of computer assisted approaches (e.g. Atom) helps to introduce main aspects of disciplinary contents and to enhance students cognitive abilities.

d. Use of laboratory experiments:

Real-time experiments (as in RTEI, Modelling) have favoured the success of the EGPs. The laboratory setting can help small experimental groups to take advantage of a hands-on activity. The experimental setting may help trainees to acquire various competencies: for example, different experimental results obtained during laboratory session can raise questions about the importance of keeping controlled experimental conditions; some experiments (as e.g. the one about greenhouse effect) encouraged the learners' reflection on the didactic advantages of using real-time systems, since opportunities of a fast monitoring of features were provided.

e. Interdisciplinary context:

Interdisciplinary topics (e.g., Greenhouse, Digestion) assist learners in acquiring disciplinary contents. Interdisciplinary contents call for student awareness to the interaction between different scientific disciplines.

Hindering factors

Hindering factors occurred in the following:

a. A short intervention cannot overcome the preconceptions within the distinct subjects; this issue was as already mentioned in WP2 relative report.

b. Simplifying steps with regard to complex content (e.g. Atom) were needed. Similarly, very often a focal point exists on qualitative aspects of an experiment; difficulties arise in controlling some parameters (e.g. Greenhouse) as well as materials for assessment may be insufficient.

c. lack of knowledge of ICT can cause problems, especially when learners are exposed to a new content; in addition, ICT requires expensive equipment (many computers).

d. Time frames. Very often there is a limited time to complete the implemented activity

e. The language issue, which is often not adequately taken into account.

3.4 Summary and Conclusions

This report describes the cross-experimentation of Examples of Good Practice, selected in the framework of WP2 work. The main goal was to provide a common framework for teacher education programs across European countries.

In general, a non-exhaustive list of competencies, seen as important for pre-service science teachers, cannot be totally met within one single, short-term, implementation of an EGP. Generally, when adopting a new approach, as it is the case here, new expertise is required, which necessitates great effort. Nevertheless, this limitation did not restrict the suitability and effectiveness of the chosen EGPs.

The framework for implementing the EGPs has been the list of competencies that are outlined in the WP1 Report. Specifically, the study investigated the competencies triggered in each of the cross-experimentation, examined their matching to those declared by the original designers and suggested plausible factors for success or failure regarding the implementation.

Following are the main conclusions and recommendations:

A. Conclusions referring to the research questions:

- Analysis across all the case studies shows an overall existence of most of the competencies outlined in WP1. However, only few of the competencies are addressed in each single case study. Apparently, a series of such activities is needed in order to develop the required competencies in pre-service programs. Pre-service program designers should plan relevant activities a-priori, taking into consideration the desired competencies.
- Overall most competencies addressed refer to the area of the Pedagogical Content Knowledge. It seems that implementing the EGPs foster the use of additional PCK related capabilities.
- While adopting cross-experimental activities, special attention should be given to appropriate methodologies, valid and reliable tools and challenging environment (e.g., laboratory based, ICT, modelling etc). This recommendation is especially important in a multi-national cross European program.
- Beyond the direct objectives of this study, an additional outcome emerges. The learners described and discussed in length findings referring to the actual activities of the EGPs. Apparently, the adaptation and application of the EGPs happened to enhance reflective and meta-cognitive behaviour among the learners. This outcome was not specified explicitly in the research objectives, namely, it was not one of the three questions.

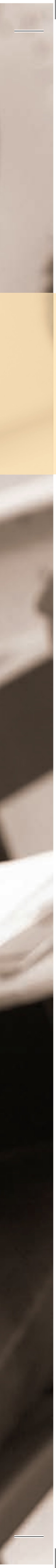
B. Implications concerning competencies

This study may also suggest directions for enriching and refining the list of competencies. Below are some examples of such directions.

- The implemented EGPs have shown clearly that "modelling" comes out as a separate competency while in the WP1 report this competency was included in the general category PCK9. The study performed here strongly indicates that the modelling activities are necessary for a Science Teacher preparation and may be identified as a separate copmetency.
- The competency related to "the knowledge, planning and use of curricular materials" (PCK12) that was defined in WP1 was hardly mentioned among the competencies triggered.

It seems that the short-term activities offered in the EGPs did not provide the opportunity for curricular planning. It is recommended to include curriculum centred activities in any future design of preservice teaching.

It is suggested that these competencies should also be elaborated in the context of in-service frameworks. This coincides with the necessity for Long Life Learning and professional development of science teachers.



Report of Work Package 4

4 Development of a Common Training Framework

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Introduction

New standards in science education are being advocated, standards which reflect the current vision of the content, classroom environment, teaching methods, and support necessary to provide a high quality education in the science for all students (NRC, 1986; Bybee, 1995). Professional development is a critical ingredient of such a reform. During the past two decades, educators and policy makers have implemented a variety of programs aimed at increasing teachers' knowledge and skills. From these efforts we have learned much about what constitutes effective professional developments as well as attributes of best practice (Loucks-Horsley et al, 1998). Teacher education in Europe has developed out of partly common, partly different contexts regarding ideas and social conditions (Buchberger, 1994). Although traditions vary according to national history, modern life, and society, they all bring the same challenges to teachers' professional work and education in different European countries.

In particular, science teacher training takes a central place in the European context. Becoming an effective science teacher is a continuous process and a life long process. This process stretches from pre-service undergraduate education to the end of a teacher's professional career. Since science has an ever-developing knowledge base and expanding technological applications and relevance to societal issues, science teachers will need ongoing opportunities to build their understanding, skills and abilities. Science teachers must also have opportunities to develop understanding of how students with diverse interests and motivation, abilities, background and experiences make sense of scientific ideas and how they should guide and support their students. In addition, science teachers should be provided with the opportunities to study and engage in research on science teaching and learning, i.e, Action Research, and to share with colleagues what they have learned.

Furthermore, remote evidence mounts that a very large number, probably the vast majority of schoolchildren do not understand physics (Dobson, 1985) and it is reflected in their lack of interest and achievements (PISA 2000, PISA 2003, TIMMS 2003). More attempts to make the fundamental ideas of school physics clearer and more logically defined seem to have no effect, other than to demonstrate that most science teachers don't understand science either (Dobson, 1985). Moreover, research findings show that teachers lack the ability to vary the classroom learning environment by introducing different types of instructional techniques. This, in many cases students find their science studies dull and un-motivating (Hofstein and Kempa, 1985).

We operate in an era in which attempts are made to reform science education. Many countries in Europe are reforming their science curriculum (Olme, 2000). The main goal of the Bologna – Declaration (1999) was to homogenize the arena of European higher education. In the wake of this effort, a possibility arises to encourage universities to prepare graduates to the promotion of scientific literacy — an asset whose value transcends national boundaries. From this perspective, structural changes will be required, at all levels, towards new science professional development programs both pre-service as well as in-service programs.

The 4th report (WP4: The Development of a Common Science Teachers Training Framework) integrates the empirical work (e.g., literature review, surveys and cross-cultural experiment) with the designed products and formulations (e.g., Desired Competencies, EGPs and Effective Science Teacher Profile) in order to generate the basic principles and guideliness of a framework of science training in Europe. This section argues that the Desired Competencies should be converted into common standards and suggests how this may be done, inspired by the methodology developed in this project as well as work conducted in the United States.

4.1 The Current Situation: A Comparison of the Science Teachers Training Systems

The WP2 report ("The Effective Science Teacher's Profile") presented the results of a survey of existing teacher training programs in Europe, focusing on secondary school science. A comparison of these programs was used to design a "Profile of an Effective Science Teacher", This comparison could also be helpful for the implementation of the Bologna process and the harmonization of Science Teacher Education Across Europe.

The comparison focused on the diploma required for teaching in secondary schools, the science majors, the pedagogical and didactical approaches, the goals of science teaching education and problems reported by science teacher educators linked with examples of good practices which could be considered as solutions to these problems.

4.1.1 Diploma requirements to teach science in secondary schools

After conducting surveys and comparisons of the systems of the participating countries we have identified three main approaches in science teacher education:

- *Specialization in science teaching after a science university degree*. In this approach, science teachers receive two distinct diplomas (e.g., Belgium for upper secondary schools; in Italy since 1999, pre-service teachers attend a two-year specialization course).
- *Integration of science and pedagogical studies into one diploma* (e.g., Belgium for lower secondary schools; Germany and Romania).
- *No specialization in science teaching* (e.g. Greece)

  In some countries (e.g. Greece, Italy), potential teachers have to undergo a specific assesment process that is performed at National level in order to accede to the profession.

4.1.2 Science majors

A science major represents an area of science study. The majors correspond to the groups of scientific disciplines that are actually taught in secondary schools..

In Italy, there are two main science majors :

- Physics Informatics and Mathematics,
- Natural Sciences : Biology, Botany, Earth science and Chemistry.

In France, there are three main science majors:

- Physics and chemistry (united in one discipline)
- Natural Sciences : Biology and Geology (called Life and Earth Sciences : SVT)
- Mathematics

In other countries (Belgium, Germany and Greece), science majors are almost the same: when students get a degree in one discipline, they are allowed to teach another one. Nevertheless, this is not the case in Romania, where students who receive a degree in one discipline are not allowed to teach another one; in this particular context, the only way to teach in more than one discipline is to get a degree in each discipline.

4.1.3 Pedagogical and didactical approaches

Pre-service education for science teachers includes approaches to pedagogy (how to teach students in the broader sense) and didactics (how to teach specific topics). In-service education is mainly based in a variety of different pedagogical approaches that are mainly implemented during workshops, seminars, conferences, summer schools and on-line, distance learning cources.

Nevertheless, there is a great variety in the amount of time devoted to these approaches, in the participating countries (e.g. from 60h (Belgium) to 379h (France)).

4.1.4 Goals of science teacher education

The goals of the pre-service programs of the participating countries are very close to each another. The following list comes from Belgium, but the goals of many of the other countries are quite similar:.

1. Being informed about his/her role inside the school institution and exercising the profession as it is defined by legal texts.
2. Mobilizing knowledge in social sciences to accurately interpret the real classroom situation to better adapt to the students.
3. Mastering disciplinary and interdisciplinary knowledge and justifying pedagogical action.
4. Being able to conceive, assess, evaluate and regulate teaching strategies.
5. Being able to plan, manage and evaluate teaching situations.
6. Showing his/her general knowledge in order to engage the interest of students in the cultural world.
7. Having developed relational competencies linked to the professional demands.
8. Being able to measure the ethical outcomes linked with his/her everyday practices.
9. Being critical and autonomous towards past and future scientific knowledge.
10. Being able to work in a team inside the school.
11. Being able to study his/her own practice.
12. Maintaining efficient partnerships with the institution, colleagues and the students' parents.
13. Organizing continuing education.

4.1.5 Problems

I. In the different countries, a **lack or insufficient knowledge of the discipline(s)** which are supposed to be addressed in the teaching process has been reported. Reasons for this could be, at least for Belgium and Italy, the fact that student-teachers trained to teach one discipline (Physics or Biology or Chemistry or Earth Sciences) in (upper) secondary schools are required to teach Sciences , (i.e. Physics and Biology and Chemistry and Earth Sciences). No university degree provides such transversal competencies. This is also the case for student-teachers graduated in Mathematics who are allowed to teach Physics.

II. Lack of reflective practice especially epistemological reflection about how science is constructed.

III. The knowledge of the discipline supplied by the university curricula is in many cases **focused on contents** (laws, theories and models) **not focusing much on those processes** which characterize the discipline and on connections with the real phenomena. This way of teaching science leads to a rather poor ability to set up secondary school activities from this perspective.

IV. Compartmentalization of the disciplines (Biology, Chemistry and Physics). Any understanding of natural phenomena within every day life and the environment requires an interdisciplinary methodology. 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. Furthermore, overcoming the compartmentalization of the different subjects is increasingly requested. This approach is accompanied by the belief that most students learn best working with meaningful problems and issues in real-world, and in collaborative groups where communication is of the essence. Additionally, most problems in science are closely linked to each other, for instance, studying photosynthesis is difficult to perform without studying the physics of light, the chemistry of light reactions, and energy flow and use in the cell. Consequently, as in the real world where successful people integrate their knowledge as they resolve the problems they face, children in our schools should learn to integrate all of their knowledge, bringing all of their resources to bear on whatever problem they are facing. Similarly, science topics could feature problems and issues that require the use of specific science concepts and skills from various science disciplines where students are expected to use this same combined language in their responses.

V. Usually, University Courses use a **teaching approach based on a lecture format classes**; experimental science courses include some laboratory activities, usually restricted to a mere verification of regularities and laws presented during the class periods and/or receipts. This situation may derive from the fact that the future teacher will pass their students their direct learning experience as university students. Research results confirm that teachers often transfer in their class-work the methods perceived and the contents learned when they where students, usually simplifying the approaches by referring to the teaching styles/models presented by textbooks. This way of teaching will conduct to a perception of Sciences as Truth rather than process built by men in order to reply to their questions.

Table 4.1: *The main problems and the suggested solutions*

Problems	**Suggested solutions**
The knowledge of the discipline supplied by the university curricula is in many cases focused on contents (laws, theories and models) and not very much on processes	• Performing real-time experiments supported by new technologies • Modeling of physical reality
Compartmentalization of the disciplines (Biology, Chemistry or Physics)	Examples of Good Practices focused on interdisciplinary strategies
Teaching approach based on lecture format lessons	The Good Examples which were proposed were organized in a "Hands-on" perspective. However, courses in education should be combined with: • Instruction in content as well as with disciplinary didactics, epistemology and history • Debate-courses • Interactive courses • Problem solving activities • Continuous assessment procedures during the whole semester (portfolios)

Often courses in education are totally separated from the instruction in content as well as in disciplinary didactics, epistemology and history; teachers have to necessarily synthesize by themselves in order to solve their specific teaching and learning problems.

The problems reported above are rather widespread among partners countries. Other problems are more related to the local context. For example:

VI. Greece does not have any initial science teacher training. Moreover to become effectively a teacher, graduated have to succeed a national contest and get an appointment to science courses in secondary schools. This last step can take several years which leads to a loosing of expertise in scientific and pedagogical knowledge. The in-service science teachers framework is presented in detail in order the situation in Greece, which is rather particular, to be explained in detail.

VII. Changes in Romanian society which had belonged during 50 years to East European Block, affect the formative side of education. It leads to a change of the pupils' mentality, which were used to think like robots executing without thinking all the "commands of the superiors". So the new task as teacher educator is a great challenge.

In Table 4.1 we summarize the main problems and the suggested solutions.

4.2 Science Teachers' Competencies

As pointed out in the WP1 Report (The Science Teachers' Competencies), many researchers, teachers' trainers and associations, who are currently working on proposing standards for science teachers' education and profession, have tried to characterize the science teacher by focusing on the involved "competencies". This concept is considered relevant in all professional fields in general and in education in particular, given the fact that these processes are based on interactions amongst human beings. Pellerey (2001) who recent years reconstructed the evolution of the competency concept in suggested that it means not only the mastery of knowledge and methods, or the ability to use them, but also the ability to integrate different kinds of knowledge, and to use them synergistically. Therefore to be competent in a certain area implies the ability to mobilize one's own knowledge and to transform it into concrete doing. Competency is an individual characteristic and is built (through self-experience and formation) in a given field and in a given area of problems. It includes the content of the learning process as well as the context where it happens and the ability to apply the grasped content (Coggi, 2002). The operational definition of science teachers' competencies: consists of knowledge, capacities, skills, and behaviours, which guarantee the quality of teachers' reflection, decisions and actions, respectively which allows for projection, organization, development, assessment, and adjustment of didactical activities.

Developing and modelling the competencies means a continuous process, and a long term process, which begins during the teachers pre-service training and continue throughout in-service training. Competencies are not a curriculum, a curriculum framework, or a plan for a curriculum. It provides policy makers with sequences of specific learning goals that they can be used to design a core curriculum—that will eventually make sense to them and will help attaining scientific literacy for all students.

Identification of competencies

In order to propose key basic principles and standards for a professional framework, one has to start from the teachers themselves, in order to determine their current expectations and needs. This method was implemented in the initial steps of the STTAE project.

The STTAE is a European research project, involving Universities from five European Countries and one Associated Country (Belgium, France, Germany, Greece, Italy and Romania). The key goal of this project was to establish a pathway for a common European Science Teachers training framework. More specifically, the focus of the project was to observe and assess the structure of science teacher education and thus design and test an innovative and effective training framework. The partnership has not indented to develop a common science teachers' training curriculum for all European countries but – through an extended survey – has aimed in developing a series of main competencies that can be applied to the different national training curricula across Europe, taking into account and appreciate differences and diversity of the existing educational systems and approaches. To summarize, the general stages of this project were:

- Stage 1: Perform a correlational survey and analysis on how the different national science teachers' education programs in order to prepare teachers to teach science effectively.
- Stage 2: Determine the main competencies that have the potential to contribute to an effective framework for science teachers training.
- Stage 3: Identify and assess a series of case studies to be used as examples of good practice (exemplary practice).

In the first stage, the study focused on identifying the science teachers' competencies and, the profile of the effective science teacher of tomorrow. This was done by inquiry research, discussion with science teachers and experts , and by a survey, administered to the participating countries.

4.2.1 Initial survey

The following findings and conclusions revealed from the comparison of the answers given by science teachers and experts in science teaching in the participating countries some general conclusions came out. The competencies we chose to discuss about and focus on are not those we identify as General Characteristics and Competencies, since these are, in many cases, independent from subject or disciplinary content during teacher education. These competencies refer to a teacher's general knowledge, verbal knowledge and cultural level, or, in other cases, to his beliefs and attitudes about teaching and learning, in other words, teachers' personality.

The common competencies that emerged from this analysis are grouped under a categorization which takes into account Shulman's work (1987): Subject matter knowledge (SMK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK). The following table elaborates on each category, referring to WP1 and to WP2.

The following list summarizes the titles of the common competencies:

Subject Matter Knowledge (SMK)

1. Competencies related to subject matter/content knowledge (SMK1)

2. Competencies related to the nature of science (NOS) including inquiry knowledge and skills (SMK2)

3. Competencies in framing a discipline in a multidisciplinary scenario including STSP (Science, Technology, Society in a Personal context) and mathematics (SMK3)

4. Competencies in knowledge of contemporary science (SMK4)

Pedagogical Knowledge (PK)

5. Competencies in mastering and implementing a variety of (especially student-centered) instructional strategies and assessments attending to individual differences (PK5)

6. Competencies in sustaining autonomous lifelong learning (PK6)

7. Competencies related to self-reflection and metacognition (PK7)

Pedagogical Content Knowledge (PCK)

8. Competencies related to the area of teaching/learning processes within the domain (PCK8)

9. Competencies in using laboratories, experiments, inquiry, projects, modeling and outdoor activities to build understanding and skills of students (PCK9)

10. Competencies in addressing students' common sense knowledge and learning difficulties (PCK10)

11. Competencies in the use of ICTs (PCK11)

12. Competencies in the knowledge, planning and use of curricular materials (PCK12)

Below, are presented some conclusions regarding the above mentioned competencies that came out as common from the surveys of each of the participants' institutions. These conclusions are based on the results of the surveys with teachers, experts and the literature review.

These Desired Competencies became the foundation for work done in WP2 and WP3. They were the basis for the choice of "Examples of Good Practices" (EGPs), which each partner designed and presented. They were also the principle measure of the "cross-experimentation" of the EGPs, as conducted in WP3. Later in this report, it will be suggested that these competencies be converted into common standards for science teaching training programs in Europe.

In WP2 relative work the Effective Science Teacher's Profile was generated, based on these competencies, the problems identified in science education and the science education literature. Table 34.2

summarizes the correlation of the desired competencies from WP1 with the profile of the effective science teacher from WP2.

Tables 4.2 and 4.3 are presenting data relating to this issue. Table 4.2 shows those attributes of the proposed profile of the effective science teacher which are matched to the various competencies. Table 4.3 shows those attributes of the profile of the effecive science teacher which are unmatched to these competencies.

Table 4.2 *Comparison of the "Effective Science Teacher Profile" with the "Desired Competencies of a Science Teacher": Matched Attributes. The following attributes from the profile match the Desired Competencies, as shown.*

Attributes of an "Effective Science Teacher Profile" Matched to the Desired Competencies	Desired Teacher Competencies
"Degree in one scientific discipline, including a strong introduction to the others and a specialization in science teaching (included or separated from the science degree)."	**SMK 1**: Subject Matter Knowledge
"Expertise and interest in … the history and philosophy of science."	**SMK 2**: Nature of Science and Inquiry Knowledge/Skills
"Design interdisciplinary teaching/learning units linking science, technologies and society."	**SMK 3**: Multi- and Interdisciplinary Framing
"Expertise and interest in contemporary science."	**SMK 4**: Contemporary Science
"Organize student centered teaching/learning approaches, based on student's conceptions and needs and on a variety of learning strategies." "Design teaching units enhancing student self-directed learning." " keen to plan, organize and evaluate lessons so that all pupils are successful."	**PK 5**: Student-Centered Approach
"Ability to reflect on his/her work and to self-study." "Ability to use the results of research in science education." "Ability to work both individually and in a team."	**PK 6**: Independent and Life-Long Learning
"Being aware of the sense of purpose of what he/she teaches." " Share and talk about his/her practice with their peers and pupils."	**PK 7**: Self-Reflection and Meta-cognition
"Ability to use a large range of teaching/ learning strategies, and organizational and management strategies in order to create environments favorable to pupils motivation and success." "Design teaching/learning units leading pupils to become aware of the sense of purpose of what they learn (situated learning to making science more relevant to students)." "Design teaching/learning units that help pupils experiment in different areas regarding the passage from their everyday experience to representations of formal science."	**PCK 8**: Teaching/learning processes
"Organize "hands-on" experiments, enhancing learning by doing instead of learning by observing, and informal learning science in social and technological context, such as field trips, arranged visits to museums or to industries and institutions that engage in scientific or technological research."	**PCK 9**: Inquiry, Modeling, Guided Practice
"Design teaching units addressing student learning difficulties by using among other elements the results of current research in science education."	**PCK 10**: Student Learning Difficulties
"Integrate ICT in teaching/learning units."	**PCK 11**: Use of ICTs
	PCK 12: Knowledge and Use of Curricular Materials

Table 4.3: *Comparison of the "Effective Science Teacher Profile" with the "Desired Competencies of a Science Teacher": Unmatched Attributes. The following attributes from the Profile have not been located thoughout the project's survey as Desired Competencies.*

A. Personal Qualities:	B. Requirements and Duties
"dynamic and reliable"	"Ability to face innovation."
"enjoys teaching and his/her students"	
"demonstrates a willingness to know his/her students"	
"adapts and changes to meet their needs"	
"tolerates ambiguity"	
""is comfortable with not knowing	
"is a leader within the classroom and with colleagues"	

This data clearly shows that the Desired Competencies are necessary but not sufficient attributes of an effective science teacher. Also necessary are "personal qualities" such as being dynamic and reliable, enjoying teaching, adapting and changing to meet student needs, tolerating ambiguity, being a leader within the classroom and with colleagues, and having the ability to face innovation.

How might science teacher training programs develop these "personal qualities" in pre-service science teachers? This is a crucial but open question. One possibility is that teacher preparation programs – in focusing on the development the Desired Competencies – will also develop the desired personal qualities in the Effective Science Teachers Profile over time. Another possibility is to consider teaching as a fine art that takes many years of development. Early cultivation of artistic practice – such as music, dance and painting -- is a part of what most societies offer their young; such early cultivation of artistic practice insures that some talented individuals will "make it to the top." Similarly, the idea has been suggested that the young might also be offered opportunities to develop teaching expertise from a young age, through such activities as peer-teaching and working as science museum guides (Wilson and Daviss, 1994). If these types of opportunities were more commonplace and encouraged, perhaps more pre-service teaching candidates would have these elusive "personal qualities."

4.2.2 Competencies Promoted by Examples of Good Practices (EGPs)

In WP2, the Desired Competences have been linked with strategies for teacher preparation in the partners' science teachers training university programs that were tested in diverse contexts. These successful approaches are presented as "Good Practice pattern cards" enabling prospective teachers who not involved in the same training system to implement them. Each partner of the STTAE project was asked to experiment at least one out of these "Good Practices" (see WP3 report). Each pattern card has its own title, and presents the justification of its proposition, the competence(s) to be developed by pre-service or in-service science teachers, its pedagogical goal, the used resources, and assignments.

The implementation of the didactic activities proposed by the Examples of Good Practice (EGPs) were implemented cross-culturally. Evidence was monitored and collected in order to Identify the "triggered competencies" in each example (for more information, see WP3).

Having in mind the categorization that proposed and adopted by the STTAE partnership, every country – team prepared the list of the competences for the "Examples of Good Example" that they designed, as presented in the following table.

4.2.3 Competences that were triggered

The competencies that were triggered are bases on the cross-national constraints and different educational contexts, the implementations of the EGPs that were conducted according to designers' instructions. In some cases, some minor adaptation was needed in order to match the context of the experimentation. In cases of major adaptations, the participating group that implemented an EGPs has discussed with the research group that designed it the modifications that are needed for effective implementation.

The list of declared competences was compared with that of the actual acquired competences. In the following table, we present the triggered competences that have been inferred from the collected data.

The presented data indicate that the cross-experimentation is a valid tool to study the transferability of EGPs in different educational contexts and that most of the competences aimed at by the EGPs' authors have been triggered, at least at the educational relevance of their acquisition. The following table, which was inserted in WP3, indicated the desired and triggered competencies for each EGP.

To summarize, this study has also suggested that to insert, in a teacher education program, experiential activities centred on EGPs is a valid strategy to "teach about competences". In general it was found out, that the most emphasized competencies were those of the pedagogical content knowledge (PCK):

- Competencies in using laboratory, inquiry, interpretation of research, modelling and guided practice to build understanding and skills of students
- Competencies in addressing students' common sense knowledge and learning difficulties
- Competencies related to the area of teaching / learning processes within the domain

This study has also suggested to insert in this program experimental activities centered on EGPs as a valid strategy to "teach about competencies". Five competencis were stressed:

- One of the competencies refers to the subject matter knowledg: "Competencies in framing a discipline in a multidisciplinary and/or interdisciplinary scenario including STSP (science, technology, society in a personal context) and mathematics (SMK3)."
- The other three competencies refer to the pedagogical content knowledge:
    - Competencies related to the area of teaching / learning processes within the domain (PCK8).
    - Competencies in using inquiry, reflection, interpretation of research, modeling and guided practice to build understanding and skills of students (PCK9).
    - Competencies addressing students' learning difficulties (PCK10).

The competency dealing with the knowledge, planning and use of curricular materials (PCK12), which was identified in WP1 relative work based on experts comments and additoions, was rarely mentioned as triggered in the implemented EGPs. Please note that this compentency was not initialy analayzed in the framework of the development of the EGPs cards for the project's implementation and for this reason is not mentioned in none of the proposed EGPs. Still the project team decide to included in the integrated analysis as there is always the possibility to be triggered during the implemenmtation.

In Table 4.4 the Desired Competencies (•) and Triggered competencies (√) for the implemented EGPs in the different countries are presented. The importance of SMK1 and PCK8 competencies is clearly demonstarted. Additionally the significant increase of the triggered cases of PCK9 (taking into account the high relevance with PCK10) demonstrate the importance for this competency in the framework of the project's implementation.

Table 4.4: Desired *Competencies (•) and triggered competencies (√) for the implemented EGPs in the different countries. The comparison is possible only for the case studies where the portfolio assesment method was adopted. The importance of SMK1 and PCK8 competencies is clearly demonstarted. Additionally the significant increase of the triggered cases of PCK9 (taking into account the high relevance with PCK10) demonstrate the importance for this competency in the framework of the project's implementation.*

EGPs	**Hosting Country**	**SMK1**		**SMK2**		**SMK3**		**SMK4**		**PK5**		**PK6**		**PK7**		**PCK8**		**PCK9**		**PCK10**		**PCK11**		**PCK12**	
Modeling	U.A (Greece)	•	√													•	√	•	√	•	√	•	√		
RTEI	U.A (Greece)															•	√		√	•	√	•	√		
Digestion	UBT (Germany)	•	√							•	√	•	√	•	√	•	√								
Atom	UBB (Romania)	•	√					•	√		√				√	•	√		√			•	√		
Greenhouse	UCL (Belgium)	•	√			•	√			•	√				√	•	√								
Electric Circuits	UL (France)	•			√					•					√		√			•	√				
Greenhouse	U.N (Italy)	•	√			•	√		√	•						•	√		√						
Atom	U.P (Italy)	•	√					•								•	√		√			•	√		√
Total		**7/8**	**6/8**	**0/8**	**1/8**	**2/8**	**2/8**	**2/8**	**2/8**	**4/8**	**3/8**	**1/8**	**1/8**	**1/8**	**4/8**	**7/8**	**8/8**	**1/8**	**5/8**	**3/8**	**3/8**	**4/8**	**4/8**	**0/8**	**1/8**
		11/11								**6/8**						**15/21**									

4.3 Guidelines and Recommendations

Thus far WP4 report reviewed and summarized three reports (WP1-WP3) aimed at developing competencies and their alignment with EGPs used by participating countries. It is clear that there is a diversity in the use and applications of these competencies. The first step in building better connections between in-service and pre-service – and, ultimately, in constructing a continuum of career-long teacher education – is for those who are responsible for teacher education to elaborate on and analyze the issues outlined above and to communicate across the in-service and pre-service boundaries to identify ways to work together to address these issues. In order to develop a general framework for pre-service and in-service professional development of science teachers, there is a need to identify the components of such a framework with the goal in mind to standardize the main components of science teachers' professional development. It is suggested that such a framework should include three major components: (1) Turning competencies into standards, (2) providing teachers with opportunities for Life-Long Learning, and (3) Models of teachers' professional development

4.3.1 Turning competencies into standards

It is recommended and anticipated that the next line of action should be a project that will further analyze and identify the components of each of the twelve competencies outlined in this document, transforming them into standards. Several researchers have focused and recognized the importance of setting "standards" for those who design and implement teacher training programs (NRC, 1996 ; AETS, 1996; NSTA, 2003). The standards provide criteria that people at the local, state, and national levels can use to judge whether particular actions will serve the vision of a scientifically literate society. They bring coordination, consistency, and coherence to the improvement of science education (National Science Education Standards, 1996). The National Science Teachers Association (NSTA) Standards for Science Teacher Preparation are based upon a review of the professional literature and on the goals and framework for science education set forth in the National Science Education Standards (NSES) (National Research Council, NRC, 1996). The standards in science education in the USA (NRC, 1996) suggested that the professional development for teachers should be analogous to the professional development in other professions. Becoming a science teacher is a continuous process that stresses from pre-service experiences in undergraduate years to the end of the professional development career. In the process of developing the standards for professional development, we have to take into account that science has a rapidly changing knowledge base, and thus science teachers should have opportunities to build on their understanding and abilities. The professional development standards present a vision for the development of professional knowledge and skill among teachers. Each of the twelve competencies listed in the previous chapters, should be further elaborated. In doing so, one should refer to the National Science Teacher Association (NSTA, 2003) standards for science teachers' preparation. For example, regarding to competencies in the area of subject matter knowledge (SMK2) - competencies related to the nature of science (NOS) including knowledge and skills, in the NSTA document it is stated:

To show that there are prepared to teach the nature of science, teachers of science must demonstrate that they:

- Understand the historical and cultural development of science and the evolution of knowledge in their discipline.
- Understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of re-

Table 4.5: *Turning Comptetencies into standards: The evolution of the Competencies assesment during the different phases of the project (WP1: Identification of Competencies according to the importance in the national training systems, WP2: Desired Competencies and their appearance to the proposed and implemented 8 EGPs, WP3: Triggered Competencies during the implementation of the EGPs in the participating countries, WP4: Identification of the Competencies that could form a Common European Training Framework for Science Teachers). The assessment was mainly based on the portfolio assessment method. The importance of SMK1 and PCK8 competencies is clearly demonstrated. Additionally the significant increase of the triggered cases of PCK7 and PCK9 (taking into account the high relevance with PCK10) demonstrate the importance for this competency in the framework of the project's implementation.*

	SMK1	SMK2	SMK3	SMK4	PK5	PK6	PK7	PCK8	PCK9	PCK10	PCK11	PCK12
WP 1	3 H	4 H		3 H	4 H			5 H	3 H		3 H	
WP 2	7/8	0/8	2/8	2/8	4/8	1/8	1/8	7/8	1/8	3/8	4/8	0/8
WP 3	6/8	1/8	2/8	2/8	3/8	1/8	4/8	8/8	5/8	3/8	4/8	1/8
WP 4	-	-	-	▼	-	-	▲	▲	▲	-	-	-

searching the world.

- 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.

Another example from the NSTA standards refers to competencies related to the subject matter / content knowledge / pedagogical content knowledge:

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:

- Understand and can successfully convey to students the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields as recommended by the National Science Teachers Association.

- Understand and can successfully convey to students the unifying concepts of science delineated by the National Science Education Standards.

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

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

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

In the process of the development of the standards for professional development, one should consider the vast amount of recent studies regarding teachers' enhancement in the areas of subject matter as well as well as its related pedagogy. The component of pedagogical content knowledge refers to teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular grade level (Magnusson, Krajcik and Borko, 1999).

In addition, one should refer to:

- The body of knowledge regarding students' learning and the recent call for attaining scientific literacy for all students.

- The environment in which the process of learning and teaching will take place.

In WP3 there is a description of the methodology agreed within STTAE project in order to tackle the following general research questions:

1. Does the proposed EGPs trigger the acquisition of competences? If so, which ones?

2. Do the competences indicated by the learners match or not with those declared by the designers of the EGPs?

3. What plausible features may have influenced the success/ not success, the matches or mismatches of the EGPs?

Questions within this context generally address a comparison of results coming from very different education contexts. Nevertheless, a major challenge of any cross-country experimentation within Europe has to take into account the existence of various national curricula within a specific (and often diverse) tradition. Generally, European curricula were not linked to each other and, thus, transferring an exemplary example from one system to another very often means more than just a simple transfer process. Similarly, adopting an example into another language frame never is just a simple literally translation into another language but it also has to deal with appropriate environments of the (hosting) country. In the STTAE framework of cross-experimentation, the principle content of an example never was changed in translating.

Finally, any implementation approach has been influenced by the pre-selection of courses of an academic university year within a specific limited time slot. This seemingly has been the case with the implementation in Italy and Germany. Nevertheless, such a situation is not unique within case study frameworks.

Taking into account all of these cross-national constraints and different contexts, the implementations of the EGPS have been made according to designers' indications. In some cases, some adaptation was needed in order to match the context of the experimentation; in case of major adaptations, the participating group that implemented an EGP has agreed with the research group that designed it the modifications needed to the implementation.

The evolution of the Competencies assesment during the different phases of the project (WP1: Identification of Competencies according to the importance in the national training systems, WP2: Desired Competencies and their appearance to the proposed and implemented 8 EGPs, WP3: Triggered Competencies during the implementation of the EGPs in the participating countries, WP4: Identification of the Competencies that could form a Common European Training Framework for Science Teachers) is presented in Table 4.5. The assessment was mainly based on the portfolio assessment method. The importance of SMK1 and PCK8 competencies is clearly demonstrated. Additionally the significant increase of the triggered cases of PCK7 and PCK9 (taking into account the high relevance with PCK10) demonstrate the importance for this competency in the framework of the project's implementation.

4.3.2 Providing teachers with opportunities for Life-Long Learning

Professional developers can be guided by the extensive body of knowledge about how effective change occurs in education settings (Fullan, 1991). Change is both an individual and organizational phenomenon affective each and every educator as well as the schools, districts, universities, and other organizations to which they belong. It should be in the process of development standards based on the competencies, one has to take into consideration that changing human beings in general takes time and persistence. Those change efforts are effective when the change to be made is clearly defined and support for change is available (Loucks Horsley et al, 1998). We suggest that science teachers should be provided with opportunities for their professional enhancement for life-long learning. Thus, future development should relate both to pre-service and in-service training programs and activities. Moreover, it is important to keep in mind that many of the opportunities for continued life-long science learning are available within informal science contexts such as science museums and zoos, after-school community programs, the media and so forth. Science educators are becoming more and more aware of the benefits of "bridging the gap" between formal and informal science contexts (Hofstein and Rosenfeld, 1996). Perhaps science teacher educators should follow suit.

In regard to the twelve competencies, a spiral model should be adapted in which teachers are exposed to the subject matter, pedagogical knowledge and pedagogical content knowledge continuously several times through their career. A life-long learning process has the potential of fostering a change in students' beliefs as well as in their classroom practice.

Science teachers, like other professionals, ought to be fully able to advance through a series of career stages that reflect both their intellectual and professional growth; teachers who demonstrate improvement in their teaching must be appropriately acknowledged. If high quality teaching is the leverage point for improving science education, and if professional development is a prerequisite for a well-qualified and effective teaching force, then teachers need a focused support system and enough time to grow as professionals.

4.3.3 Models of teachers' professional development: Development of leadership

The process of defining and characterizing the standards of science teachers' professional development, there is a need to research and consider effective models for this effort. At the very center of professional planning is the decision about which the strategies of approaches to use. While the workshops (WP1-WP3) investigated the effectiveness of the competencies in the various topics of science learnt in schools, there is still a need for further studies with the goal in mind to identify the best practices in which there is a good alignment between the competencies and the studied topics. In recent years strategies for professional development were researched extensively (see for example Louck-Horsley et al, 1998). Hofstein and Even (2001) claim that continuous professional development can be enacted in different teachers' centers – regional or national, which main goals are to:

- Provide teachers with continuous and sustained support for professional development of science and mathematics teachers.
- Provide science and mathematics teachers with opportunities to engage in life-long learning.
- Create an environment of collegiality and collaboration among teachers who teach the same or related subjects, an environment which encourages reflection on their work in classroom.
- Incorporate the process of change into professional development (some examples include curriculum change and new and varied instructional techniques).

Teaching science effectively in the classroom requires much more than just a straightforward implementation of the curriculum. One of the most promising and effective methods to attain the goals of reform and to enhance professional development is to develop leadership among science teachers (Hofstein and Even, 2001). In Israel, the national teachers' centers are responsible for the following activities:

- Development of teacher leaders who will initiate, support, conduct and lead professional in-service development.
- Counseling and support for the regional teacher centers and other regional professional development activities for teachers.
- Development and establishment of high standards in the pedagogy and mathematics and science teaching and learning.
- Development of models for effective professional development of mathematics and science teachers.
- Establishment of a clearinghouse for relevant computer assisted instruction, special experiments, and relevant instructional methods and programs and curricula from all over the world.
- Dissemination at the national level of relevant professional information.

Another suggested model for professional development of teachers is Action Research (Mamlok-Naaman, Navon, Carmeli and Hofstein, 2003). Action Research is an inquiry in which teachers research their own work and their students' learning in the classroom (Feldman & Minstrel, 2000). According to Feldman (1996), the primary goal of Action Research is not to generate new knowledge, but rather to improve and change classroom practices. The process of Action Research can be described as a cycle of planning, implementation, observation, and reflection. Implementing changes and improving classroom practices is an iterative process (Kemmis & Mctaggart, 1988; O'Hanlon, 1996; Zuber–Skerritt, 1996). Each cycle of Action Research is repeated and all cycles form a spiral. Lewis and Munn (1987) indicated three main reasons for conducting teacher-based research: (1) to try to determine what is actually going on, (2) to monitor and thereby formatively influence the direction of new developments, and (3) to evaluate what is already taking place.

Loucks-Horsley, Hewson, Love, & Stiles (1998) wrote that

Action research has evolved in the education community into an ongoing process of systematic study in which teachers examine their own teaching and students' learning through descriptive reporting, purposeful conversation, collegial sharing and critical reflection for the purpose of improving classroom practice. (p.95)

The use of action research as a strategy for professional development is based on the following assumptions (Loucks-Horsley et al., 1998, p.97):

- Teachers are intelligent, inquiring individuals with important expertise and experiences that are central to the improvement of education practice.
- By contributing to or formulating their own questions and by collecting data to answer these questions, teachers grow professionally.
- Teachers are motivated to use more effective practices when they are continuously investigating the results of their action in the classroom.

Yet another model for the professional development of science teachers – known as "the evolving model" -- posits that teachers over time need to develop along three "focal areas": as learners, as teachers and as educational innovators (Rosenfeld S., Scherz, Z., Orion, N. and Eylon, B., 1997; Rosenfeld S., Scherz, Z., Orion, N. and Eylon, B., in submission). According to this empirically-based model, teachers will naturally undergo a common development sequence for each of these three focal area -- from enthusiasm and confusion about goals and frustration about achieving these goals to the accomplishment of these goals -- and they need long-term support in these processes.

To summarize, we presented a few models for professional development, which are based on current ideas and conceptions about student learning of science.

The aim was to convey the message that there is more than one way. Each model should be adapted to different goals of teachers' preparation, whether it refers to pre-service professional development or to in-service professional development as well.

4.3.4 The user-centered approach in Teachers Training Programmes

Teachers tend to teach as they were taught. Teachers of science form their image of science mostly through their science training. If that image is to reflect the nature of science as presented in these competencies, trainees must "receive" science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding. Regardless of the specific structure and content of teacher training programs, it should at first facilitate an understanding of the science processes from a users view and allows the learner to adjust to the changing needs that a user experiences.

Therefore, instruction in science teacher training programs should be conducted so that the trainee students are placed in the role of the "user". So, they should be designed as heavily based on investigations, where in-service and pre-service teachers have direct contact with phenomena, gather and interpret data, or involved in groups working on real, open-ended problems. Such training programs must allow teachers to develop a deep understanding of scientific ideas and the manner in which they were formulated.

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