EuSTD-web

European Teachers Professional Development for Science Teaching in a Web-based Environment

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EuSTD-web

Book

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Section 1

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1.1

GENERAL INTRODUCTION
Mick Dunne and Stanislaw Dylak

When a committed and enthusiastic group of practitioners come together with a common purpose and their efforts results in a worthy product it will not be surprising that they want to further develop and refine their work. Such a group of academics from across Europe met in the autumn of 1999 in Warsaw, Poland and conceived a 3 year Comenius funded project christened ‘SySTEM’. The central objective of SySTEM was to produce essentially a paper-based Pan European Postgraduate Training and Qualification for Teaching Science at Primary Level. The motivation for this was multifaceted but primary located in an identified need to fill a gap in the field of continuing professional development that related to the need for a post-graduate qualification in primary science that transcended international boundaries. Although similar endeavours had met some success the scale of this work tended to be limited in their international scope whereas this work involved nine universities in seven countries spread right across Europe (Bulgaria, Sweden, Estonia, Poland (3 universities), Czech Republic, Portugal and the United Kingdom).

Another major factor that influenced the direction taken by the project team was the need for teachers in many countries to achieve a second or higher degree; this was most obviously so in Poland that was experiencing a huge compulsory drive towards equipping its entire teacher work force with a Masters level qualification. The requirement for teaching professionals to be able to access professional development opportunities at a second degree level has continued as seen, for example, by the UK government’s commitment to its school-based professionals becoming qualified with a Masters degree in Teaching and Learning (MTL).

Of course many factors influence the choice of a project but the development team were totally committed to the production of a resource that not only would have a major beneficial impact on teachers but the ultimate goal was to see young learners within the primary phase benefit from more effective teaching and learning experiences.

This project was judged successful not just because it met the requirements identified by Brussels but because a valuable resource base had been developed and was becoming increasingly used. However, this use was limited not least because it was restricted to a paper-based form and given the project team’s desire for a wider level of engagement with the science education modules of SySTEM and second Comenius project was presented to and accepted by the European Union and so EuSTD emerged. Many of the original project members and institutions continued with this development of SySTEM although the number of Polish universities was reduced from three to two which was compensated for by the involvement of the University of Helsinki, Finland.

As you will read EuSTD was conceived as a web-based resource using an open-access virtual learning environment that had the capacity to extend and deepen a user’s knowledge and understanding of what constitutes effective primary science practice. Its content was essentially shaped by the primary science education modules developed in SySTEM and by the introduction of a small number of new modules. The module hierarchy, based on three levels, was retained and further explanation of this is provided in this
document. Essentially level one is designed to reveal some professional development needs of a participant which is addressed by undertaking one or more level two modules. Level three, the final level, is based on active engagement in an agreed action research project that is collaborative in nature involving teachers from at least two contrasting international settings.

It was very quickly understood that moving from a paper-based entity to one that was essentially virtual placed very different demands on a participant. Effective end-use would be dependent on a wide range of factors including whether ICT resources including internet access was available (ideally broadband) through to a basic level of competent ICT skills and even a willingness to accept a more solitary level of working (solitary in the sense of being physically apart from peers for much of the study time). What was quickly obvious was that there were wide ranging differences in how effective online learning was perceived. In Estonia distant learning is often based on films of lectures while Finland makes much use of streaming media, but in Sweden e-books were popular whereas in the UK it was common to find online modules.

The paper-based modules of the original project tended to have traditional forms of assessment instrument employed to gather data often used to make judgements about the performance of the participant. Having moved to a web-based resource necessitated reviewing the means by which assessment information was captured. It is generally agreed that assessment by single method (testing, examination, assignment writing, presentation...) present a narrow view of the learner. Furthermore the benefit to the individual concerned of such an experience can be limited. Portfolios are seen as useful in supporting individuals in improving in their ability to assess their strengths and weaknesses and in identifying what they know, what they are learning and areas that need improvement. Portfolio development ideally necessitates some level of interaction either with peers and/or teachers in order to gain a more complete picture of their own achievements and progress. This form of assessment allows individuals to develop a fuller understanding of themselves as learners but this only works if they are actively involved in the process of assessment i.e. a measure of self-assessment is desirable. This instrument is often seen as a form of context-embedded assessment that is the evidence generated is an integral component of the task being carried out (it is not an assessment-afterthought).

An e-portfolio seemed to be an obvious choice given that electronic evidence could include inputted text, electronic files, web-based resources, e-mail dialogue (with tutor, peers...), digital images, multimedia, blog, hyperlinks, or any of the following evidence in a digitalised form teaching materials, completed tasks, observation data, teacher/tutor-completed checklists, personal self-reflections, etc. Having agreed that an e-portfolio would be most suitable the project team continually wrestled with other related issues such as who owned the portfolio and ethical issues in relation to tutor access.

While many questions were never fully addressed such as those alluded to above the project team strongly believed that this concept of a web-based resource would nevertheless allow:

- Ongoing training and development opportunities which are critical in ensuring young learners are exposed to high quality educational experiences
- A more individualised professional development path to be identified
- A CPD opportunity contextualised in the work-based location of the participant
- Greater choice being afforded who are no longer limited to local opportunities for CPD that are traditionally delivered by their local or regional university or college
• Successful participation in EuSTD results in teachers well-placed to meet not only contemporary primary science related professional demands but to be better equipped to face the demands of the future
• Experience an exciting and innovative collaborative CPD process that can have beneficial impacts not only within the classroom or school but beyond
• Move from the abstract notion of a European teacher to its conceptualisation

A major challenge to the project team was in the identification of a shared educational philosophy that would help shape the structure, organisation and delivery of a CPD resource located online. Such a perspective needed to take cognisance of a paradigm shift that reflects changes within the European Union; Eastern European, Nordic and ‘Western European’ educational traditions with quite distinct characteristics moving to a wider, shared understanding of principles and practices. Overcoming partner preconceptions and working towards a consensus of general agreement about key educational terms such as ‘didactics’, ‘investigation’, ‘assessment’ and ‘experiment’ were just some of the many challenges faced. A particularly thorny issue related to the use and meaning of teaching and learning goals which, as the reader will discover, are often rooted in both the national context and national imperative(s) such as science and society in Sweden.

Relevant pedagogy

A culturally relevant pedagogy, the term elaborated and improved by Professor Gloria Ladson-Billings from the University of Wisconsin-Madison is now widely recognized and accepted as a culturally relevant theory of education. This idea has also been explored by a number of other authors most notably Aikenhead (2001) and Peacock (2005). This pedagogy is mostly based on rethinking a student as a teachers’ partner in the learning/teaching process. We should consider this experience from the point of what students bring to pedagogical processes while also reflecting on the environment in which they have been raised, their intelligence, interests, pre-knowledge and the many different ways of thinking about both science and how it is taught. According to Ogbu and Simons (1998) it is only through the provision of a culturally relevant pedagogy that students/learners are able to maintain their cultural identity while succeeding academically. In other words learners should get some help or at least recognition and consideration by a teacher as to their particular economical, social and cultural background at the beginning of any educational event. This does not mean that as teachers we should limit ourselves to only students’ languages and behave as students do. We, the teachers need to use this culturally relevant information to provide a more sensitive and personalized teaching and learning experience. For example, we need to know and about students’ highly variable and individualized ideas about nature and science and understand how their culture is inevitably connected with such a position.

It is especially important in teaching science that we should be sensitive to students’ language. Students frequently know a great deal about the nature but all too often it is locked in another language, the highly personalized language of the learner and not the specialised language of the subject teacher. Learners through their direct experiences with nature typically generate generalizations that are significantly influenced by such everyday observations. Moreover they also have emotions connected to knowledge and in this way make conscious and subconscious links between both the outside and their inside (internalized) world. Teachers need to not just acknowledge the existence of these two world states but be prepared to talk about them in order that learners will see that we take value their thoughts or pre-knowledge, including how these are expressed through their unconventional language, very seriously. By doing this we are more likely to convince our students that we know and appreciate them and perhaps begin to communicate with them emotionally. They are then more likely to develop a closer to understanding about our passion for teaching is driven by a strong
desire to achieve a shared understanding of one another. We believe this is a crucial position to adopt if one is to provide successful, efficient and effective teaching, something reflected in Humberto Maturana’s (online) culturally relevant reflection below:

"Thus, all living beings are intelligent, that is, all can participate in domains of consensual behaviors, and differ in the nature of those domains and in the magnitude and diversity of plastic behaviors that they may live. We human beings do not differ in this in terms of other living beings, but what is peculiar to us in this respect, is that we exist as such in the recursive interlacing of language and emotions”.

**Social constructivist approach**

Let us assume that what has been written above is in some way the background for a contrasting philosophy of teaching bound up in constructivist principles. Teachers and students bring to a classroom their own worlds (the street, shopping centre, family home…) in which they have lived. These worlds are different in many aspects and such cultural incongruency is very often the reason for total or partial rejection of alternative worlds (such as that of the science teacher). Both students and teachers, partners in the teaching and learning process, must have a mutually understood communication space supported in part by special language, which must be shared by both sides.

The challenge is that very often teachers expect learners to use the specialist subject terminology associated with science (this applies to other subjects too however science has a particularly well developed subject specific language). Teachers frequently attempt to introduce and maintain an official or conventional language of educational communication. However this language is very often outside of and alien to the student’s culture and interests. It is firmly believed that this is a major cause of inhibiting a learner’s positive engagement with learning science and this problem is made all the greater when their beliefs, values, attitudes and wider cultural factors are ignored. Many teachers do not genuinely communicate with students as even though they may talk and listen to them too many assumptions are made about what is happening to the learner.

We believe it is often the case that three language levels can be identified as functioning in teaching any subject. The first is the formal language of the subject which is often seen in text books and teachers’ worksheets; the second is proposed by teachers as a means to communicate with students in the process of teaching; and the third language is that used by learners when (usually in explorative conversation) they refer to the subject that they are learning. This is a particularly challenging aspect of teaching science in school, college or university. Nature and science are all around students, students are in constant contact with them even if they themselves are unaware of this. They quickly develop an individualised psychological understanding based on personalised common-sense knowledge. Teaching science without considering the existence of a private scientific literacy developed by the learner can cause major obstacles to learning. Teachers often place most value on the acquisition of the formal language of science and ignore informal expressions which may be just as valid but do not meet their expectations of subject specific language-use. Few teachers would consider building scientific language on the foundations of everyday terms tied to personally held common sense knowledge. One of the best means to tackle some of the challenges previously identified is to adopt a social constructivist approach to teaching. Such a strategy allows teachers to recognise and use learners’ pre-existing knowledge and understanding which becomes revealed amongst other things through learner-learner or learner-teacher or teacher-learner dialogue.
From extrinsic to intrinsic motivation

Often teachers incorporate motivation in students’ minds and souls through the use of didactical instruments like marks, tests, punishment and reward or even exciting examples of experiments or other similar activities. We could say that on the one hand, this practice is the easiest way to motivate students but on the other hand it is not very efficient one. This kind of motivation very often is short lived and ‘evaporates’ once the lesson has been finished or the school day has ended. Fewer and fewer students are becoming genuinely interested in science in spite of the use of motivational practices such as that provided by very positive role models.

When an enthusiastic science teacher carries out even an intrinsically exciting experiment or demonstrates something genuinely interesting to learners the positive impact will often be transitory and short lasting. But when learners have some ownership of a scientific activity as through when planning an experiment their mind is more likely to be more fundamentally influenced and where this practical work is related to the lived world of the learner the effect is much more likely to be longer lasting; too much of the science that is taught has little bearing or relevance to the lived world of today’s learners. Teachers of science need to begin by recognizing what learners bring into a learning context. They need to use appropriate strategies that both reveal and value the learners’ pre-knowledge and understanding. They need to allow children to talk with each other and with the teacher in order to reveal not just pre-existing ideas but what it is that motivates and interests them. Professor Rosalind Driver was one of the very first to understand this and actively researched the significance of children’s pre-existing scientific ideas and thoughts. The ideas described above have in many ways shaped EuSTD’s module structure and content; see for example, the module that focuses on educational design processes.

Language barriers, differences in work practice, contrasting values, beliefs and understanding, philosophical and ideological differences were never going to be completely overcome and more often than not general agreement was the best that could be hoped for. However one thing that united the project team more than anything else was the desire to raise the quality of primary science education. There was unanimous acceptance that where access to traditional CPD opportunities was limited or even non-existent then it should be addressed. Where primary science experiences tended to be characterized by an impoverished pedagogical repertoire then it should be enriched. That empowering teachers through choice and opportunity was better than coercion. Sustained good practice in primary science is more likely to be achieved when participants have a strong sense of ownership. Novel but meaningful contexts motivate and enthuses not just pupils but teachers of primary science. Above all else broadening personal perspectives and improvement in scientific literacy were of critical importance not just for the educational well being of pupils in school but for the future well-being of all of us.
References


1.2

LEARNING, KNOWING AND KNOWLEDGE-BUILDING IN AN ON-LINE COMMUNITY

Claes Malmberg, Susana Caixinha and Helder Caixinha

This chapter deals with the concepts of learning, knowing and knowledge-building and what it means to be an active member in a learning community. It also illustrates participation in an on-line environment. The last part of the chapter gives an overview on different technical tools for collaborative work and knowledge building in learning communities. The aim is to give helpful tools and thoughts on how to develop a sustainable learning community in primary school science.

Introduction

Discussion on learning has changed its focus from the acquisition metaphor, in which the learner is viewed as a recipient of knowledge to the participation metaphor, with a view on the learner as active in a learning community (Sfard 1998, Lave and Wenger 1991). In the former metaphor learning is to acquire something, in the later it is to become a participant in a social practice.

The acquisition metaphor brings to mind the activity of accumulating material goods. It makes us think about the human mind as a container to be filled and the learner becoming an owner of these goods. Learning is to acquire concepts and principles within a domain of knowledge (Greeno and et al. 1997).

The participation metaphor focuses on knowledge and learning as integrated parts in a social practice. The learner is seen as a person interested in participation in certain kinds of activities rather than in accumulating private possessions. Learning is conceived as a process of becoming a member of certain community. This entails the ability to communicate in the language of this community and to act according to its specific norms.

Scardamalia and Bereiter (1999) point out knowledge-building as an important activity in a learning community. Knowledge-building is defined as “the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts”. Collaborative knowledge-building moves away from approaches of learning focused on individual minds in two ways: first, by focusing on group activities, which include roles for individuals within the groups, and secondly by noting the importance of spoken, written or published texts that capture newly constructed knowledge (Stahl 2002). Scardamalia and Bereiter have argued that the educational need in the current era requires increased capacity for innovation, and they suggest that the knowledge-building perspective is one vehicle for moving in that direction (Scardamalia and Bereiter 1999).
Some considerations for EUSTD- Web for Primary Science

One of the outputs for the Comenius project European Teachers Professional Development for Science Teaching in a Web-based Environment (EUSTD- Web) is a net-based resource for primary teachers and teacher students with an interest in developing skills and competences in science education. When the members of the project, involving researchers from eight different countries, discussed this web based resource, constructivism was laid as the theoretical framework. This framework views learning as an active and social process. In this chapter will we discuss three aspects of interest; activity, participation and collaboration. The aim is to make these three aspects characterizing both the way the electronically resource is used by the participating teachers and the way the teaching is supposed to be delivered in their classrooms. In this section these aspects will be related to the fact that the resource is delivered on the web and that most of the communication are net based. This fact has consequences on the way the interaction takes place. We also think that this is a new way to communicate for some of the participants, with new roles, new ways to build a dialogue and new ways to construct meaning.

The aspects activity, collaboration and participation are mirrored in the 10 modules. First of all, the modules are built on active participation. In other words, the participant should not look upon her/himself as a passive receiver of knowledge. It is only through active contribution that the module learning outcomes can be reached. All modules presuppose collaboration between the participants in groups in which they share ideas and experiences, give their view on articles connected to the modules etc. Through this activity the group will develop greater meaning than what a single participant can do. Taking part in the EUSTD-Web does also mean that one is participating in a learning community for primary school science. One might be a newcomer in this community. Our hope is that this course will help to give the participant a more central position in the learning community.

The EUSTD-Web is aimed at improving primary science education. The content and even the titles of the modules tell us that the three aspects described above are also a part in the meeting with the students in the classroom. The modules are dealing with real-world problems, with motivation, formative assessment, educational design etc. All this stands on a foundation of activity, collaboration and participation.

Activity

With this aspect we stress that knowledge is important when it is being used by particular participants with the aim to solve problems in specific situations (Wells 2001). To make it clearer it can be contrasted by “general knowledge” as a commodity in individual minds, to be retrieved on demand and independent of the context. Our focus on activity changes the view from the concept knowing-that to the concept knowing-how. Knowing-that consists of holding a true belief. Knowing-how is a matter of skills. These skills are not only practical, as when a professional carpenter is skillful with his hammer. It has also to do with how skillful a student in elementary school is in using the multiplication table in counting how long time she need to save her pocket money given to her every week until she can buy a computer game very much sought after. It can also be illustrated by how a researcher in plant ecology can interpret the theory of evolution to better understand the adaptation of spruce to different climate zones, how a car owner understands fuel consumption is related to pollution with the help of the laws of thermodynamics, or how a cook is able to use and perhaps adapt a recipe to suit people with food allergies and intolerances. These
examples focus on how skilful persons are to use the multiplication table, a hammer, a rule, a theory, a law or a recipe to solve a problem or to reach a goal. The hammer, rule, theory, law and recipe are all examples of physical and mental tools used to fulfill an action. To have knowledge means, from this perspective, to be able to handle tools in with specific aims in specific contexts. Learning takes place in action when the tools are used to solve problems.

**Collaboration**

The second aspect, collaboration, indicates that in learning, students should not be defined as solitary individuals, each working independently with each others. As stated in the last section our achievements are not only our own, since they presuppose tools which have been created by others to be used for specific aims in a social context. The purpose for using the tools is to solve problems and the best way to do that is in collaboration with others. When you solve a problem you are often searching for a solution which means that you are involved in an activity in which you are constructing new meaning or building new knowledge. It might not be new knowledge for the world, as in a research process, but at least new knowledge for the group in which you are a participant. This is a knowledge-building activity. To grasp the idea of knowledge-building, educators have to understand (Bereiter 2002):

- Knowledge-building is not only a process; it is aimed at creating a product.
- That product is some kind of tool – for instance a model, a recipe, a theory, a hypothesis, an explanation or an interpretation of a literary work.
- A tool is real and preferable something students can share and use
- Knowledge-building is a social process shared with others

Let us consider a group of fourth-grade students discussing the sight after they have read something about it or seen a video:

1. **Student 1**: I think we can see objects through beams from the eye
2. **Student 2**: But how does it come into the eye?
3. **Student 1**: Don’t know...
4. **Student 2**: It must be beams from the object
5. **Student 3**: Yeah, the sun. Cause we can only see when it’s light.

The discussion continues on like that. The students are coming up with certain propositions, which are advanced by other students building on them. The same propositions might be contested by others. Occasionally students are raising questions. The role of the teacher does not consist of much more than answering questions and managing the process. What is going on here? From the point of the teacher it’s not more than a normal learning activity. The focus for the teacher is on pupils understanding of eye and sight. For the students actively engaged in the problem it’s different. For these students the discussion about the sight is a real discussion, whose purpose is to find the truth or the best explanation. This is a discussion dealing with theories and explanations, on the level on which these students grab it, carried out in a mode of critical inquiry. These children are taking part in a knowledge-building activity with the learning is going on incidentally. With other words, the children are members of a learning community, although novices in most respects. This fits nicely with the concept “legitimate peripheral participation. (Lave & Wenger 1991). The concept is representing the students’ role. They have to work, like newcomers in any community, to gradually
be a part of the centre of the community were most of the activity is going on. They do so in contributing in ways that are within their growing capacities and that are acceptable by the the more experienced Ordinary schooling should provide opportunities for this type of peripheral participation letting the students graduate into the world of work with knowledge-building, as a contrast to pure knowledge transition. In next section the concept learning community will be elaborated.

**Participation**

The third aspect, participation, is linked to being a committed member in a learning community. Primary school teachers need for a strong science knowledge base has been raised by Appelton (2007). To enter the primary-school setting is an enormous step for pre-service teachers (Fleer 2003). The learning community for primary school contrasts with that of the science discipline. A learning community can be described as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Lave & Wenger 1991). The community has an identity which is defined by the participants’ common interests. To be a member or participant implies a commitment to the community. The members are either experienced or a newcomer. So what does it mean to primary science? In what we call a learning community both children and adults are engaged in learning activities and knowledge-building in a collaborative way. The roles and the responsibilities for teachers and students differ but the aim is to foster children’s learning and knowledge-building skills as the same time as the teachers are involved in their own knowledge-building activities. The teachers are responsible for guiding the overall process and for supporting children’s learning, to create learning environments and plan for interaction and collaboration among the children. But they are also responsible to develop the learning community.

**Collaboration for learning**

According to Slavin (1996), collaborative student-student interaction is an effective way of learning. Numerous studies have compared student-student interaction to traditional teacher-student interaction (Johnson & Johnson, 2002; Slavin 1996). The result of the studies is a growing consensus among researchers about the positive effects of collaborative learning on student achievement. There are, despite the high level of interest, still open questions about why interactive learning methods affect achievement and under what conditions collaborative learning has these effects (Webb & Palincsar, 1996; Slavin, 1996).

Aiming at explaining the achievement effects of collaborative learning, Slavin presents three major perspectives. The first perspective is called the motivate perspective. Clear goals and modes of assessment, assessing individual as well as group achievement, may create motivation. Examples on different types of assessment are given in Module 3 Formative Assessment of Learning.

The way the task is constructed is another precondition. How one can construct tasks to motivate students is described in EUSTD-Web in Module 1 Teaching Science through Environmental Education, Module 2 Cognitive Motivation in Science Education and in Module 8 Active Teaching Strategies. If the task is constructed in a way which makes it possible for the individual group member the reach her or his personal goal only when the group as a whole is successful the effect of collaboration will increase. This requires that the group outcome is assessed and that each participant’s contribution is made visible. The participants’ interdependence of each other makes it
advantageous to help and encourage other group members to make an effort for the groups’ success. This is contrary to the competitive situation students often experience in school. The second perspective depends on the social climate within the group. The success depends on the strength of emotionally and social ties between group members. In a well functioning group members support each other because they care and are concerned about each other’s success. These two perspectives focus on the social and psychological aspects of group work.

The third perspective focus on the discourse, in other words how participants contribute through utterances and how they negotiate different ideas. This presupposes activity, discussion, and argumentation. Collective knowledge building is the force for the group member to make their best. It is fundamental that participants react on each other’s contributions. One is presenting her or his thoughts. Another takes up these thoughts and elaborates on them and broaden them. The result might be new knowledge to which both have contributed. Our focus is on the third perspective that is on the cognitive elaboration that takes place in a group. Cognitive elaboration is a theoretical perspective in which collaborative learning is assumed to be effective because it requires participants to elaborate their understanding in a social context.

**On-line learning**

In the field of on-line learning there has been a change from individualistic work to group work. The previous dominating model with communication from student to teacher has disadvantages in that students are isolated and therefore experience a lack of interaction with other students. The need for supervision is high, the student has to be very self-disciplined, the interaction between teacher and student is characterized by assessment and there is little room for relational nature of learning (Laister & Kober 2001). A result of the change of direction on course delivery is the focus on collaboration and communication among students in small groups and that this discourse creates the preconditions for collaborative knowledge-building.

In this chapter we use on-line learning and net based learning as synonyms. We also refer to this type of activity as an asynchronous and text based interaction, not to be mixed with synchronous chat or videoconferencing.

Computer supported collaborative learning is different than group work within a face to face ‘traditional’ learning environment. Computer supported learning makes it possible for the participants to be separated both in time and space, they can choose where and when to work as long as they have access to the internet. Another difference is the mode of interaction. A web-based discussion is typically mediated by text compared with a face to face discussion mediated by speech. In a written communication the utterances have to be much more elaborated and structured than is the case in an oral communication. Furthermore, a written, net-based communication is stored and can be re-read and re-used (Lipponen 2002). It is possible to follow one’s own as well as others work and go back to it whenever one need. These aspects create opportunities for collaborative knowledge-building.

If we accept the assumption of the dialogue as a means for the joint construction of meaning, a certain level of equality in contributions is presupposed. An amount of co-operation is needed for a net-based dialogue to be sustained. A dialogue is an interplay between two or more partners. A desire on the part of all partners to contribute is needed. A central element in the dialogue is that the partners augment each other by their contributions. The partners listen to and reflect on the
contributions of the others and by responding create something they had not been possible to create alone. The dialogue thus creates joint meaning. If a person doesn’t respond to the texts sent, the dialogue will come to an end. Dialogue partners create meaning both as producers and as listeners: One person presents her/his thinking. The other person listens and responds to the text of the first person. The result is expanded knowledge to which both partners have contributed. The dialogue, thus, is a collective product and not the sum of the single communicative acts (Hoel 1995).

From the perspective of joint knowledge-building, silent group members do not contribute. Their knowledge remains their own and is not shared by the group. Not contributing thus is negative for the group.

This knowledge building perspective gives at least two implications for education (Scardamalia and Bereiter 1999):

1. Focus on the problem instead of focus on the topic. The authors claim that knowledge building is a distinctive variant of problem based learning, emphasizing the process rather than the product. There is thus an emphasis on the dialogue and participant contributions to that dialogue.

2. Contributing to solving problems instead of displaying knowledge. Traditionally teaching is concerned with students demonstrating what they know. In normal life using conversation to display what one knows is considered self-centred. In conversations one is rather supposed to say things that contribute to the common purpose.

Focus is on the social aspects of knowledge. Knowledge regarded as possession is replaced with knowledge as activities and participation. Moreover, learning activities can never be considered separately from the context within which they take place.

An example of a net based dialogue

To illustrate an on-line group discussion we present a dialogue from a computer supported course taken by primary teacher students in Mathematics and Science during their first semester at the university (Malmberg 2006). The dialogue is presented below as a transcript. The task the students are working with continues over seven days and results in a group product, a 10 pages report. The dialogue deals with the dilemma of establishing a garbage dump, at Mossheden, or to expand an existing dump, at Ellingviken. The planned location for the new dump in Mossheden is a sparsely populated area and the existing dump at Ellingviken is close to a coastal city.

1. **Marianne**: Mossheden is the best alternative from my point of view. It’s not possible to expand the garbage dump at Ellingviken any longer. One has to think in a long-term perspective.
2. **Viktoria**: Does one need to expand? Isn’t it possible to inform people to use recycling centres to decrease the waste volume?
3. **Marianne**: It’s not possible to recycle all waste. If the garbage is incinerated, only 75% “disappears”, 25% will stay as ash. The ash is dumped at the garbage dump. Consequently, the dump has to expand.
4. **Lisbeth**: That’s true Marianne. Furthermore, the existing dump has to expand within a year.
5. **Malena**: I agree with you, Viktoria. Is it really necessary to establish a new dump? /.../ From year 2010 it’ll be prohibited to place organic substances at garbage dumps. /.../ We need to know more about how the municipality plans their treatment of waste.

6. **Anna**: I have the same opinion as you. Mossheden is the best solution. We have to consider the nature conservation area close to Ellingviken /.../

7. **Anna**: Reading more about the problem made me change my mind. I believe Ellingviken is the best location. I agree with Viktoria and Marianne, saying that the best solution is to recycle the waste and go along without a new dump. But still, my choice is Ellingviken. I motivate this with arguments from an article, showing possibilities to clean water before it reaches the sea /.../

8. **Marianne**: Who wants a garbage dump just outside a city? /.../

9. **Malena**: Well, we have it in the city were I live. No one complains.

10. **Helene**: This is tricky question! /.../ We have to consider the opinion against Mosshed. People are concerned about their drinking water. /.../ The geologist, Bertil Svensson, states that the risk is neglectable (article 1), but /.../ we do have the problem with transportation of the waste. A consequence is increased carbon dioxide /.../ The ornithologist Jan-Erik, says that a garbage dump at Ellingviken will be “the kiss of death” for birds in the surrounding /.../ My solution is to make the garbage dump at Ellingviken safer and cleaner and to inform people about recycling.

11. **Viktoria**: I conducted an interview with the head of the waste company in my municipality. Spontaneously he told me that Ellingviken is the best alternative. The Mosshed alternative is connected with a lot of problems concerning groundwater. He told me that it is easy to solve water pollution problems at Ellingviken. One has to use a rubber carpet to isolate garbage from groundwater. It is also possible to use rest products from the incineration for road construction. /.../ I think we should vote for Ellingviken.

So, what is going on in this dialogue? First of all, the group of students can be defined as a learning community, even if it is short-lived and only lasts for a couple of weeks. The participants are involved in an activity with shared interests and common goals to reach, to create a product in which they have to argue for the best location of a city-dump. Through their focus on the task one can say they have a commitment to the community.

There are some important aspects of the dialogues well worth to describe. First of all one can notice that the students are using a pamphlet of resources when they are discussing the task. They contribute with their own experiences, every-day knowledge, and experts statements. These resources will be used like bricks when they are producing their final product. But their utterances are also used as thinking devices, particularly when they don’t agree with each other. When this happens they do have to negotiate meaning and it is under these circumstances collective knowledge-building takes place. In other words, disagreement and conflicts in opinions is good fuel for new knowledge to be constructed. In some cases students refer to sources they use. When doing so it is possible to evaluate the sources with questions as “How do they know?”, “What data is used for that conclusion?” or “Is the source reliable?” This doesn’t happen in the above transcribed discussion. It is not surprising, since critical thinking is one example of transferable skills school often fail to teach students.

The dialogue shows that the students are important resources for each other’s learning. The dialogue reveals resources existing in an individual student’s texts and used by other participants of the group. The individual participant thereby gets access to resources, which she might not have
found herself. One interesting aspect of the dialogue is the length of the utterances. The participants in the on-line dialogue produce much longer utterances than what is normal in a face to face discussion. This may have several explanations. First of all, a net based dialogue makes it possible for the participants to prepare their utterances. They can read what they are supposed to answer and think it over before they write down their own contribution. Furthermore, the net based mode makes it possible to find information from other sources before one’s own utterance is constructed. On the other hand, when one has made a contribution one can’t be sure if someone listens, reads it or responds to it. And in any case, the response will be delayed, since this is an asynchronous medium. Therefore, timing is an important factor in a net based discussion.

An example of a dialogue in the primary-school classroom

With the short transcript in this section we try to illustrate how collaborative work can be like in the primary classroom. It is a quote from a group discussion in a Swedish primary school, among 10-year old students (Malmberg & Ideland 2009). They are discussing how to decrease carbon-dioxide emissions by sacrifices in everyday life. Their task was to make a stand for two among four different suggestions on how to lower carbon-dioxide emission. They had to chose from: a) Parents should not be allowed to drive their children by car to school, b) Restrictions of families’ holidays by airplane. Each family will not be allowed to fly more than one time a year within Sweden or Europe, alternative one long distance travel outside Europe, c) Each family is only allowed to own one car and use it two days a week on leisure time and c) Prohibition against fruit grown outside Sweden.

A part of the task was to write a letter to the Swedish Minister for Environment involving their suggestions. The discussion is an example on when real-world issues and children’s own values are integrated with school science

1. **André**: Airplanes destroy very much.
2. **Barbara**: But then (if you restrict the travelling) you can’t go anywhere you like.
3. **Cecilia**: I don’t like this suggestion. It says that you cannot go to Europe and Åre (ski resort in the north of Sweden) the same year.
4. **David**: I have only been to Denmark and suddenly I cannot go to Australia or New Zealand.
5. **André**: I like travelling, but if many give up travelling, it (CO2 emissions) will decrease. You don’t have to go like three times a year.
6. **Barbara**: Maybe one trip to Åre and one to Europe. And it’s possible to go by train to Åre.
7. **André**: But I am going on vacation three times this year!
8. **David**: /---/ You do want the possibility to go abroad, you don’t want to stay at home just because an airplane waste a little carbon dioxide.

Compared with the on-line discussion among teacher students described above one can notice that even in this case from primary school, the participants are bringing in resources to the discussion. They are referring to voices they have listening to, for instance when André says that airplanes destroy a lot or when Barbara says that it is possible to go by train to Åre. These utterances say something about different vehicles energy consumption or that much less carbon dioxide is emitted when one use the train. They are also referring to their own experience in every-day life. In the same way as among the teacher students previously, the primary school students’ utterances are used as thinking devices. They are building on each other and are negotiating the possibilities how to go on with their travel habits at the same time as they live environmentally friendly.
The discussion reveals children’s way to reason in controversial issues that are related to their everyday life. The students brought in experiences from everyday life as well as science related knowledge. Their different living conditions are mirrored in the way they approach the problem. When they negotiate among and within themselves and reflect how much they are willing to sacrifice they often try to legitimate their own way of living.

The 10-year old students use science knowledge as well as social knowledge as tools to create meaning and to negotiate between different positions. They are aware that different transportation has different impacts on the environment and discuss car, airplane and train. They bring in knowledge about trains’ and boats’ that their impact on the environment is low. Airplanes on the other hand are described as having a severe impact and cars somewhere in-between.

The authenticity of the task is highlighted through how the children’s discussion is connected to their own lives. Their experiences become important and are used frequently. They associate to each other’s utterances and use them as thinking devices for the ongoing discussion.

By discussing “real world problems” in terms of personal sacrifices and societal consequences the complex issues become possible to deal with (for teachers and students) and what is learned has a value outside school.

Even if global warming is a huge, complex problem it can be handled by young children when it is constructed in terms of everyday life. By creating possibilities for the children to make a difference, and engage in problem-solving, their feelings of empowerment probably will increase.

**Some consequences for an on-line learning community**

To develop an on-line learning community is different from developing a learning community in which participants are meeting each other face to face. We are simply dealing with different modes of communication. In this section we will highlight some aspects of importance which may help a participant to be a member in a net based learning community.

The first thing we should like to put forward concerns the interaction between the talker and the listener. One interesting aspect is how immediate the answer is, in other words the timing of the communication. A face to face dialogue is always in real-time. In a normal conversation face to face you will have an immediate answer on your utterance. You can see it in the eyes of the listener, if they nod or if they answer verbally. A net based communication is quite different. You cannot see the persons you are “talking to”, you don’t know if they “listen” and it is not possible to know when, or if, you will get an answer. There are at least two aspects of this. First of all, when you make a net based utterance you expect a response and the sooner you get it the better. If you don’t get a response within a certain time-span you’ll easily give up and your engagement in the dialogue may cease. An agreement among the participating members is a way to overcome this threshold. Such agreement can state that everyone needs to contribute within a specific time-span, depending on for instance, the intensity of the discussion or the length of a course. Secondly, an effect of late contributions to a dialogue decreases the chance for them to produce responses. A discussion often has an introduction followed by intense interaction leading to some kind of closure when the participants come to an agreement or have articulated their standpoints. A contribution after the closure, which is more or less obvious, will not contribute to the discussion as a thinking device. It means that it will not provoke the discussion to new directions.
Next thing concerns the way the utterances are produced. Face to face utterances are produced in action and are often directly influenced by the members taking part. Usually one has very short time to formulate what to say and it often happens that someone interrupts. An utterance produced in a net based discussion is different. One has a lot of time to prepare oneself and no one will interrupt. At the same time, one has to articulate oneself more explicitly and structure the sentences to a higher degree. A consequence often noticed is that participants produce long utterances involving many themes and with references to many sources. This is contributions other participants can learn a great deal from. One problem with long utterances is that they often don’t get any responses. They are to rich in content, with many themes, which makes it hard to answer the entire utterance. It is better to make more but shorter contributions, containing one theme each, and with dialogic hooks like “This is my opinion, but what do you think?”

The third thing that should be mentioned is the importance of elaborating on each other’s contributions, in other words, to respond to and engage in the utterances. In many net based dialogues the members are playing “The believing game” (Elbow 2001) characterized by support, listening to and trying to understand. In the communication participants are using an everyday language in which they seldom are critical to each other’s contributions or to the external sources they refer to. To argue, debate, be critical and doubt stand in contrast to this. When doing so one is playing “The doubting game”. This is a well known game in the academic culture and it helps us to test ideas and develop theories. We should like to introduce the concept of a critical friend (Handahl 1999) as a link between the believing and the doubting game. A critical friendship involves critical and doubting voices at the same time as having reliance to the members in the learning community, to be confident as to their competences within their subject, to expect personal integrity and last but not least a fundamental reliance that the critical friend has good intentions to help you to develop. If these criteria are fulfilled the learning community will have greater possibilities to develop.

From a technological perspective

The Comenius project European Teachers Professional Development for Science Teaching in a Web-based Environment (EUSTD-Web) used a specific piece software called Moodle1 for the delivery of the Internet-based course with its included modules. A number of factors influenced this choice.

- Moodle is open source and readily available to all countries taking part in the project
- All languages of the countries involved were supported by Moodle
- The design of Moodle is based around a socio-constructivist paradigm which fits well with the project’s aims

In the developers’ description of their pedagogical approach one can read that their software may help the teacher to change her or his role from:

...being ‘the source of knowledge’ to being an influencer and role model of class culture, connecting with students in a personal way that addresses their own learning needs, and moderating discussions and activities in a way that collectively leads students towards the learning goals of the class. (Moodle 2009)

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1 http://moodle.org
The software Moodle is structured as courses that contain activities as forums, glossaries, wikis, assignments, quizzes, choices (polls), databases etc. The strength in the software is when these activities are combined into sequences and groups.

Since Moodle is one of many possible tools this section will describe other different online tools.

In the current age of Web 2.0 and its multitude of online tools and services, teachers and students have a plethora of technologies to develop a sustain an web-based learning community. As Ingo Blees and Marc Rittemberg (2009), state in their paper “Web 2.0 Learning Environment: Concept, Implementation, Evaluation”, a clustering of characteristics results in four main perspectives for such an environment:

- Openness and permeability to peers and non-peers outside the community, building a true open learning portal;
- Active participation from all participants, incorporating and integrating known instruments, consuming and producing learning content and managing its life cycle. All content is tagged in a folksonomy reflecting their interests and prior knowledge’s;
- Making visible in a transparent way the motivation of each participant. And supporting the initial socialization among them
- Allowing the analysis and evaluation of individual and group learning activities, resulting in feedback that could encourage motivation.

Integrating these new learning environments are common and popular web 2.0 interactive tools and services such as: Wikis, Blogs, Podcasts; RSS Feeds, Social networks and File-sharing. A comprehensive list of Web 2.0 tools and services for learning can be found at the Centre for Learning & Performance Technologies web site at http://www.c4lpt.co.uk/recommended/.

**Tools for collaborative work and knowledge building in learning communities**

In a learning activities scenario with spatial/time gaps between teachers and students, online collaborative tools tend to have a higher degree of adoption and successful implementations. Participant’s motivations and needs play a crucial role in these success stories. It’s expected that younger generations would be more receptive to these new paradigms as they are growing with them in a daily basis. The incorporation of these tools in a classroom in support of an adequate pedagogical strategy could represent a clear improvement on traditional interactions and knowledge building processes.

Popular collaborative tools can be found at http://mashable.com/2007/07/22/online-collaboration/, a web portal that systematize (mashes up) multiple information sources on this topic, as a fine example of the power of an online collaborative tool. Another important tool list focusing this collaborative topic is available at http://thinkofit.com/webconf/workspaces.htm#groupware. Most of the interaction conducted inside these tools is structured around discussion forums (also known as bulletin boards). A detailed comparison matrix for online discussion forums is also available at http://www.forummatrix.org/.

In recent years blogging tools have became very popular among teachers and students. On the blogosphere communities abound supported by these tools such as Edublogs (http://edublogs.org/) where everyone can open a blog or a set of blogs to support a learning community and its learning activities. These web logging tools allow simple interaction trough time-based posts and its replies
or comments. Multimedia elements can easily be embedded in those messages, enriching its user generated content. More information about these tools can be found at: http://en.wikipedia.org/wiki/Blog_software or http://www.weblogmatrix.org/.

Another major trend in this field is the so called micro-blogging tool Twitter (http://twitter.com) where everyone can build a blog with 140 characters posts. This tool extends the concept of community introducing the concepts of followers (someone who is following the micro-blog) and following (someone who is being followed by the micro-blog author's). Between these users a flexible and easy interaction can be established with public or private messages (called tweets). The follow concept introduced, reinforces the links established and contributes to the sustainability of such communities. The Edublogs promoters summarize ten scenarios to incorporate a blog into teaching practices (http://edublogs.org/10-ways-to-use-your-edublog-to-teach/):

- Posting learning resources by uploading and attaching to the blog posts all resources used within learning activities. Every resource can then be a subject of discussion among teachers and students;
- Creating open discussions in reply to topics launched in a teacher or student post. These discussions can be moderated by the teacher or have a peer-review strategy implemented with students;
- Publishing a class journal or other kind of online publication where different media types can be embedded extending enormously the capabilities and reach of traditional paper-based publications. Students can contribute and edit it autonomously or under teacher's supervision, thus increasing the student's engagement and motivation;
- Creating an easy assembled class newsletter, with relevant events and information for students;
- Empowering students in the blog management process, allowing them to produce content and other resources for the learning activities planned, thus cutting some work load from the teacher;
- Producing and sharing all reflections on classes in a collaborative way. By letting other teachers know his work, ideas and fears, important feedback can be obtained from other educators and incorporated in own practices;
- Creating rich multimedia content embedded and aggregated from multiple sources on the web or produced in class;
- Creating blogs on a multidimensional approach. From a personal blog, to institutional blogs, event blogs, student blogs, group blogs, project blogs...
- Creating feedback drop boxes that involve the learning community in a holistic approach, with students and their parents and any other stakeholders in the learning process, commenting and discussing the teacher’s practices, student’s attitudes and progress or any other subject relevant to the community;
- Developing deeper and more complex blogs with an hierarchical navigation structure, that allow the establishment of a true class web site.

The use of blogs and its implications are summarized by some well know authors in the field:

"This is the difference represented in the shift from traditional classroom based learning and network learning. The idea of the latter is that learning occurs when the learner immerses him or herself in a community of practice, learning by performing authentic tasks, learning by interacting with and becoming a member of the community." (Stephen Downes)
“What can you know about a professional who doesn’t blog his or her work? How do you know they are competent, that they have the respect of their peers, that they understand the issues, that they practice sound methodology, that they show consideration for their clients? You cannot know any of this without the openness blogging (or equivalent) provides. Which means, once a substantial number begin to share, there will be increasing pressure on all to share.” (Stephen Downes)

“There is something that happens to a person when they hit that “publish” button - you cross a threshold - you move from consumer to producer - you put your intellectual neck on the line and I really think that you aren’t the same person after that.” (Mark Oehlert)

“The lack of formality and the ease of cross-referencing other blog content or references means it is great to accelerate discussion and promote broader thinking and understanding.” (David Wilson)

Wikis

A powerful collaboration tool perfectly suited to support learning communities and its knowledge building processes in a collaborative way are the so called Wikis (named after a Hawaiian word meaning quick). These tools allow a group of students with or without a teacher moderation, to build, share and link information. With a wiki the knowledge building process inside the community can be captured in terms of everybody’s interactions and contributions.

The collaborative process deeply embedded in any wiki’s content building task, provides a simple way to contribute and annotate the content itself in any of its developing stages. All concentrated in one big central repository, fully indexed and searchable, with an easy access. Another advantage is reflected by the fact that the knowledge built by one class of students, can be reused, reinterpreted and reshaped by subsequent classes, linking different student’s groups and their social and cultural contexts. By keeping an accurate version control of any document being built (in a collaborative fashion), teachers or any other wiki’s supervisor can go back to a previous stage of development. Tracking changes and who have made them allows greater control of all interactions.

Tools like the one that supports the Wikipedia, the most famous Wiki of all (MediaWiki available at: http://www.mediawiki.org/wiki/MediaWiki) go even further by attaching a discussion forum to each content being built. That opens new possibilities to students by letting them engage in discussions and reflections about every one’s contribution. As Ingo Blees and Marc Rittemberg (2009) refer, wikis can be very useful tools for building student’s e-portfolios, comprising multimedia learning objects. The same authors state that “the flexibility of the overall structure of a Wiki, however, allows for characterising all learning objects as dynamic, as basically all of the contents can be changed by means of linking. Owing to the principles of dynamic generation and change, at both levels of individual objects and their organisation the Wikis are highly interactive (...)”. Several wiki tools can be adopted as mentioned in the Wikipedia at: http://en.wikipedia.org/wiki/List_of_wiki_software. A detailed features comparison can be found at: http://www.wikimatrix.org/.

In a modern wiki-centric classroom as Vicki A. Davis mentions in her blog at: http://coolcatteacher.blogspot.com/2006/08/how-i-use-wikis-what-do-you-do.html, the wiki acts as a hub for classroom organization and content repository. On that space full of openness students can build contents, take notes and develop reports or exploratory projects. Even topics that go beyond the usual classroom topics can be approached and developed. Being a well organized repository of each student’s contributions, a wiki can be part of some individual assessment projects.
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Section 2

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2.1

**SCIENCE CURRICULUM IN COUNTRIES PARTICIPATING IN EUSTD-WEB**

Jari Lavonen

*Introduction*

A national level curriculum for compulsory schooling is one of the most important tools for implementing national education policy. In such a curriculum there is typically a general part in which the main goals for education in compulsory schools are described (Field & Leicester, 2000; Concepción, Murray & Ruud, 2002). In many countries, according to these objectives compulsory education should support students' growth towards ethically responsible membership in society, and provide students with the knowledge and skills necessary in life and lifelong learning. Moreover, education should promote equality in society and the students' abilities to participate as a full member of the society. In addition to these kinds of general sections there are also national level guidelines or goals for each school subject. Consequently, the national level curriculum is more than just a list of topics, syllabus, to be covered by subjects in all countries.

There are differences in terms used in national level documents and, therefore, the translation of the meaning of concepts from local language to English is not simple. In general, goals are used here to describe the overall purpose of a subject or a course within a national level curriculum. Goals are typically broad, intangible and abstract. They indicate general intentions and are not easily validated. Aims (objectives) break down goals into measurable behaviours that demonstrate competency. Objectives are stated in narrower, more precise, concrete and measurable terms and are always stated in terms of what the learner should know or be able to do. A syllabus means a description of the topics or main content of a subject or a course. Knowledge areas and required skills are described in detail in a syllabus. Standards are statements of what students are expected to know and be able to do or have attained by the end of a course or compulsory schooling.

The purpose of this chapter is to describe science education in countries participating in EuSTD-web. Firstly, some national education policy issues and the education system will be analysed. Secondly, Science in the National Curriculum is analysed and discussed. Each analysis of the curriculum documents were performed by an expert in each country, participating in EuSTD-web, based on an agreed structure.

*National level curriculum*

Many countries try to balance two opposing views: some countries believe all schools should follow a similar curriculum and other countries believe municipalities or even individual schools should be able to establish a local curriculum based on the national level (framework) curriculum (Kelly, 1999). Next the national level curriculum will be analysed in countries participating in EuSTD-web from the point of view of centralised, national level curriculum and local level curriculum based on local level decision making. These two approaches have an effect on teaching and assessment in the science classroom.

In the Bulgarian National Curriculum, general goals and subject specific goals, basic concepts in each subject (syllabus), integration and cross-curricular themes, and final-assessment criteria (standards) at the end of the primary and secondary stages are described. In the National Curriculum goals and contents are allocated to certain grades. Science as separate subjects starts from the 3rd grade. There are no local curricula or syllabuses
Curricular documents are developed at two levels in the Czech Republic: the national level and the school level. The national level in the curricular documents system comprises the National Education Programme and Framework Educational Programmes (FEPs). The Framework Educational Programmes define binding educational norms across various stages: pre-school education, basic education and secondary education. Basic education should help pupils to form, shape and gradually develop their key competencies and provide them with the dependable fundamentals of general education mainly aimed at situations that are close to their real life and behaviour. The content of basic education within the education framework is divided into nine, roughly defined educational areas. Each educational area comprises one or more interlinked educational fields. Each educational area contains the characteristics of the educational area, the objectives of the educational area and its educational content. The school level consists of school educational programmes (SEPs), forming the basis of education in the individual schools which take responsibility for the preparation and development of local curriculum. The school will divide the educational content of each of the educational fields into subjects and will detail and, where appropriate, add subject matter to the curriculum with respect to the pupils’ needs, interests, inclination and talents so that the development of the key competencies is best pursued (FEPBC, 2005).

The English National Curriculum (DES and QCA 2004) is a free, universal and fixed curriculum that is taught to all pupils in all state schools in England; it is a statutory requirement. The curriculum is divided into blocks of years, known as ‘Key Stages’². There are four Key Stages: Key Stages 1 and 2 (Years 1 - 6 of Primary school) and Key Stages 3 and 4 (years 7 – 11 in Secondary school). Before Key Stage 1 is the ‘Foundation’ stage. Through Key Stages 1-3, pupils study a range of compulsory subjects, including science. In Key Stage 4, pupils study a smaller range of compulsory subjects (including science) alongside studying for nationally recognised qualifications in a range of subject areas. For each subject taught at school, the National Curriculum breaks down how a child’s understanding of key concepts should develop during their years of schooling. The ‘programmes of study’ set out what pupils should be taught in each subject at each key stage; no direction is provided about how to teach this content.

In each of the compulsory subjects, the knowledge, skills and understanding required in each subject are outlined, and standards or attainment targets are set. National tests are set to determine how pupils are performing against the attainment targets. An attainment target sets out the ‘knowledge, skills and understanding which pupils of different abilities and maturities are expected to have by the end of each key stage’ (DES and QCA, 2004 p.7). The level descriptions provide the basis for making judgements about pupils’ performance at the end of Key Stages 1, 2, and 3. The majority of pupils are expected to work at:

- Levels 1-3 in Key Stage 1 and attain Level 2 at the end of the Key Stage
- Levels 2-5 in Key Stage 2 and attain Level 4 at the end of the Key Stage
- Levels 3-7 in Key Stage 3 and attain Level 5/6 at the end of the Key Stage.

There are two additional levels: Level 8 and ‘exceptional performance level’ for pupils who are of higher ability. Attainment targets consist of eight level descriptions of increasing difficulty, plus a description for exceptional performance above Level 8. Each level description describes the types and range of performance that pupils working at that level should characteristically demonstrate (explained in more detail later).

In the Finnish National Core Curriculum, general goals and subject specific goals, basic concepts in each subject

² Key Stage 1: Ages 5-7 (Years 1-2); Key Stage 2: Ages 7-11 (Years 3-6); Key Stage 3: Ages 11-14 (Years 7-9); Key Stage 4: Ages 14-16 (Years 10-11)
Science in Polish schools for general education is taught at every level – primary (Grades I-III), elementary (Grades IV-VI), gimnazium (lower secondary school, Grades VII-IX) and lyceum (higher secondary school, Grades X-XII). At the first level science is taught as a cross-curricular activity for teachers and students, at the elementary level science is taught as an integrated subject, at the third level biology, chemistry, physics, and geography are taught as separate subjects. The same pattern is followed at the lyceum level, however students who are not going to undertake university studies based on science, instead attend lessons described by a subject called przyroda (nature); the subject being understood as being more like scientific understanding within and about the natural world. The Curriculum Framework (Core Curriculum) is a state document approved by the Ministry of Education. It has been elaborated by a group of specialists (teachers and professors). The Curriculum Framework used to be a basic template for teachers to develop their own, personalised and contextualised curricula to be used in the teaching process for their students. In order to be implemented the curriculum proposed by teachers has to be validated by the school committee and signed by the head teacher of the school. In the first part of the Curriculum Framework (Core Curriculum) are described goals for teaching at the elementary level (i.e. gaining knowledge, skill of using knowledge, attitudes connected to knowledge and knowledgeable situations), the main skills (i.e. scientific thinking, reading, mathematical thinking, communication, IT skills, skills of learning how to learn) and general description of the circumstances for gaining the objectives. The most general aims (goals) are treated as general requirements but content of teaching is described in language of particular (specific) requirements (Regulation of Polish Ministry of Education in 23.XII, 2008).

The Ministry of Education is responsible for the design and content of the curriculum in Portugal. Nevertheless the implementation and the organisation of the schools are under the responsibility of the municipalities. The Portuguese Education System is universal, compulsory and free up to school leaving age. It is divided into Basic Education, Secondary Education, Higher Education and Post-graduate studies. Basic Education is divided into 3 cycles and has an overall duration of nine years. Children aged 6-15 are required to attend it either at public or private schools.

- **1st cycle**, 4 school years, provides a general education, with pupils taught by a single teacher (who may however be assisted by others in specialist areas). The content of this curriculum, with 284 pages, includes the following aspects: aims; structure of the Curriculum; main principles of the pedagogical nature; components of the different subject areas; and syllabus.

- **2nd cycle**, 2 school years, in which the learning process is organised into interdisciplinary areas mostly with one teacher for each area. The content of this curriculum has two volumes. The first volume includes: goals and aims; contents; a general methodological line and evaluation criteria. The second volume includes: the organisation plan and sequence of the teaching and learning and also suggestions for a bibliography.

- **3rd cycle**, 3 school years, organised around a unified curriculum, including a variety of vocational areas, with one teacher for each subject or group of subjects. The content of the Physics and Natural
Sciences curriculum, with 42 pages, includes: an introduction; specific skills for scientific literacy to develop in the 3rd cycle; evaluation and organisation themes; and bibliography.

The Swedish curriculum for the compulsory school is short, only 21 pages and introduces the content as follows: Fundamental values and tasks of the school; Goals and Guidelines (norms and values; knowledge, responsibility and influence of pupils; school and home; transition and co-operation; the school and the surrounding world; assessment and grades; and responsibility of the school head). Sweden also has a Syllabus for school subjects. For each school subject there are goals to aim for and goals for pupils to attain for Grades 5 and 9. The syllabuses are designed to make clear what all pupils should learn, and at the same time they provide a great deal of scope for teachers and pupils to choose their own materials and working methods. Goals to attain in the ninth year of school are the basis for assessing whether a pupil should receive the "Pass" grade. At the moment grades (pass, good, excellent) are given to students in school year 8 (NAEC, 2006).

This review identifies how the National Curricula of Bulgaria, England, and Portugal attempts to standardise the content taught in schools. This approach is strongest in England, where learning outcomes of students are controlled through national assessment. In the Czech Republic, Finland, Estonia, Poland, and Sweden there has been a tradition that municipalities or even individual schools establish the local curriculum based on the national level (framework) curriculum. One consequence of this being greater freedom and responsibilities there is at the local level, the more diversity there is in science education and assessment among teachers.

**Science in the national level curriculum**

A curriculum for a school subject describes what is to be learned in that subject and, therefore, it could be described as a road map for the journey of learning, showing the route to take, the stops to make along the way, the things to see, and the distances between places. Crucial to the curriculum of a subject is the definition of the goals (aims and objectives) for learning. In addition some important contents or concepts could be named in the curriculum. Methods of instruction may be included. Sometimes a curriculum can be equated with a syllabus, which means an outline and summary of topics to be covered. In addition to goals, contents and methods, assessment strategies may be introduced into the curriculum.

There are two common ways to organise science education in different countries: integrated science and subject specific science. An integrated curriculum is a systematic organisation of science content and parts into a meaningful pattern and it is rooted in ideas from Dewey about democratic education (Fensham, 1992). Integrated science curricula have a long history in Anglo-Saxon education. Table 1 describes how science subjects (subject specific/ integrated) are allocated for school years in EuSTD-Web countries. One lesson equals 45 minutes.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Students' age (median)</th>
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<tr>
<td>Bulgaria</td>
<td>Pre-school Comprehensive school, Basic education primary school  Integrated environmental and natural studies is a subject named “Man and nature” comprising the fields of biology, geography, physics, chemistry, and health education.  1 and 2 Grade 1 h per week  3 and 4 Grade 1.5 h per week</td>
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<td></td>
<td>lower secondary school  5 and 6 Grade: Biology, Physics  Chemistry  2 hours/week/year</td>
<td>8</td>
<td>9</td>
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<td>13</td>
<td>14</td>
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<td></td>
<td>Integrated Biology and Health  education  2 hours/week/year</td>
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<td></td>
<td>Separate Physics and Astronomy  2 hours/week/2 years</td>
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<td></td>
<td>Chemistry and environment protection  2 hours/week/2 years</td>
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<tr>
<td>Czech Republic</td>
<td>Pre-school Comprehensive school Integrated environmental and natural studies is a subject group comprising the fields of biology, geography, physics, chemistry, and health education. Altogether min. 12 hours/week/5 year = 2.4 hours/week/year</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
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<td></td>
<td>Separate: Biology, Geography, Physics, Chemistry. Altogether min. 21 hours/week/4 year = 5.25 hours/week/year</td>
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<td>Also integrated subjects are allowed.</td>
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<tr>
<td>England</td>
<td>*Primary School Key Stages 1 and 2 There are four principal areas of Primary science that pupils study: - scientific enquiry - life processes and living things - materials and their properties - physical processes. Development in knowledge and understanding of these four areas becomes more detailed and complex throughout the Key Stages. The teaching of Biology, Physics and Chemistry are not taught as separate subjects but are delivered through an integrated approach.  Key Stage 1: typically 1.5 – 2 hours/week  Key Stage 2: typically 2 - 3 hours/week Hours: ~ 10% of the timetable</td>
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<td>Secondary School Key Stage 3 The four principal areas of science that pupils studied in Key Stages 1 and 2 continue in more depth: - the teaching of Biology, Physics and Chemistry remains integrated. Hours: ~ 20% of the timetable</td>
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<td>Key Stage 4 Pupils continue to study Science. Delivery may be integrated or as separate subjects. Pupils can take a GCSE qualification in Science (*integrated’/co-ordinated’) or in the three separate disciplines. Hours: ~ 20% of the timetable</td>
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<tr>
<td>Finland</td>
<td>Pre-school primary school Some science orientation activities  Integrated environmental and natural studies is a subject group comprising the fields of biology, geography, physics, chemistry, and health education.  Altogether 9 hours/week/4 year = 2.25 hours/week/year</td>
<td>8</td>
<td>9</td>
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<td>12</td>
<td>13</td>
<td>14</td>
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<td></td>
<td>lower secondary school  5 and 6 Grade: Biology and Geography  1.5 hours/week/year</td>
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<td></td>
<td>Integrated Physics  3.5 hours/week/year</td>
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<td></td>
<td>Separate Chemistry  3.5 hours/week/year</td>
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<td></td>
<td>1 hour Physics and Chemistry  3 hours/week/3 years</td>
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</tbody>
</table>
### Table 1 (continued) Science subjects allocated for grades in EuSTD-Web countries

<table>
<thead>
<tr>
<th>Grade</th>
<th>Students’ age (median)</th>
<th>Poland</th>
<th>Integrated education comprising the fields of all school subjects</th>
<th>Lower secondary school</th>
<th>Integrated/biology, Geography, Physics and Chemistry 3 hours/week/year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>6</td>
<td>primary school</td>
<td>lower secondary school</td>
<td></td>
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<tr>
<td></td>
<td>7</td>
<td>8</td>
<td>Integrated education</td>
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<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>science subjects as follows:</td>
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<td></td>
<td>11</td>
<td>12</td>
<td>biology, Geography, Physics and Chemistry</td>
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<tr>
<td></td>
<td>13</td>
<td>14</td>
<td>6 hours/week/year</td>
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<td></td>
<td>15</td>
<td></td>
<td>=18 hours/week/year</td>
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<tr>
<td>Portugal</td>
<td>Primary School Education</td>
<td></td>
<td>First cycle</td>
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<td></td>
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<td>During the first cycle environment and social studies; Portuguese; and Mathematics are studied or personal and Social development (25 hours) or Religious Education (1 hour) are supported</td>
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<td></td>
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<td>Second cycle</td>
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<td></td>
<td>The curricular plan is organised according to pluri-disciplinary areas: Mathematics and Science 3.5 hours/week/year and Arts and Technological education 3 hours/week/year</td>
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<td>Third cycle</td>
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<td></td>
<td></td>
<td></td>
<td>Separate:</td>
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<tr>
<td>Sweden</td>
<td>The school is free to organise science subjects in a way that is appropriate for the school as long as the pupils attain the goals. However, students are guaranteed 1066 lessons (800 hours) in science and technology from year 1 to year 9. The school has freedom to organise subjects, when they should be introduced, how many hours per week, and if the subjects shall be integrated thematically. Though, generally speaking, primary school years 1-3 organise science subjects thematically often with social science subjects and Swedish. Typically there is approximately 3 hours a week. In school years 4-6 schools normally have approximately 3-6 hours per week. Even if there are goals to attain in biology, physics and chemistry school science at the primary school level mainly focuses on biology.</td>
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</table>

Based on the table above, England has a totally integrated curriculum where science content is systematically organised into a meaningful pattern for the whole of compulsory education. In Bulgaria and Portugal the 6 first grades, in the Czech Republic the 5 first grades, in Finland the 4 first grades and in Poland only the 3 first grades are organised as integrated environmental and natural studies. This integrated environmental and natural studies is a subject group comprising typically the fields of biology, geography, physics, chemistry, and health education. Consequently Poland and Finland have the most subject oriented curriculum. In Sweden schools can choose whether or not to teach separate science subjects or integrated science.

The lesson hours allocated for science education in EuSTD-Web countries give an indication of the priority given to science. However, the calculation of lesson hours is not simple. In many countries the lesson hours are given between minimum and maximum or even in percentages. Moreover, there are differences in what is understood to be a science subject. For example, in Sweden technology is included and geography not included in the time allocation whereas in Finland geography is included. The largest amount of science subjects is in Poland: about 40 lesson hours to 9 years of compulsory education. In the Czech Republic, England, and Finland there are about 30 lesson hours to 9 years of compulsory education. The smallest amount of lesson hours, about 20
goals for science teaching and learning

Crucial to the curriculum is the definition of the course or subject objectives that are in some countries expressed as learning outcomes. These goals could be classified in several ways. In addition to goals, some important contents or concepts are named in the curriculum. Sometimes curriculum is equated with a syllabus which means an outline and summary of topics to be covered. In addition to goals and contents, assessment strategy could be introduced in the curriculum. In some cases the curriculum is divided into a general part and subject specific part. In the general part general education objectives or an ideal citizen is described. Here we will illustrate examples of goals that can be found in the science curriculum of the countries participating in the EuSTD-web project. The examples have been chosen in each country by bearing in mind what is typically mentioned in goals, like for example goals for learning science content knowledge, science methods and the nature of science (e.g. Hodson 1996, Millar, Le Maréchal & Tiberghien, 1999, p. 42–47).

In Bulgaria the goals for science education could be classified as follows: goals for learning Science subject matter; goals for learning Scientific method; and goals for learning nature of Science. Moreover, there are goals for increasing students’ interest in Science, familiarity with science-society links, and co-operative skills.

Examples of goals for science learning in Bulgaria

In Bulgaria the goals for science education could be classified as follows: goals for learning Science subject matter; goals for learning Scientific method; and goals for learning nature of Science. Moreover, there are goals for increasing students’ interest in Science, familiarity with science-society links, and co-operative skills.

Examples of goals for science learning in Bulgaria

Goal for Science subject matter (concept, principles, knowledge) has the major priority in the science curriculum. Examples of goals for learning Science subject matter are:

- In Grades 3, 4, 5, 6 progress is made towards the basic concepts and principles of biology, physics and chemistry.
- In Grades 7 – 8 the pupils learn to use appropriate concepts, quantities, and units in describing natural phenomena and technological questions.

Examples of goals for learning Scientific method:

- In integrated science (comprising biology, physics, chemistry) pupils will learn in Grades 3, 4, 5, 6:
  - to make observations and measurements; to look for information on the subject of study;
  - to carry out simple scientific experiments clarifying the properties of phenomena.
- The core task of science instruction in Grades 7 through 8 is to strengthen pupils’ skills in the experimental acquisition of information. The pupils will learn in physics in Grades 7 – 8:
  - scientific skills; such as the formulation of questions and the perception of problems;
  - to make, compare, and classify observations, measurements, and conclusions; to present and test a hypothesis; and to process, present and interpret results;
  - to plan and carry out a scientific investigation in which variables affecting natural phenomena are held constant and varied and correlations among the variables are found out;
  - to use various graphs and algebraic models in explaining natural phenomena; making predictions; and solving problems.
- The pupils will learn in chemistry and biology in Grades 7 – 8
  - to use research methods typical from the standpoint of acquiring scientific knowledge; and to evaluate the reliability and importance of the knowledge;
  - to carry out scientific experiments and to interpret and present the results.

Examples of goals for learning the nature of Science:

- In all grades the core task of physics instruction is to broaden the pupils’ conception of the nature of science. Instruction guides the pupil to think in a manner characteristic of science, in acquiring and using knowledge, and in evaluating the reliability and importance of knowledge in different life situations.

Examples of goals for affecting the pupils’ interest to study Science:

- In Grades 3-8 the mode of instruction and the examples of practical application in everyday life and experiments have to stimulate the pupils to study science.

Examples of goals for stimulating the pupils to become familiar with society:

- In Grades 3-8 the mode of instruction and the emphasis on the importance of science and technology in everyday life, the living environment, and society have to stimulate the pupils to take care of their environment and act responsibly in it.

Examples of goals for development of co-operative skills:

- In Grades 3 to 8 the purpose of the experimental orientation and emphasis on group work is to help pupils to learn cooperation skills.

In the Czech Republic in Grades 1-5 the goals emphasise students’ interest in Science and use of science
knowledge in everyday situations. Later, in Grades 6-9 the goals emphasise development of science process skills. Examples of goals for science learning in the Czech Republic are described below.

Examples of goals for science learning in the Czech Republic

In Grades 1–5 progress is made towards expressing positive feelings towards themselves and their surroundings in a natural manner; getting to know the essence of health and the causes of diseases; reinforcing preventative behaviour; effective decision-making and acting in various situations where the health and safety of themselves or others is at risk.

In Grades 6–9 the pupils will learn: to test natural phenomena and their interconnections through the use of various empirical fact-finding methods (observation, measurement, experimentation) as well as various forms of rational thinking; to ask themselves questions regarding the form and causes of various natural processes; to properly formulate these questions and to seek satisfactory answers to them; to test hypotheses on natural phenomena through several independent methods; to assess the importance, reliability and correctness of collected natural-science data in order to confirm or refute previously articulated hypotheses or conclusions; to become involved in activities promoting a respectful attitude towards natural systems; personal health and the health of others; to understand the connections between human activities and the state of the environment; to think about how energy resources can be efficiently used in as practical way as possible, including the widest use of renewable energy resources possible, in particular solar radiation, wind, water and biomass; to form skills for responding appropriately when coming into contact with substances or situations which represent a real or potential threat to human life, health, property or the environment.

The goals for science learning in England are presented as ‘attainment targets’. These attainment targets set out the ‘knowledge, skills and understanding that pupils of different abilities and maturities are expected to have by the end of each Key stage’ (Education Act 1996 as cited in DES and QCA 2004 p.7). Each level description describes the types and range of performance that pupils working at that level should characteristically demonstrate. In science, the level descriptions indicate progression in the knowledge, skills and understanding set out in the four main sections of the programme of study:

- scientific enquiry
- life processes and living things
- materials and their properties and
- physical processes

Examples of goals for science learning in England are described below.

Examples of goals for science learning in England

Scientific enquiry
At the age of 7 (Key Stage 1), the majority of pupils should attain Level 2. An example of one element of this level description is: ‘Pupils respond to suggestions about how to find things out and, with help, make their own suggestions about how to collect data to answer questions’.

At the age of 11 (Key Stage 2), the majority of pupils should attain Level 4. An example of one element of this level description is: ‘Pupils recognise that scientific ideas are based on evidence. In their own investigative work, they decide on an appropriate approach to answer a question. When appropriate they describe, or show in the way they perform their task, how to vary one factor while keeping others the same’.

At the age of 14 (Key Stage 3), the majority of pupils should attain Level 5/6. An example of one element of this level description is: ‘Pupils describe evidence for some accepted scientific ideas and explain how interpretation of evidence by scientists leads to the development and acceptance of new ideas. In their own investigative work, they use scientific knowledge and understanding to identify an appropriate approach.’

Life processes and living things
At the age of 7 (Key Stage 1), the majority of pupils should attain Level 2. The content of this level description is: ‘Pupils use their knowledge about living things to describe the basic conditions that animal and plants need in order to survive. They recognise that living things grow and reproduce. They sort living things into groups, using simple features. They describe the basis for their groupings. They recognise that different living things are found in different places.’

At the age of 11 (Key Stage 2), the majority of pupils should attain Level 4. The content of this level description is: ‘Pupils demonstrate knowledge and understanding of life processes and living things drawn from the key stage 2 or key stage 3 programme of study. They use scientific names for some major organs of body systems and identify the position of these organs in the human body. They identify organs of different plants they observe. They use keys
based on observable external features to help them to identify and group living things systematically. They recognise that feeding relationships exist between plants and animal in a habitat, and describe these relationships using food chains and terms.’

At the age of 14 (Key Stage 3), the majority of pupils should attain Level 5/6. The content of this level (6) description is: ‘Pupils use knowledge and understanding drawn from the key stage 3 programme of study to describe and explain life processes and features of living things. They use appropriate scientific terminology when they describe life processes in animals and plants. They describe simple cell structure and identify differences between simple animal and plant cells. They describe some of the causes of variation between living things. They explain that the distribution and abundance of organisms in habitats are affected by environmental factors.’

Similar to Bulgaria, in Finland the national level curriculum describes goals for learning Science subject matter, goals for learning Scientific method, and goals for learning the nature of Science. Moreover, there are goals for increasing students’ interest in Science, familiarity with science-society links, and co-operative skills. Examples of goals for science learning in Finland are described below.

Examples of goals for science learning in Finland

**Examples of goals for learning Science subject matter:**

- In Grades 5–6 progress is made towards the basic concepts and principles of physics and chemistry.
- In Grades 7–9 the pupils will learn in physics to use appropriate concepts, quantities, and units in describing physical phenomena and technological questions.

**Examples of goals for learning Scientific method:**

In Grades 5–6 pupils learn in physics and chemistry:
- to make observations and measurements; to look for information on the subject of study;
- to carry out simple scientific experiments clarifying the properties of phenomena.
- The core task of physics instruction in Grades 7–9 is to strengthen pupils’ skills in the experimental acquisition of information.

In Grades 7–9 pupils learn in chemistry:
- to use research methods typical from the standpoint of acquiring scientific knowledge; and to evaluate the reliability and importance of the knowledge;
- to carry out scientific investigation and to interpret and present the results.

**Examples of goals for learning the nature of Science:**

- In Grades 7–9 the core task of physics instruction is to broaden the pupils’ conception of the nature of physics. Instruction guides the pupil in thinking in a manner characteristic of science, in acquiring and using knowledge, and in evaluating the reliability and importance of knowledge in different life situations. The purpose of the experimental orientation is to help the pupils to perceive the nature of science.

**Examples of goals for affecting the pupils’ interest to study Science:**

- In Grades 5–6 the instruction must stimulate the pupils to study science.
- In Grades 7–9 the purpose of the experimental orientation is to stimulate the pupils to study physics and chemistry.

**Examples of goals for stimulating the pupils to become familiar with society:**

- In Grades 5–6 the instruction must stimulate the pupils to take care of their environment and act responsibly in it.
- In Grades 7–9 the instruction in physics helps the pupils understand the importance of physics and technology in everyday life, the living environment, and society. It also provides capabilities for making everyday choices, especially in matters related to environmental protection and the use of energy resources.

**Examples of goals for development of co-operative skills:**

- In Grades 7–9 the purpose of the experimental orientation is to help pupils to learn cooperation skills. The pupils learn in physics to work with and investigate natural phenomena safely, together with others.

Again, similar to Bulgaria and Finland, in the Polish national curriculum, there are goals for learning Science subject matter, goals for learning Scientific method, and goals for learning the nature of Science, and moreover, there are goals for increasing students’ interest in Science, familiarity with science-society links, and co-operative skills. The goals for science education (elementary school, Grades 4–6, integrated science: biology, chemistry, physics, and geography) in the Polish core curriculum can be classified as described below.
Examples of goals for science learning in Poland

Examples of goals for learning Science subject matter: me and my surrounding; field orientation; observation; experimentation and modelling; man in the natural environment; features of chemical substances; the landscapes of Poland and Europe; human organism; health and health care; electrical and magnetic phenomenon in nature; The Earth in the Universe; Lands and Oceans; the world's landscapes; transformations of chemical substances; movement and force in nature.

Examples of goals for learning Scientific method: Asking questions; establishing a hypothesis and verification; allying gained knowledge to every day life situations; observations, measuring and experimenting on live nature and on the artefacts of nature.

Examples of goals for learning the nature of science: a) indirect goals: observation and measuring; experiencing; experimenting; documentation and presentation; asking scientific questions and looking for answers; b) direct goals: foreseeing a course of some nature processes; explaining simple interrelations in nature; observing and doing experiments following instructions; registration of research results in different codes and interpreting them; using proper terminology.

Examples of goals for affecting the pupils’ interest to study Science: training students in asking questions and looking for answers such as, why, how come, what will happen if.

Examples of goals for stimulating the pupils to become familiar with society: explaining the influence of human beings on nature and giving examples of positive and negative influences of human beings on nature; explaining the negative influence of alcoholic beverages, drugs and nicotine on personal and social health.

Examples of goals for cooperative skills development: (only indirect goals) undertaking an activity towards giving circumstances for personal and social safety; giving examples of assertive behaviours in situations or in circumstances of group pressure.

In Portugal, the general goals in basic education are very future oriented. According to the goals, the teaching of science should create conditions for a global and harmonious personal development, develop values, attitudes and behaviour, which contribute to the development of democratically aware and active citizens; and facilitate the acquisition and mastery of the knowledge, tools, skills, capacities, attitudes and values needed to make an informed choice about further educational options or employment opportunities. Examples of goals for science teaching and learning in Portugal are described below.

Examples of goals for science learning in Portugal

According to the first goal, teaching of science should create conditions for a global and harmonious personal development, by allowing students gradually to discover their interests, aptitudes and capacities which allow a personal training in individual and social dimensions. The first goal, as an individual dimension, includes the promotion and creation of situations that are favourable to self knowledge and to having a positive relationship with others; increase the progressive development of self confidence etc.

According to first goal, teaching of science should develop values, attitudes and behaviour, which contribute to the development of democratically aware and active citizens. In the second goal, the basic and intellectual acquirements are the structure knowledge in several domains and imply the promotion of the progressive domain of the verbal and non-verbal communication; the comprehension of the Portuguese language (oral and written); learning the first foreign language; to improve the technical development of practical problems; to start the technological knowledge and proper work environments; etc.

According to the first goal, teaching of science should facilitate the acquisition and mastery of the knowledge, tools, skills, capacities, attitudes and values needed to make an informed choice about further educational options or employment opportunities. The third goal, more related to citizenship, includes the needs of increasing the practice of a new learning of the relationships of the individual and the environment; promotion of the attitudinal and work habits of autonomous works as well as in groups; assuring the collaboration with proper entities and families; etc.

Sweden groups the goals for science teaching and learning under four main titles as in England and in Portugal. Examples of goals for science learning in Sweden are described below.
Examples of goals for science learning in Sweden

<table>
<thead>
<tr>
<th>Concerning nature and Man pupils should</th>
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<tbody>
<tr>
<td>- have knowledge within some scientific areas;</td>
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<tr>
<td>- have a familiarity with narratives about nature which are to be found in our own culture and that of others;</td>
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<table>
<thead>
<tr>
<th>Concerning scientific activity pupils should</th>
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<tr>
<td>- be able to carry out simple systematic observations and experiments, as well as compare their predictions with actual results;</td>
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<tr>
<td>- be familiar with some episodes in the history of science and through this have an insight into different ways of explaining nature;</td>
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<tr>
<td>- have an insight into different ways of understanding nature, through on the one hand science with its systematic observations, experiments and theories, as well as on the other hand by the approaches used in art, literature, myths and sagas,</td>
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<table>
<thead>
<tr>
<th>Concerning use of knowledge pupils should</th>
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<tbody>
<tr>
<td>- have knowledge of how Man's attitude of curiosity to scientific phenomena has led to social progress;</td>
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<tr>
<td>- have knowledge of management of resources in daily life and about practical measures for conserving resources;</td>
</tr>
<tr>
<td>- have an insight into how arguments over daily environmental and health issues can be built up through the use of personal experiences and scientific knowledge.</td>
</tr>
</tbody>
</table>

Based on the boxes above, in each country participating in the EuSTD-web project, there are goals for learning science subject matter, goals for learning scientific method, and goals for learning the nature of Science. Moreover, there are in some countries, in the national curriculum, goals for increasing students' interest in Science, familiarity with science-society links, and co-operative skills. However, based on the typical examples, described in the boxes, each country emphasises the goals in different ways. In Bulgaria, Finland and in Poland different types of goals are emphasised equally. The Czech Republic emphasizes development of science process skills in their national level curriculum. Some countries, like England, Portugal, and Sweden, group the goals for Science education under a few main titles. In England the titles are: scientific enquiry; life processes and living things; materials and their properties and physical processes. In Portugal, the titles are very future orientated: the teaching of science should create conditions for a global and harmonious personal development, develop values, attitudes and behaviour which contribute to the development of democratically aware and active citizens; and facilitate the acquisition and mastery of the knowledge, tools, skills, capacities, attitudes and values needed to make an informed choice about further educational options or employment opportunities.

Content areas of science

The syllabus or content areas of Science are introduced in different ways in each EuSTD-web country. Here we provide analysis of the contents in the Programme for International Student Assessment (PISA) and its Scientific Literacy framework. In PISA 2006 there were four content areas: Physical systems, Living systems, Earth and space systems, and Technology systems. These areas represent important knowledge that is required by adults for understanding the natural world and for making sense of experiences in personal, social and global contexts.

Content areas in the Bulgarian national science curriculum could be easily classified according to PISA 2006 Scientific Literacy framework. Examples of contents for science learning in Bulgaria are shown below.

Examples of contents for science learning in Bulgaria

<table>
<thead>
<tr>
<th>Examples of contents of physical systems:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- producing heat, light (from Grades 4-8 gradually develop);</td>
</tr>
<tr>
<td>- motion and equilibrium phenomena due to forces (from Grades 4-8 gradually develop);</td>
</tr>
<tr>
<td>- natural structures and proportions (from Grades 4-8 gradually develop);</td>
</tr>
<tr>
<td>- motion and forces, models of uniform and uniformly accelerating motion (from Grades 4-8 gradually develop);</td>
</tr>
<tr>
<td>- various basic phenomena of vibrations and wave motion; production, detection; observation, reflection, and refraction of wave motion (from Grades 6-8 gradually develop);</td>
</tr>
<tr>
<td>- interpretation of chemical reaction equations and the balancing of simple reaction equations (from Grades 6-8 gradually develop);</td>
</tr>
<tr>
<td>composition of air; the atmosphere (from Grades 4-8 gradually develop);</td>
</tr>
</tbody>
</table>
- properties of water and its importance as a solvent; investigation of natural waters; water purification (from Grades 4-8 gradually develop).

**Examples of contents of living systems:**
- structure and main vital functions of the human body; reproduction; physical; psychological and social changes accompanying puberty (Grades 3-8); In 8th grade human anatomy, physiology and health are the main topics.
- structure and activity of the cell (Grades 5, 6, 7);
- ecologically sustainable development and the substance and objectives of environmental protection (Grades 3-8); In Grades 7 and 8 in Chemistry and environment protection it is the main topic.
- the ecosystem and its structure and operation; distinctive features of forest and aquatic ecosystems; independent research on one ecosystem (Grades 7-8);
- biological and cultural evolution of human beings; distinctive features of the human species (Grade 8).

**Examples of contents of earth and space systems:**
- motion of the earth and moon, structure of the solar system (Grades 4 and 8);
- structures of the Earth’s systems (lithosphere, atmosphere, hydrosphere) (Grades 6 and 7);
- interactions and the corresponding forces; motion and equilibrium phenomena that arise from those interactions; occurrence of those phenomena in nature (Grades 6-8);
- the Earth’s gravity (Grades 6 and 8);
- interactions that keep structural components together; binding and release of energy in processes occurring between components (Grades 5-8).

**Examples of contents of technology systems:**
- various ways of producing electricity and heat; energy resources (Grades 4-8);
- electromagnetic induction and its use in energy transmission; use of electricity at home (Grades 7-8);
- origin, utilisation, and recycling of products and materials belonging to the living environment; safe usage of those products and materials (Grades 5-8).

Content areas in the Czech Republic’s national science curriculum could also be easily classified according to PISA 2006 Scientific Literacy framework. However, the curriculum emphasises physics and chemistry more at Grades 6-9 than in Portugal. Examples of contents for science learning in the Czech Republic are described below.

**Examples of contents for science learning in the Czech Republic**

In Grades 1–5:

**Examples of contents of physical systems:**
- orientation in time, chronological order – telling time, time as a physical quantity, history as a sequence of events over time, calendars, era, generation, daily schedule, seasons;
- substances and their properties – classification of substances, changes in substances and states, comparing substances and measuring quantities with the practical use of basic measurement units;
- water and air – occurrence, characteristics and forms of water, water cycle in nature, characteristics, composition, air flow, importance for life.

**Examples of contents of living systems:**
- municipality (town), local countryside – components, position in the countryside, the history and present day of the municipality (town), important buildings, transport infrastructure;
- surrounding countryside (local, regional) – the Earth’s surface and its forms, continental waters, distribution of soils, flora and fauna, the influence of the landscape on people’s lives and vice versa, orientation points and lines, cardinal points;
- regions of the Czech Republic – Prague and selected areas of the Czech Republic, natural resources, production, services and trade;
- our country – home, landscape, nation, the foundations of the system of government and political system of the Czech Republic, state administration and local government, state symbols;
- Europe and the world – continents, European countries, the EU, travelling;
- minerals and rocks, soil – economically important minerals and rocks, weathering, the birth of soil and its importance;
- plants, fungi and animals – features of life, existential needs and manifestations, the course and way of life, nutrition, body structure in some of the most familiar species, their importance for the environment and people.

**Examples of contents of earth and space systems:**
- Earth and the universe – the solar system, day and night, seasons of the year.

**Examples of contents of technology systems:**
- living conditions – diversity of the conditions for life on Earth; importance of the atmosphere, waters, soils, fauna and flora on Earth; climate and weather;
- balance in nature – importance, mutual relations between organisms, major natural communities;
- considerate conduct towards nature, environmental protection – human responsibility, protection and creation of the environment, protection of flora and fauna, waste disposal, natural and environmental disasters;
- human body – existential needs and manifestations, basic structure and functions, sex differences between men and women, basics of human reproduction, development of the individual;
- partnership, parenthood, basic sexual education – family and partnership, biological and mental changes during adolescence, ethical aspects of sexuality, HIV/AIDS (forms of transmission);
- care for one’s health, proper nutrition – daily regimen, drinking regimen, movement regimen, healthy nutrition; illness, minor injuries and wounds, first aid, accident prevention; personal, intimate and emotional hygiene – stress and its risks; influence of advertising;
- addictive substances and health – refusing addictive substances, gambling slot machines and computers;
- personal safety – safe behaviour in high-risk environments, safe traffic behaviour as a pedestrian and a cyclist, emergency situations (bullying, maltreatment, sexual abuse, etc.), brutality and other forms of violence in the media; professional assistance services;
- public emergency situations.

In Grades 6–9 (Physics):
**Examples of contents of physical systems:**
- motion of bodies – uniform and non-uniform motion; rectilinear and curvilinear motion;
- gravitational field and force of gravity – direct proportion between gravitational force and a body’s mass compressive force and pressure – relationship between compression force, pressure and the contents of a surface on which the force acts;
- force of friction – friction, influencing the magnitude of friction in practice;
- resultant of two forces of the same and opposite directions;
- Newton’s Laws – First, Second (qualitatively), Third Laws of Motion;
- equilibrium on a lever and fixed pulley;
- Pascal’s Law – hydraulic equipment;
- hydrostatic and atmospheric pressure – the connection between hydrostatic pressure, depth and the density of a liquid; the connection of atmospheric pressure and certain atmospheric processes;
- Archimedes’ Principle – buoyant force; immersion, suspension and floating in a fluid at rest;
- forms of energy – kinetic and potential energy; internal energy; electrical energy and power; production and transmission of electrical energy; nuclear energy, nuclear fission, nuclear reactor, nuclear power plant; protecting humans against radioactive radiation;
- properties of sound – the necessity of a medium for the diffusion of sound, speed of sound in various mediums; deflection of sound from a barrier, echo; sound absorption; pitch;
- state changes – melting and solidification, latent heat of melting; evaporation and condensation; main factors influencing evaporation and boiling point of liquids;
- electrical circuit – source of voltage, elements, switch;
- electric and magnetic fields – electric and magnetic force; electric charge; heat effects of electric current; electric resistance; direct current electromotor; transformers; safe conduct when working with electrical devices and equipment;
- properties of light – sources of light; speed of light in a vacuum and in various mediums; shadow, solar and lunar eclipses; reflection imaging on a plane, concave and convex mirrors (qualitative); refraction by thin converging and diverging lenses (qualitative); dispersion of white light by a prism.

**Examples of contents of living systems:**
- renewable and non-renewable sources of energy.

**Examples of contents of earth and space systems:**
- the solar system – main components; phases of the Moon;
- stars – their composition.

**Examples of contents of technology systems:**
- measured quantities – length, volume, mass, temperature and change in temperature, time;
- states of substances – relationship of substances’ state to their molecular structure; diffusion.

When planning the delivery of science lessons in England, schools are required to also consider the general teaching requirements for ‘inclusion’, ‘use of language’, ‘use of information and communication technology’ and ‘health and safety’ that apply across the programmes of study. In Science at Key Stages 1, 2, and 3 the knowledge, skills and understanding in each programme of study identify the four areas of science that pupils study:
- Scientific enquiry
- Life processes and living things
- Materials and their properties
- Physical processes
An example of how the content area of ‘Life processes and living things’ is developed through Key Stages 1, 2, and 3 is described below.

### An example of how the content area of ‘Life processes and living things’ is developed through Key Stages 1, 2 and 3 in England

<table>
<thead>
<tr>
<th><strong>Sub-section: ‘Variation and classification’</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Stage 1:</strong></td>
</tr>
<tr>
<td>Pupils should be taught to:</td>
</tr>
<tr>
<td>- recognise similarities and differences between themselves and others, and to treat others with sensitivity;</td>
</tr>
<tr>
<td>- group living things according to observable similarities and differences.</td>
</tr>
<tr>
<td><strong>Key Stage 2:</strong></td>
</tr>
<tr>
<td>Pupils should be taught to:</td>
</tr>
<tr>
<td>- make and use keys;</td>
</tr>
<tr>
<td>- how locally occurring animals and plants can be assigned to groups;</td>
</tr>
<tr>
<td>- that the variety of plants and animals makes it important to identify them and assign them to groups.</td>
</tr>
<tr>
<td><strong>Key Stage 3:</strong></td>
</tr>
<tr>
<td>Pupils should be taught:</td>
</tr>
<tr>
<td>- Variation: about environmental and inherited causes of variation within a species;</td>
</tr>
<tr>
<td>- Classification: to classify living things into the major taxonomic groups;</td>
</tr>
<tr>
<td>- Inheritance: that selective breeding can lead to new varieties.</td>
</tr>
</tbody>
</table>

In Finland the orientation for describing the science content in the curriculum is very subject oriented. However, the content could be easily classified to the four content areas of PISA 2006 as described below. However, most of earth science belongs to geography.

### Examples of contents for science learning in Finland

**Examples of contents of physical systems:**
- producing heat, light (Grades 5–6); |
- motion and equilibrium phenomena due to forces (Grades 5–6); |
- natural structures and proportions (Grades 7–9); |
- motion and forces, models of uniform and uniformly accelerating motion (Grades 7–9); |
- various basic phenomena of vibrations and wave motion; production, detection; observation, reflection, and refraction of wave motion (Grades 7–9); |
- interpretation of chemical reaction equations and the balancing of simple reaction equations (Grades 7–9); |
- composition of air; the atmosphere (Grades 7–9); |
- properties of water and its importance as a solvent; investigation of natural waters; water purification (Grades 7–9).  

**Examples of contents of living systems:**
- structure and main vital functions of the human body; reproduction; physical; psychological and social changes accompanying puberty (Grades 5–6); |
- structure and activity of the cell (Grades 7–9); |
- ecologically sustainable development and the substance and objectives of environmental protection (Grades 7–9).  

**Examples of contents of earth and space systems:**
- motion of the earth and moon, structure of the solar system (Grades 5–6); |
- structures of the Earth’s systems (lithosphere, atmosphere, hydrosphere) (Grades 7–9); |
- interactions and the corresponding forces; motion and equilibrium phenomena that arise from those interactions; occurrence of those phenomena in nature (Grades 7–9).  

**Examples of contents of technology systems:**
- various ways of producing electricity and heat; energy resources (Grades 5–6); |
- electromagnetic induction and its use in energy transmission; use of electricity at home (Grades 7–9); |
- washing and cosmetic materials; textiles (Grades 7–9).  

In Poland, the content areas of science could be classified to the four content areas of PISA 2006. However, here the areas are introduced according to classification of areas in the national level curriculum to 15 content areas as described below.
**Examples of contents for science learning in Poland**

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Me and my surrounding (for instance: students will describe a place for learning in elementary school)</td>
</tr>
<tr>
<td>2.</td>
<td>Sense of direction (orienteering) (for instance: a student will identify an objects on a map)</td>
</tr>
<tr>
<td>3.</td>
<td>Observation, natural experiences, modelling (for instance: a student will observe the phases of a plant’s development)</td>
</tr>
<tr>
<td>4.</td>
<td>The nearest surrounding (for instance: a student will observe and name a typical organism existing in the forest and so on)</td>
</tr>
<tr>
<td>5.</td>
<td>Man and environment (for instance: a student will propose activities favourable to the natural environment)</td>
</tr>
<tr>
<td>6.</td>
<td>Features of chemical substances (for instance: a student will give examples of using different substances to build tools for everyday using)</td>
</tr>
<tr>
<td>7.</td>
<td>Landscapes of Europe and Poland (for instance: a student will give examples of interrelations between some features of the landscape and human beings’ activity)</td>
</tr>
<tr>
<td>8.</td>
<td>The organism of the human being (for instance: a student will name a particular organic system)</td>
</tr>
<tr>
<td>9.</td>
<td>Health and health care (for instance: a student will list the rules for correct eating and implement them)</td>
</tr>
<tr>
<td>10.</td>
<td>Electrical and magnetic phenomena in nature (for instance: a student will give examples of electricity in nature)</td>
</tr>
<tr>
<td>11.</td>
<td>The Earth in Cosmos (for instance: a student will describe the shape of the Earth)</td>
</tr>
<tr>
<td>12.</td>
<td>Lands and Oceans (for instance: a student will point out on an atlas the different lands, oceans, and the poles)</td>
</tr>
<tr>
<td>13.</td>
<td>Landscapes of the World (for instance: a student will describe landscapes of the world)</td>
</tr>
<tr>
<td>14.</td>
<td>Changes of chemical substances (for instance: a student will give examples of reversible changes)</td>
</tr>
<tr>
<td>15.</td>
<td>Movement and forces in nature (for instance: a student will describe different kinds of movement)</td>
</tr>
</tbody>
</table>

In the Portuguese national curriculum, contents for Science in the three cycles of basic education are organised according to four general themes: earth in space, earth in transformation, sustainability on Earth, better living on Earth. In these content areas, Science, Technology, Society, and Environmental issues are emphasised. Examples of contents for science learning in Portugal are illustrated below.

**Examples of contents for science learning in Portugal**

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The first theme - Earth in space - focuses on the location of the planet in the universe (Solar System) and their interrelation in this vast system, and the understanding of phenomena related to the Earth’s movements and its influence on life.</td>
</tr>
<tr>
<td>2.</td>
<td>The second theme - Earth in transformation - is intended so that students acquire knowledge relating to the components of the earth and the phenomena that occur on it. Examples of contents are: Earth tells its story, internal dynamics of the Earth, consequences of the internal dynamics of the Earth, internal structure of the Earth and external structure of the Earth.</td>
</tr>
<tr>
<td>3.</td>
<td>In the third theme - Sustainability on Earth - it is intended that the students become aware of the importance of acting in the Earth’s system, not causing imbalances, contributing to the management rules of the existing resources. For sustainable development, education must take into account the diversity of physical environments; biological, social, economic and ethical. The learning of science in a global and interdisciplinary perspective, which enhances skills and knowledge through active learning and context, research, communication, decision making, contribute to a sustainable future. Other areas of the 3rd theme are sound and light, chemical reactions, and global change.</td>
</tr>
<tr>
<td>4.</td>
<td>The fourth theme - Living Better on Earth - is aimed at understanding that the quality of life means health and security in a collective and individual perspective. Biotechnology, an important area in scientific and technology society, in which we live, is essential knowledge concerning the quality of life. Examples of contents of the 4th theme are: life transmission, human organism in balance, science and technology and life quality, movement and strengths, electric and electronic systems, materials classification.</td>
</tr>
</tbody>
</table>

In Sweden the content areas described in the curriculum are similar to the content areas in PISA, although, most earth science belongs to geography, which is a part of social studies in the Swedish curriculum. We describe the content of the Swedish curriculum according to the Swedish science curriculum below.
Examples of contents for science learning in Sweden

Pupils should learn in Biology

concerning nature and Man
- to recognise and be able to name common plants, animals and other organisms in the local environment, as well as be familiar with their environmental requirements;
- be able to give examples of the life cycle of some plants and animals and their different growth processes;
- be familiar with important organs in their own bodies and their functions;
- have an insight into human reproduction, birth, puberty, ageing and death;
- have an insight into the effects of addictive substances on health;
- have a familiarity with narratives about nature, which are to be found in different cultures.

concerning scientific activity
- have an insight into experimental work, as well as making field observations in their immediate environment;
- be familiar with some examples where discoveries in biology have influenced our culture and view of the world.

concerning use of knowledge
- have an insight into and be able to discuss the importance of habits which promote good health.

Pupils should learn in Physics

concerning nature and Man
- have an insight into how the planets rotate around the sun, as well as how the earth and the moon move in relation to each other, and be able to relate the calendar and seasons of the year to these movements;
- have an insight into basic meteorological phenomena and contexts;
- have an insight into technical applications of electricity circuits and permanent magnets;
- have an insight into the fundamentals of dispersion of sound, and hearing, as well as the properties of light and the functions of the eye;
- be familiar with narratives about nature, which are to be found in our own culture and that of others.

concerning scientific activity
- have their own experiences of systematic observations, measurements and experiments;
- be familiar with some examples where discoveries in physics have influenced our culture and view of the world.

concerning use of knowledge
- have an insight into how physics can throw light on existential issues, e.g. the origins of the universe, conditions of life on earth and other planets, as well as energy and resource issues.

Pupils should learn in Chemistry

concerning nature and Man
- have knowledge of the concepts of solids, liquids, gases and boiling, evaporation, condensation and solidification;
- be familiar with different kinds of mixtures and solutions;
- be familiar with some of the factors that cause substances to be broken down, and be able to give examples of how this can be prevented;

concerning scientific activity
- have their own experiences of carrying out experiments with everyday chemical products safely;
- be able to make observations about different materials and have an insight into how these can be categorised.

concerning use of knowledge
- have an insight into how a knowledge of chemistry can be used in discussions on the use of resources and environmental issues, as well as how a knowledge of chemistry can be used to improve our living conditions.
- have an insight into the risks connected with the use of chemicals in the home, how they are labelled, and should be handled.
Although the descriptions of content areas or syllabuses in national science curricula in EuSTD-web countries are made differently, the content areas could be classified in most countries according to PISA 2006 Scientific Literacy framework: *Physical systems, Living systems, Earth and space systems, and Technology systems*. In Bulgaria, Finland and Czech Republic and, moreover, to some degree in Poland, the content areas are described in each science subject. Content areas in these countries were easily classified according to PISA framework. England, Portugal and Sweden have different approaches to describing the content areas. The English curriculum identifies the four content areas of science: scientific enquiry; life processes and living things; materials and their properties; and physical processes. In Portugal, science education is organised into four general themes: Earth in space; Earth in transformation; sustainability on Earth; better living on Earth. Finally, in Sweden content areas in Biology, Chemistry and Physics are classified into three groups: nature and Man; scientific activity; and use of knowledge.

**Summary and Discussion**

In this chapter some basic trends in education systems and national and local level curricula for compulsory schools in the EuSTD-web countries have been described. Especially, goals and content for national level science curriculum in each country have been analysed and, moreover, direct comparisons between the countries have been made.

We have read that while National Curriculum in Bulgaria, England, and Portugal standardises the content taught in schools; whereas in the Czech Republic, Finland, Estonia, Poland and Sweden municipalities or even individual schools form the local curriculum based on the national level (framework) curriculum.

Compulsory education is divided in each EuSTD-web country into two, three or four cycles from the point of view of science education. In Bulgaria, Czech Republic, Finland, Poland, and to some degree in Portugal science subjects are taught separately during the last 3 – 5 years of compulsory education. In all Nordic countries there is a national level framework curriculum which includes descriptions of the goals of compulsory education, values it is based on, aims of the subjects and a short description of subjects.

We have identified that in all countries there are goals for learning Science subject matter, scientific method, and the nature of Science. Moreover, there are in some countries, in the national level curriculum, goals for increasing students' interest in Science, familiarity with science-society links, and co-operative skills. However, each country emphasises the goals in different ways. In Bulgaria, Finland, and the Czech Republic and, moreover, to some degree in Poland the content areas are described in each science subject and could be easily classified according to PISA framework. England, Portugal, and Sweden have different approaches for describing the content areas.
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2.2

CONTINUING PROFESSIONAL DEVELOPMENT (CPD) FOR SCIENCE TEACHERS

Ani Epitropova, Joanne Courtney, Jari Lavonen and Veijo Meisalo

Introduction

It can be said that teacher education forms the basis for all educational systems – success and failure of school education has been credited to teacher education as for example, in the context of PISA evaluations. There has been important European development in initial teacher education in the context of the Bologna process and the Lisbon strategy (European Commission, 2007). However, in the course of the present project it became obvious that in the participating countries the organization of CPD varies largely in many respects. We have chosen three cases, Bulgaria, England, and Finland, to illustrate the large differences and discuss what can be learned from the present situation.

It may be noted that the problematic situation concerning CPD has been observed in many countries. For instance, in Finland the Ministry of Education appointed in autumn 2008 a committee for ‘Ensuring professional competence and improving opportunities for continuing education in education’ (2009). The report of this committee expresses concern on the recent decreasing development in the participation of educational personnel in CPD activities, which the committee disclosed to be happening in this country. On the other hand, it is obvious that while there are problems in the outcomes and in the participation in CPD in many European countries there is also a lack of coherence in the relevant systems across Europe. The three cases presented in this chapter describe many aspects of the situation, while it has to be understood that all problems of CPD for active teachers can not be approached in this short chapter.

Definition

In scientific literature, as well as in the documents specifying CPD in the countries which participate in the afore-mentioned European project, there are various definitions of the nature of CPD for teachers. The cited definitions are an example of the variety of these specifications and show the parallel directions in which the essence and organization of CPD are defined.

<table>
<thead>
<tr>
<th>State</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>Continuing professional development (CPD) consists of reflective activities designed to improve an individual’s attributes, knowledge, understanding and skills. It supports individual needs and improves professional practice. There are many possible sources of CPD, as shown in the diagram below. Some forms of CPD may encompass elements from more than one of these sources.</td>
</tr>
</tbody>
</table>
Finland
Organisation of CPD for teachers is divided in two systems. In-service training is considered to be training to update the knowledge and skills of teachers who are already working in schools, during their course of employment. This training to update professional skills covers all kinds of effort organised by local school authorities or co-ordinated by the National Board of Education, but delivered also often by external training providers. Further education leading to new competence levels is organised mostly by universities. This means often doctoral studies while competent teachers have formally easy access to graduate studies.

Bulgaria
The promotion of professional qualification is a stage of continuous training where through different forms of post-graduate education, the adequate professional realization of pedagogical specialists is governmentally assisted.

According to Grant (2005) “Professional development ... goes beyond the term “training” with its implications of learning skills, and encompasses a definition that includes formal and informal means of helping teachers not only learn new skills but also develop new insights into pedagogy and their own practice, and explore new advance understanding of content and resources.”

In England national priorities are set for teachers' continuing professional development (CPD). These national priorities help CPD providers plan to deliver an appropriate range of high-quality programmes to support teachers' professional development. The national priorities for teachers' CPD are grouped into three categories:

   Pedagogy : This covers: behaviour management, subject knowledge, supporting curriculum change.
   
   Personalization: This covers: equality and diversity, special educational needs (SEN) and disability.
   
   People: This covers: working with other professionals, school leadership.

In England the continuum of teacher education from pre-service education to induction period and continuous professional development over the active years in the teaching profession seems to be well developed and tightly guided by Standards associated with different competence levels, as discussed below. We may note that there is no induction phase for new teachers, neither in Bulgaria nor in Finland.
What are the laws and regulations concerning and defining CPD?

England

CPD in England seems to be tightly guided by specific standards: In 2007 the Training and Development Agency (TDA) devised a set of professional standards for teachers over five stages. These five stages are described as: ‘Qualified Teacher Status (QTS) ’, ‘Main Scale Teacher’, ‘Post-threshold Teacher’, ‘Excellent Teacher’ and ‘Advanced Skills Teacher’. Within these stages are sets of ‘standards’ which define the ‘professional attributes, knowledge and understanding and skills’ for teachers within each of the five stages. These standards can be used as a guide to determine an individual teacher's needs for CPD as well as providing a backdrop for discussions about current performance and areas for future professional development. These standards also demonstrate how a teacher’s expectations can grow and change at different stages of their career as they take on different roles within a school. The standards are designed to help teachers to recognize their existing expertise and achievements as well as any development needs. They may also help teachers to develop a clearer and more relevant job description or career path.

After completing undergraduate or postgraduate study, trainee teachers are awarded the ‘Qualified Teacher Status (QTS)’ mentioned above they also complete a Career Entry and Development Profile (CEPD). This includes areas of strength as well as areas for development. The developmental areas must be addressed during their first teaching year (which is in Europe often called the induction phase of CPD, see e.g., ETUCE, 2008, 49; OECD, 2005; Eisensmith, 2007) new teachers are known as ‘Newly Qualified Teachers’ (NQTs),

During the QTS year, trainee teachers complete a set of professional standards known as ‘QTS standards’. As a continuation of this, during their first teaching year, new teachers are required to complete additional professional standards known as ‘Core standards’. It is of special interest for the continuum of CPD that success and completion of these standards are achieved with support from staff in the school that has employed them, most specifically by a nominated mentor. In addition to this, NQTs are given a reduced timetable, (usually a 10% reduction in teaching duties) to enable them to develop their professional knowledge. Schools are responsible for delivering CPD to these newly qualified teachers and this is financed through the school’s CPD budget. Local Education Authorities provide additional funding to schools to support NQT professional development.

Bulgaria

Following a 1997 ordinance by the Minister of Science and Education, five professional pedagogically-oriented degrees have been legally established in Bulgaria. According to article (2) of this ordinance, the promotion of professional qualification is a stage of continuous training, where through different forms of post-graduate education, the adequate professional realization of pedagogical specialists is being governmentally assisted. There is no clear-cut initiation phase, but a higher level of professional competency of pedagogical cadres serves as a basis for their acquirement of professional degrees. The paths for professional development and growth in the perimeters of this system are described further on in this chapter. It is of interest to note, that Bulgaria has been seen as exemplary in developing the CPD system under co-operation of the Ministry of Education with teachers’ and employers’ organizations (ETUCE, 2008, 47). Another, more dynamic and current opportunity for the enhancement of professional qualification, is participation in university courses, or organizationally provided ones, designed by either national or international projects.
Finland

In Finland there is little legislation concerning the professional development of teachers. The focus is on in-service education and is considered to be the responsibility of employers, normally municipalities acting as local school authorities. However, the National Board of Education co-ordinates national in-service programmes and also puts courses out for tender. There is no official system for any initiation phase for new teachers, neither are there properly defined steps in the teacher career development. CPD organized by local authorities often focuses on diverse local matters and is seldom adequately systematic. It is problematic that there seems to be little co-ordination of local activities and this may be a reason for the identified decreasing trend in the popularity of CPD courses, which was quoted in the Introduction.

The professional development of teachers is considered to be a type of postgraduate education and is usually organized at universities. There has been a successful doctoral school for mathematics and science teachers active over recent years, but numbers has been rather modest. However, there has been a successful co-operation of Finnish and Swedish doctoral schools (Lavonen & Strömdahl, 2008). Graduate schools have a special national goal to support the strengthening of teacher education. Through educating doctoral students, there will be more doctors teaching in primary and secondary school teacher education in the future. Therefore, the quality of teacher education will supposedly be improved. Secondly, the graduate school is interdisciplinary. This has increased collaboration between subject departments (physics, chemistry and biology) and pedagogical departments. Furthermore, this collaboration has been a fruitful starting point for the discussion, development and even research of teaching and learning at the subject departments.

How is CPD funded?

In Bulgaria, the Ministry of Science and Education delegates a part of the annual budget to each school for the purpose of promoting the qualification of teachers. The Principal of the respective school takes administrative decisions regarding the utilization of the delegated resources. Participation in the five-degree qualification programme or in other related courses requires the accordance of the school governing staff.

In England funding for CPD is allocated to schools to enable them to match budgets to priorities for development and/or improvements in CPD areas that have been identified. These priorities can be at national and local level. In general, schools produce three documents that are key to deciding on priority areas for CPD. These three documents are generally known as: i) ‘The School Development Plan’, ii) ‘Subject Area Development Plan’ and iii) ‘Departmental Review’. Each of these three documents results in the development of ‘Improvement Plans’ and emerging priorities for CPD in these three improvement plans will be decided upon by the CPD budget holder.

Governors and school leaders agree the overall allocations and priorities for funding in advance, and annually, governors and leadership teams must agree the funding allocated for professional development. In addition to this, some funding may be allocated to teams or individuals for their own professional development needs but this must be approved by the budget holder. As a result, therefore, schools’ spending on CPD can vary widely from one institution to the next, with some schools allocating a considerable budget to CPD while others may allocate a very small budget. As such then, spending for CPD varies significantly from school to school.

Access to CPD opportunities for teachers is, therefore, variable according to the factors previously discussed. Individual teacher’s continuous professional development plans are dependent on their school’s budget and this means that in some instances teachers’ personal targets for their professional development may not have priority because of the focus of the school’s Improvement Plan. It may well be the case that in such circumstances teachers may have to fund their own CPD or spend additional hours over and above ‘normal
duties’ to pursue an area of interest for their own personal professional development if the school cannot support
the teacher financially to do so. However, schools do try their best to recognise and address the needs of
individuals and their developmental requirements within their budget constraints.

In Finland, municipalities are responsible for financing in-service training of teachers, but they may get these
expenses covered partly from the state budget through a complicated compensation system. During years of
very tight local budgeting there have been serious cuts in allocated funds. National funding is provided by the
Ministry of Education (ME) through the Finnish National Board of Education (FNBE) for allocating resources to
different types of organizers of training programmes. Altogether, FNBE is responsible for national level
implementation of educational programmes and strategies including in-service education. Some private funds
have also been available for teacher CPD – for instance foundations or organizations of industry have been
willing to support courses and programmes for science and technology teachers.

Most teachers enrolled in further education study on part-time basis, financing their studies themselves or
through scholarships. However, we have to remember, that there are no fees for doctoral education in Finland.
The doctoral school mentioned above has been financed by the Ministry of Education, but there are few posts
only for full-time doctoral studies.

**What are the forms and manners of CPD implementation?**

In England CPD can be undertaken in a variety of ways – ranging from: teachers embarking on a programme of
individual self study, attending courses that are delivered ‘in-house’ (within the school environment) or through
the employment of external consultants. There are many possible sources of CPD, for example: coaching and
mentoring, whole school development events and collaborative planning, as well as virtual networks or courses
offered by local authorities, colleges and universities.

In Finland, different types of in-service courses are organised by in-service training centres of universities,
teachers’ unions, different non-governmental organizations, etc. (see e.g., Dillon & Aineslahti, 2007). Examples
of the structure of implemented in-service courses can be found in the report by Ahtee and Pehkonen (1997)
and some analysis in the book chapter by Ahtee, Lavonen, Parviainen, & Pehkonen, (2007). These courses are
often organised as distance education or multiform training. The web site, www.taydennyskoulutus.fi, includes
information about the extension studies provided by the Finnish universities. The English version of this service
includes basic information about continuing education in the Finnish universities as well as information about
courses held in English. The organizers of CPD courses have basically much more freedom than those in England
or Bulgaria, but the problem is how to get proper funding and how to attract those teachers who are in need of
brush-up of their skills and knowledge.

In Bulgaria, CPD is primarily directed to acquiring one of the five degrees specified in the ordinance of the
Ministry of Science and Education. Participation in the courses organized by universities and other institutions
satisfies the individual needs of teachers to enrich their competency in a given direction. This type of education
also exists in the form of web-based courses, as well as distance learning. However, the above-mentioned two
forms of education are new to Bulgarian teachers and are currently solely organized by educational projects. The
lowest professional degree – fifth, can be acquired by people who:

1. At the moment of the candidature, have at least four consecutive years of pedagogical experience;
2. Have a minimum grade of 4.50 or more on an oral, outlined exam.

The fourth professional degree can be acquired by people who:

1. Have already acquired the fifth professional degree;
2. Have a minimum grade of 4.50 or more on an exam, containing questions from the specific
professional area of the candidate.

The third professional degree can be acquired by people who:
1. Have already acquired the fourth professional degree;
2. After acquiring the fourth professional degree, graduate from a one-year professional pedagogical specialization with an average grade of 4.50 or more.

The second professional degree can be acquired by people who:
1. Have already acquired the third professional degree;
2. After acquiring the third professional degree, have a minimum grade of 4.50 or more on a written project, based on an analysis of the results by the candidate diagnostic procedure. Through the written project candidates should express their skills in applying diagnostic procedures in their professional activity, with respect to making optimal pedagogical decisions.

Candidates present their written project consisting of at least 30 standard, typewritten pages with the following exemplary structure:
- Reasons for the choice of topic; goal and tasks of the diagnostics;
- Subject and objective of diagnostics; grading characteristics and features of the analyzed event;
- Central diagnostic method; focus, tools, grading manner; additional diagnostic methods (should they be needed);
- Description of the diagnostic procedure;
- Presentation of results: statistical processing of quantitative results; analysis and interpretation of results;
- Summary and conclusions; bibliography.

The highest first professional degree can be acquired by people who:
1. Have already acquired the second professional degree;
2. Successfully defend a related to the pedagogical practice of the candidate written project, characterized by an exploratory and innovative nature, and consisting of at least 60 standard, typewritten pages, which shall serve as an expression of the candidate’s skills for creative interpretation of professional problems and innovative thinking.
3. Present publications of professional, pedagogical problems, related to the subject of the project, defined under p.2.

Candidates present a written project with a topic of a research and innovative character and the following exemplary structure:
- Theoretical setup of the topic;
- Outline of the goal and tasks of the research, hypothesis; definition of the subject and objectives of the research, grading characteristics of the researched events;
- Description of the methodology of research; description of each stage of the experiment;
- Systematically order and processing of empirical data; analysis of results with reference to the conceptual, theoretical part and the hypothesis;
- Summary and conclusions; bibliography on the topic.

From this detailed description of the requirements and stages of the process of acquiring a professional degree it can be seen that the enactment and the presentation of an active research is a necessary condition for the acquirement of the two highest degrees of qualification for teachers in Bulgaria.

**Which institutions provide CPD?**

Professional in-service degrees in Bulgaria are given by three institutes which are the only legal sources of the documents of acquired degree of CPD. Specialized courses and other forms of qualification are also offered by universities and other institutions. An example of such a course is the established under the web-based project module for science teachers. The participation in such forms of qualification is attested for by a certificate and it
is important for the development of professional competency of teachers, as well as for determining the number of points for an additional differentiated payment.

There is no similar degree system in Finland. Many teachers participate in this training voluntarily with little support from their schools. Finnish teachers have generally quite positive attitude to professional development (Purhonen & Parviainen, 1996), but their in-service training has not had adequate resources and has been rather weakly organized. An effort was made to change the very non-coherent in-service teacher training to a more systematic one already in the context of the major reform of school curricula and teacher education in the seventies and eighties. In the transition period, the weak implementation of the obligatory in-service training increased resistance towards the training. Therefore, e.g., in-service training days of pedagogical organisations of teachers were accepted as an adequate form of training. Finnish Association of Teachers of Mathematics, Physics and Chemistry has annually organised in-service days for science teachers. The local training days have also been allowed to be substituted with long-term university in-service courses. For example, the national LUMA programme was launched in 1996 in order to develop the teaching and learning of mathematics and the natural sciences (Lavonen, Meisalo, & Juuti, 2004). In this context, financing for new school laboratory equipment, pedagogical study materials for teachers, and long-term in-service training programmes were also made available to teachers. An example of a much smaller CPD project is the Virtual School for Physics and Chemistry Teachers described by Lavonen, Juuti, Aksela, & Meisalo (2006).

Another type of in-service training is intended for helping unqualified teachers to possibility to gain a formal qualification. According to PISA 2006 School Questionnaire data, 97% of Finnish schools reported that there was no serious lack of physics, chemistry, or biology teachers (OECD 82%). On average, 10% of full-time teachers in the participating schools did not have an appropriate qualification. However, there is a need especially when qualification standards are upgraded, to offer a possibility for teachers to study further for reaching the new standards and an example of such an approach was the DFCL course organized by Department of Physics, University of Helsinki by the end of the nineties (see http://didactical.physics.helsinki.fi/dfcl/vanhat/english/summary.htm).

Finally, it is to be noted that the further education of teachers towards higher academic degrees is included in the concept of CPD although in Finland the focus is usually on in-service education. Since qualified Finnish teachers have an academic Master level basic education they have also easy access to postgraduate training. These efforts have been facilitated by doctoral schools focusing on further education of teachers (see above and Lavonen & Strömahl, 2009). There has also been important co-operation between doctoral schools in other European countries, especially with Sweden, but also with Germany, Estonia and other Baltic countries, etc. Having in mind the current conditions in Bulgaria, most of working sciences teachers and primary school teachers have a Master’s degree qualification and have opportunities to participate in all forms of CPD.

**Summary and Discussion**

In this chapter some fundamental trends in CPD in the three EuSTD-web countries have been described. The essence, organization and funding of in-service teacher training in each country have been analysed. In England the focus has been on different standards guiding CPD, while in principle there is much freedom in choosing the form of studies. In Bulgaria CPD is primarily directed to acquiring one of degrees specified by the Ministry of Science and Education and is currently project-based. In Finland there has been much emphasis on research-based teacher education, but the role of researchers in CPD has not been systematically organized. Each of these countries has distinct national features in the organization of CPD for teachers. Each country has certain weaknesses but also strengths. However, there seems to be little development towards European homogeneity.
We believe that high-quality professional development should reflect the best available research and practice in teaching and enable teachers to develop further expertise in subject content, teaching strategies, uses of ICT, and it has to be planned collaboratively by teachers and those who will facilitate that development. These activates should include self-initiated projects, self-assessments, and portfolio assessment. In-service teachers are learners who actively construct their own understanding about teaching and learning preferably in the context of professional learning communities. This is achieved through building on their personal teaching experience and determined by their attitudes and beliefs. Action research and full utilization of ICT including web-based education are important parts of this process. Co-operation of educational authorities of all levels, researchers, teachers’ unions, etc. is also essential.
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Наредба No 5 за условията за повишаване квалификацията на педагогическите кадри в системата на народната просвета и реда за придобиване на професионално-квалификационни степени. Обнародвана, дв. бр. 6 от 1997 г., попр., бр. 8 от 1997 г., доп., бр. 73 от 1997 г., изм. И доп., бр. 101 от 1999 г. Available at:

Правила за реда и начина за провеждане на процедурите за придобиване на професионално-квалификационните степени съгласно наредба No 5 на МОН от 29.12.1996 г. Available at:
Section 3

Edited by
Jan Lesz, Malcolm Smith and Krzysztof Wawrzyniak
THE STRUCTURE AND OPERATION OF EUSTD - WEB

Jack Holbrook and Jan Lesz

Key words:
Lifelong learning, online learning, Continuing Professional Development, Virtual Learning Environment.

Introduction

The use of a virtual learning environment (VLE) has been developed to provide a pan-European platform to deliver materials for the professional development of science teachers working in the 7-14 age range. Within this sits a progressive structure consisting of three levels (I, II, III) see Figure 1.

This structure provides a hierarchy which leads practicing teachers through the process. Level I provides a ‘gateway’ to the system through the use of audits (needs analysis) and taster courses designed to identify the professional needs of these teachers. This gateway is crucial in that it can also raise awareness of opportunities for professional development that the teacher may be unaware of but may, nevertheless, identify a crucial area of training that he or she needs to improve their classroom practice.

Having moved through the Gateway at Level I the teacher is presented with modules at level II. These focus on areas identified by the needs analysis and provide an in-depth training programme designed to meet the objectives outlined for each developmental area. Following completion of Level II the teachers can progress to level III. These Level III modules are based around practitioner based action research but with a pan European dimension designed to improve the teachers’ wider understanding of education within the European Community.

In some cases teachers could progress through to Level III without completing any Level II modules. This would depend on the experience and circumstances of the individual and following consultation with the partner offering the training.
The learning modules

The modules are designed to follow a mainly constructivist paradigm, however other theoretical approaches are utilised as appropriate. The importance of interaction of the learners is recognised and designed into the modules. The learning materials are contextual and based around the experiences and background of the teachers. The sharing of good practice is an important aspect of the course design especially at level II. The operation of the three levels is described in detail in the following chapters illustrated with exemplar material from the trialling process.

Level I: The ‘Gateway’ Module

The need to establish a mechanism to determine whether EuSTD-web modules were appropriate for teachers was recognised in an earlier project (SySTEM 94343 CP_1_2001-1-PT-COMENIUS-C21/09). The mechanism developed for this was the creation of a ‘Gateway’ module, taken by participants (i.e. teachers undertaking the modules) before embarking on any modules at Level II. The ‘Gateway’ was designed to examine the initial expectations of participants, to ascertain the suitability of the module for the participant and to determine the interest of participants in following any particular module, or set of modules. The Gateway module concept is located within the EuSTD-website (http://cms.ua.pt/eustd-web) and, as described below, sets out to provide further information on the purpose of each individual module. It also guides the potential participant through administrative aspects associated with setting up their EuSTD-web account. If required it will provide advice to potential participants in choosing suitable modules, based on their past professional experiences and educational awareness.

The Gateway module concept within EuSTD-web, and examples of how it operates, are described below. The Gateway module includes:

- Informational Components
- Administrative and Advisory Components

The design of the Gateway module is illustrated in figure 2.
The Gateway module is located on the EuSTD-Website. It is designed to be attractive to visitors to the website and to illustrate the purpose of EuSTD-web (short description of EuSTD-Web in figure 2) in providing professional in-service teacher support through web-based tuition modules.

The Gateway also provides a list of module titles offered. At present this is a simple list, but as the number of module titles increases (as indicated in figure 2 by the comment “complete or short list” placed in brackets). The information component is designed to include a search engine enabling the creation of short lists of modules based on the visitor’s preferences, e.g. using key-words.

By ticking on a title in the list, a new window is opened, which provides additional information on the corresponding module. This function is indicated in figure 2 under “short description of module.” An example of a short description module window is shown below:
Welcome to EuSTD-web!

- Thank you for being interested about participating in this module. It is designed especially for those teachers who are supporters of constructivism in education and student centred teaching, regardless of their current understanding of these terms. The module is designed to build understanding of these terms.
- We invite you to travel into the land of student’s ideas about the world, actively explore your student’s world views and investigate possibilities for using this knowledge in designing science teaching.

**Overall aims:**
- To discuss the practice of educational theories, for example by Vygotsky, Bernstein and Rosch,
- To enhance skills in interpreting students’ statements,
- To acquaint oneself with mechanisms in using information about a student’s world image in constructing a personal educational system.

**The course includes 4 training parts (sessions) and one summing-up part:**
1. introductory Test,
2. Reading A,
3. Reading B,
4. Teachers’ research
and
5. Summary of the work and evaluation.

The individual parts are presented as a sequence. This means, that before you can start your own research, a crucial part of the course, you are asked to work with texts, which introduce terminology and methods expected to be useful in your research.

In part (5) you are starting to implement the results of your research in your teaching.

**Duration:** expected to be about 4 months.

**Title:** Pupil’s World image and science education

With the module selected (one short description module window open), the visitor may proceed from the Gateway’s Information Components to the Advisory and Administrative Components, see lower part of figure 2. This occurs automatically after clicking the "save module choice“ button. (Not shown in figure 2).

A registration questionnaire appears on the screen which the visitor can complete (see below).
1. First name:
2. Surname:
3. E-mail:
4. Gender (1 female, 2 male).
   Select gender: 1 2
5. Age (1=<20, 2=21-30, 3=31-40, 4=41-50, 5=>50)
   Select age indicator: 1 2 3 4 5
6. Computer experience. How often do you normally use a computer? (1 never, 2 seldom, 3 average once a week, 4 average once a day)
   Select experience: 1 2 3 4
7. Internet availability. Do you have an Internet connected computer at home? (1 no, 2 yes)
   Select the appropriate response: 1 2
8. Internet experience. How often do you normally use the Internet? (1 never, 2 seldom, 3 on average once a week, 4 on average daily)
   Select experience: 1 2 3 4
9. Familiarity with computer supported distant education. Have you participated in computer supported distant education? (1 never, 2 one time, 3 two or three times, 4 a number of times)
   Select familiarity: 1 2 3 4
10. Teacher experience. For how long have you been a teacher? (1 Less than one year, 2 Between one and five years, 3 Between 6 and 10 years, 4 More than 10 years)

After successful registration the following will occur:

(a) an account for the participant is created,
(b) the participant’s module choice is saved, and
(c) an advisory questionnaire appears on the screen related to the selected module.

The advisory questionnaire

The questionnaire items are designed to provide guidance to the participant and tutor as to whether the module selected is suitable for study. The participant is invited to answer each of the items, or leave blank where the response required is not sufficiently clear, or where the participant chooses not to answer. When the questionnaire is completed and the submit button clicked (not shown in figure 2), the completed questionnaire is automatically saved and then added to the participant’s files made available to the tutor.

If the evaluation of the completed questionnaire is considered “insufficient”, or “inappropriate”, additional guidance will be offered to the participant. It should be noted that the form of the advisory questionnaire will vary according to the requirements of the module chosen. Some examples are shown below:

Example 1 – first 4 questions out of 10 shown related to the module “Understanding Science”

For each of the statements given below, indicate on the right whether you strongly agree, agree, disagree or strongly disagree by placing a "x" in the appropriate box.
Example 2 - First four questions out of 10
Related to the module "Cognitive Motivation in Science Education"

1. How would you improve the interest of your students in science?
   A. more information
   B. more tasks
   C. interesting experiments done by teacher
   D. interesting experiments done by students
Circle the number that appears under your selected answer.

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2. Which teaching activities do you prefer?
   A. examination
   B. repetition
   C. explanation
   D. motivation
Circle the number that appears under your selected answer.

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3. From the list below, underline the terms you are familiar with, understand, and are able to use in your work:
   Simple experiments, motivation, interest, problem tasks.
Circle the number of underlined terms:

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4. What do you know about motivating students?
   A. nothing
   B. a little
   C. only basic information
   D. I understand what motivating is
Circle the number that appears under your selected answer.

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An overall description of the advisory questionnaire

These questionnaires are designed so that the participant can complete and submit these via the internet. If the participant’s responses generate an ambiguous outcome an interview is offered (face to face or through other suitable means) in which the participant and the tutor discuss the responses and the tutor puts forward advice as to further action to be recommended. After successfully completing this advisory component the participant submits the appropriate fee and is enrolled in EuSTD-web for the selected module (see figure 1 – the correspondence involved is not shown).

Summary

The gateway module is made up of a collection of administrative and introductory or advisory components, which the participants complete. It is expected that in most cases the participant will proceed and register with the EuSTD-web to continue on the programme. However, in some cases further guidance may be necessary and will be provided as appropriate.
3.2

THE STRUCTURE AND OPERATION OF LEVEL II

Mateusz Leszkowicz and Krzysztof Wawrzyniak

How you start level II

All modules from level II are preceded by the Level I undertaken by a participant as described in the previous chapter. On completing Level I the participant is presented with level II modules. The suitability of each level II module for an individual teacher is identified on the basis of the Level I activities. Each level II module has an appropriate advisory questionnaire. Completing these questionnaires provides a needs analysis that enables the appropriate selection of level II modules i.e. areas identified as possible in-service provision needs.

Operating Level II

Level II modules are designed around the constructivist paradigm and ensure that participants interact with each other as well as the learning environment. This interaction is crucial not only to fulfil the learning objectives of the module but also to broaden knowledge and learn from other people’s experiences.

The significance and importance of critical self reflection during work on the module should not be underestimated. The foregoing requires that tutors supporting the participants play a crucial role and this will be discussed later in this chapter.

There is no limit of the number of modules to be taken by a single participant though tutors may suggest, after analysing the Gateway activities, which modules best meet their needs. Furthermore, some modules may be recommended by tutors as pre-requisites for other modules, because of their complementary nature. It is also possible that, under certain circumstances, participants could skip level II and progress straight to modules at level III.

Level II within the system

Level II modules are the professional development modules that provide the main in-service support provision for teachers within the project. There are ten modules at this level, each providing an in-depth training programme. These modules cover areas such as:

- Pedagogy (teaching skills related to classroom practice),
- Pedagogical content knowledge (developing effective teaching strategies for specific subject areas) (Grossman et al., 1989),
- Philosophical aspects (why educate through science?) what educational theories are applicable to the teaching of science subjects?)
- Enhancement of subject knowledge (Surgue, Day, 2002).

Each module is complementary to each other. The titles of every level II module together with their learning objectives are shown below.
Module 1 - Teaching Science through Environmental Education (A cross-curricular approach to the concept of water)

Learning Objectives:
- further develop their scientific knowledge (concepts, culture and use) in environmental issues;
- evaluate different teaching-methods in science and environmental education and use this information to inform their own practice;
- create a set of lessons based on authentic conflicts of interests in man's use of natural resources.

Module 2 - Cognitive Motivation in Science Education (A set of cognitive motivational teaching techniques)

Learning Objectives:
- obtain key theoretical and practical knowledge and understanding of cognitive motivational teaching techniques in science education;
- guidance in the educational skill how to activate students in science education by cognitive motivation;
- gain an ability to evaluate the cognitive motivational process (both the evaluation of students and self-evaluation) in science education.

Module 3 - An Introduction to the Assessment of Children's Learning in Primary Science

Learning Objectives:
- gain an overview of assessment processes and practices;
- develop practitioner knowledge of the purpose of diagnostic and formative methods of assessment;
- recognise the interrelationship between planning, assessment and curriculum evaluation;
- develop expertise in planning for assessment;
- begin to understand how assessment evidence is gathered, recorded and applied;
- implement formative and diagnostic assessment strategies;
- reviewing and evaluating participant's own practice in assessing children.

Module 4 - The Nature of Science and Science Education

Learning Objectives:
- understanding the nature of science
- appreciate differences between scientific theories and laws
- appreciate differences between science and science education (or the goals of teaching of science in schools);
- determine the purpose of science education and hence targets teacher should have in mind.

Module 5 - Global Science – an integrated approach

Learning Objectives:
- understanding the phenomena of the natural world from main principles, crossing core contents of different areas of science;
- recognizing the planet Earth as a structured system of sub-systems, deeply interactive in equilibrium in which mankind has strong responsibilities;
- recognizing science programs as a way to improve self-reflection, co-operation and solidarity;
- improving scientific literacy towards the achievement of a developing attitudes and values, as far as the utilisation of science and technology in a social context is concerned.

Module 6 - Pupils’ World Image and Science Teaching

Learning Objectives:
- making scientific theories practicable;
- improving abilities of analyzing pupil's statements;
- learning mechanism of using information about pupil's world image in construction of own didactical system.
Module 7 - Teaching and Learning in Science

Learning Objectives:
- helps a teacher to become familiar in how different teaching methods;
- help students to reach the learning objectives of science;
- become familiar of how cognitive, practical, and problem solving skills are learned in science studies.

Module 8 - Active Teaching Strategies

Learning Objectives:
- know how to create effective learning environment;
- critically evaluate a diverse range of active teaching strategies;
- recognize the importance of matching learning objectives with appropriate teaching strategies;
- recognize the value of active learning in accelerating pupils cognitive development;
- identify the value of active teaching strategies as a mean of developing children’s communication and social skills;
- plan, organize and deliver an active learning project.

Module 9 - Action Research Module

Learning Objectives:
- explain key features of action research and state its usefulness to teachers;
- identify ways to carry out action research in the classroom;
- carry out action research using an observation schedule, questionnaire, through conducting an interview, a case study, or administering/marking a test;
- disseminate outcomes of action research to others by means of a report.

Module 10 - Educational Design

Learning Objectives:
- teaching participants to design lessons and courses, further studies on this area and organizing self professional development of those competencies;
- teaching participants to be effective consultants on the field of teaching science and planning educational change;
- preparing participants for further studies on this area and organizing self professional development on the field;

How level II is structured

Each module within level II of the project has been designed to have a consistent ‘look and feel’ to provide continuity between modules. Every module has a similar arrangement to the one shown in figure 2. All the modules start with the module title followed by a brief overview. The introduction to the module includes background information and reading as well as information about the authors. The ‘Netiquette quick guide’ comprises some general communication and cooperation rules concerning proper behaviour in a web-based environment, while the ‘Socialise & Ice-Breaking forum’ is devoted to getting to know each other before starting the module work. The ‘Module News and Announcements Forum’ is where information about the course will be posted as the participants work through the module.
Participants will study examples of different types of evidence (such as children's work i.e., writing, drawings, reports from experiments and test results) with the main focus on matching assessment evidence with assessment purpose. Questioning, discussing, observing, drawing, writing, concept mapping, testing (both formative and summative) will be explored. Assessment strategies in whole class teaching will be examined. Assessment of knowledge and skills will be compared to assessment of scientific process skills. How the data/information generated can be used to inform assessment will be identified. Differences between formative and summative assessment will be developed. Emphasis on how assessment information can be used in both the short-term and medium-term. Helping children to assess their own work will be explored.

Learning Objectives

- To gain an overview of assessment processes and practices;
- Develop practitioner knowledge of the purpose of diagnostic and formative methods of assessment;
- Recognise the interrelationship between planning, assessment and curriculum evaluation;
- Develop expertise in planning for assessment;
- Begin to understand how assessment evidence is gathered, recorded and applied;
- Implement formative and diagnostic assessment strategies;
- Reviewing and evaluating participants own practice in assessing children.

KEYWORDS:

Assessment, formative, summative, evidence, recording, reporting, planning.

Introduction to the module

- Introduction
- Session Breakdown/Learning Programme

Netiquette

- Netiquette - a quick guide

Icebreaking Activity...

- News and announcements
- Icebreaking Forum - Getting to know one another!

1 Session 1 - An introduction to assessment

Each module consists of a number of sessions with each following a common layout similar to the one shown below (figure 2). As can be seen it follows directly from the section shown above.
There is also a common layout for each session in the module. Within each session are three distinctive phases. The first, the introduction, is a single page and gives an overall plan of the session including the learning objectives (Fig 3). The circles are clickable links that take the learner to different aspects of the session.

The second, the developmental phase, is where the resources and support materials are provided to meet the learning objectives. In this phase a number of pages are linked using hyperlinks to build a learning space. As
students work through this phase they complete a number of tasks. These tasks present meaningful contexts and materials together with guiding information that support the learner as they move through the task. At all times active participation of the students is encouraged both by the design of the learning and support materials and the role the tutor plays; the development of reflective practice (Schön, 1983) is integral in both the philosophy and design of the course. The use of discussions is a key element in providing the constructivist learning environment outlined earlier. It relies heavily on the tutor supporting and facilitating this process. The role of the tutor will be covered in more detail later. Fig 4 shows a screen shot of the first task entitled 'What is Assessment?'

The final phase is a single page providing students with the learning outcomes of the session and the information they need to provide as part of their assessment (Fig 5). It may also provide links to further reading. Participants are encouraged to ensure that all the work is completed before moving on to the next session within the module.
Role of tutor/instructor

The role of the tutor in Level II modules is seen as three fold. Firstly, a tutor provides direct instruction – tasks to be completed in a specific manner and generally supporting the participant through this process. See below for a typical example from the pilot:

Regarding your questions:

1 - has to select a sample of material for evaluation (in electronic form to be submitted for discussion group)

2 - yes, this is individual, but must then discuss the elements of the group

3 - that the poster was removed. See where the "warnings" which aims for each session.

I hope I have helped,

Secondly, tasks within level II modules encourage participants to enquire, reflect and look for non typical solutions for typical problems and situations. This follows constructivist ideas and aims at developing participants’ independent thinking developing greater internalisation and deeper understanding. The tutor’s role in this area is crucial. They need to guide and support discussions and contributions by the participants rather
than control and lead. The participants have much to bring to this area in terms of their skills and experience. It is important that tutors on the course encourage participants to share these with others as they journey through the tasks. The aim of this type of approach is to encourage autonomy on the part of the participants so they take charge of their learning and development (Fosnot, 1996). Please see the example below.

(Tutor to group)
Has anybody else used this method to identify misconceptions? Did it work?
What other methods have you found helpful?

Thirdly, project modules and tutors themselves are open to a diversified socio-cultural context encouraged by the European dimension of the project. Cultural differences and experiences can lead to a reconstruction of beliefs and new ways of thinking and acting (Brown, Duguid, 2000, p.138). Tutors need to handle this area with care and without prejudice.

(Tutor responding to an individual post on a group forum about the use of formative assessment)

This is an interesting observation. What do others think about these ideas related your schools and the structure of your education system?

After completing a level II module, the participant may decide to study another level II module to develop different aspects of their teaching. Alternatively they may move on to Level III which is discussed in the next chapter.

References


3.3

THE STRUCTURE AND OPERATION OF LEVEL III

Luis Marques, Lucia Pombo, Josef Trna and Eva Trnova

Introduction

This chapter is concerned with the operational aspects of Level III. A broader view about the nature and development of Level III will be presented in Section 4.

The following five areas will be discussed:

1. What Level III is,
2. Why would a project be selected?
3. How it could be developed,
4. How long it may take
5. The role the tutor plays in the process.

What Level III is

As previously discussed, Project EuSTD-web system has three levels, and is a professional training programme in the area of science education. Level III is conducted by teachers in their own classrooms, using an action-research methodology working with other teachers in a pan-European dimension. This is designed to facilitate skilled teachers from different participant countries working together within an action-research methodology context. Working in a pan-European dimension is a major characteristic at Level III. The design of the selected projects will facilitate skilled teachers, from different countries, working together.

The authors stress that one of the assumptions of Level III is to develop competences which are:

- related to science processes (recognising scientifically investigable questions, identifying evidence needed in a scientific investigation, drawing conclusions, communicating valid conclusions, ...)
- concerned with cross curricular issues (autonomous learning, cooperation or ability to solve problems,...)
- linked to enhance wider cooperation between European science teachers and trainers, utilising electronic communication science education trainers/facilitators and classroom action research related to the web-based modules.

Why would a project be selected?

The authors assume that several key areas such as developing the teacher’s investigative skills and self reflection can be identified to support the submitted project. Another important aspect would be the attempt to bridge the gap between science educational research and science school practices. More educational research needs to be focused on the classroom that then informs practical knowledge and improves the quality of teaching. It is claimed that the effectiveness of teaching in schools would be substantially improved if it was a research-based profession, assuming the relevance of a cross cultural dimension, especially within a constructivist framework. This is a key aspect of work at Level III.
At Level III, the project facilitates skilled teachers from different participant countries working together on action-research projects. The overall aims are to enhance wider cooperation between European science teachers and trainers using electronic communication for improving science teaching.

**How it could be developed**

An in depth discussion between participants about the nature, aims and the respective implementation of Level III will take place. The potential of Level III consisting of action-research projects, linked to Level II, will be progressively defined. One possibility is that the research project could be carried out in the context of a master thesis.

A trans-national group is formed. For the pilot, Biology teachers from the Czech Republic and Portugal worked together. This group was responsible for submitting a project proposal for Level III and, for the corresponding application within the classroom and subsequent assessment. The Biology teacher of the Secondary School of Viseu, Portugal, and the Biology teacher of the Secondary School of Gymnasium Boskovice (Czech Republic) designed and completed the programme with their pupils.

The project was developed mainly within a web context. However, several face to face sessions took place as recommended by Collis and Moonen (2001).

The supervision of school practices in science teaching has been completed in those different contexts, as an online partnership study.

The main aims of the pilot project were:

(i) to analyse the influence of sharing knowledge and experiences in the process of personal and professional development of teachers involved in the project;

(ii) to encourage the development of a partnership among peers with diverse experiences, both national and trans-national;

(iii) to recognize the importance of ICT in the process of shared experiences of teaching and learning.

(iv) to develop a cross cultural experience with students, within an European framework, towards the achievement of a more holistic perspective of the curricular activities.

The research project was developed using the action research cycle as shown in Fig. 1.

*Fig 1 – A diagram showing the development of the process, the action-research cycle.*
The information was gathered by: (i) observation, (ii) interaction and dialogue between the teachers, (iii) administration of a questionnaire to collect students’ opinions, and finally (iv) by a development of a portfolio.

**How long it may take**

This will depend on a number of issues and because of this it is impossible to quantify an exact time. Following the pilots the group suggests that an allotted time of less than one year would be unrealistic. The rationale for requiring a period of time of more than one year is related to the implementation and evaluation of the Level as a whole, involving exchange of experiences, recruitment of teachers from two countries and discussions between them. Another important issue that emerged was the need for participating teachers to discuss and share their views related to their cultural and educational backgrounds which took time to develop.

At Level III, the pilot involved teachers, on average, for 60 hrs. Discussions between teachers from the two participant countries extended over a period of months where classroom data collection and analysis was involved.

The work took place from April 2007 to September 2009. Initial internet based communications (via Skype and email) took place, followed by the first face to face meeting between the teachers at the University of Aveiro in September 2008. In this face to face session a better understanding developed between the two teachers involved in the project with the sharing of experience and materials developed by the teachers in their respective educational systems. Some important decisions were made such as a clearer definition of activities to be undertaken and associated timings. A questionnaire was developed to be implemented between March and May 2009 to ascertain the effectiveness of the activities within the classroom. The responses from the questionnaire are then be analysed and conclusions drawn. As can be seen the pilot project took place over some eighteen months. Other projects could take longer but we would advise against projects lasting more than two years.

**Role of the tutor**

The theoretical framework of this project intends supervision and reflexive training of teachers as reflection in, about and for the action (Schön 1995; Alarcão 2005; Sá-Chaves 2007). The experience of Level III was carried out in the context of a scenario of “peer supervision” (Sá-Chaves 2007). Baker e McNicoll (2006: 28) stress that

> ‘peer mentoring draws on the notion that collectively within a group of peers there is a pool of skills, experience and resources that can be used to support educators as they review their work experiences in order to develop their professional skills and competencies – “no one knows as much as all of us’.

In this context, there is a teacher who is aware of the importance of lifelong learning, so she has decided to try to understand the importance that a “crossed look” (Sá-Chaves, 2007) can have on her practice. Furthermore, how that “crossed look” can help to guide her professional actions, where no one has to have a “top position”.

Being aware that “two eyes are more enriching than an only one” (Sá-Chaves, 2007,p.38), the "look" of B act as a powerful tool for initiating the process of reflection on the knowledge of A, as well as the specific content that A teach. A collaborative dimension plays here a relevant role

> “a collaborative and reciprocal process whereby one peer observes another’s teaching and provides supportive and constructive feedback. Its underlying rationale is to encourage (continued) professional development in teaching and learning through critical reflection, by both observers [...]” (Lublin in Prodait, 2006: 1)
According to Mintzberg (1995) supervision entails a vision of quality, intelligence responsibility, freedom, experience, warmth and sympathy, conducted in peaceful surroundings. This supervision is associated with support and regulation, e.g., it is a process that prepares participants to:

- act in complex situations;
- critically observe;
- question;
- communicate;
- experiment with different roles
- manage plural and complex relationships
- further develop self-knowledge and practice.

Supervision is regarded as the process that allows a deep look at the practice of each one, turning into self-supervision (Alarcão, 2005:177). In peer-supervision both teachers should include:

- Feedback (essential to support and for regulation).
- Feedback on the methodological suggestions, the written notes, some reflections, etc.
- Questioning and request for clarification, critical questioning or stimulator questioning;
- Support / encouragement;
- Recommendation;
- Summary / balance;
- Conceptual and theoretical clarification; ...

Using the words of Alarcão & Tavares (2003:59) as far as the supervision process is concerned, in this Project it is intended that this could include "activities of mutual collaboration and help" between the involved teachers encouraging a

"spirit of dialogue that passes for a good relationship based on trust, respect, commitment and enthusiasm, in cordial friendship, empathy between colleagues who, despite the difference in educational systems, seek to achieve the same objectives."

Synthesising, one can say that the role of the teacher is developed within a triangle whose vertices are reflection, collaboration and investigation.
References


Section 4

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4.1

EXAMPLES OF EUSTD-WEB

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Key words:

*PCK, CPD, E-modules, web-based, knowledge-society, European teacher, e-portfolio*

European Science Teachers’ Professional Development for functioning in a web-based environment (EUSTD) is a training programme in the field of science education and is designed for practicing science teachers to upgrade their skills and competences, such that their Pedagogical Content Knowledge (PCK) becomes expanded and deepened. Through experience the project team identified two main barriers (amongst several others) to the promotion and application of novel and innovative technology in the teaching and learning of science. These were:

- Efficient transfer and dissemination of accessible information to practising science teachers.
- The motivation of science teachers to learn and use pioneering educational technology in their practice.

EuSTD is designed to alleviate these barriers, and also to increase the familiarity of using ICT collaboratively with other teachers and trainers across Europe. We anticipate the improvement of the quality of science teaching and learning through enhanced PCK, taking into account the challenges defined by the European education policy and the guidelines emerging from science education research.

Often science education within In-Service CPD can be characterised by not being adequately systematic or of a sufficiently high enough quality. During the course of a teacher’s professional path, which may last 40 years, many new pedagogical developments occur as indeed do innovative educational technologies emerge which are often the products of educational research. However practising science teachers may limit their PCK through both not recognising and/or applying them. Furthermore their often isolated nature (primary school teachers with responsibility for science operate without the benefit of others to share their ideas and practice) limits opportunities for collaboration and exchange with like-minded colleagues. Consequently improvement in teaching and learning provision may be hindered not necessarily because the teacher is not open to change; a problem exacerbated by geographical isolation.

High quality in-service teacher training for practicing science teachers is vital, and it is here that EuSTD has a role to play. Its methodology aims to increase opportunities for shared experiences amongst and between teachers and, in addition, provide a forum for the dissemination of good practice based on research findings. It is also envisaged that those teachers involved in this initiative will more easily access CPD opportunities particularly for those with difficulties related to the geographical distance between teacher and trainers, both within and between countries. The involvement of, and trans-national collaboration between teacher training universities, science teacher associations and both teachers and schools also serve to enhance practitioner development. Professional learning should be:-
systematic, in that we see it as an interplay between individuals and their environments. This casts professional development as the development of capabilities that occurs as a consequence of situated social practices. There is still a place for event-based educational professional development, but it complements, rather than displaces, situated social learning (Knight et al. 2006, p.320).

Professional development for science teachers can have a range of aims that can address a variety of needs, from nationally identified educational priorities to the particular needs of schools or individual teachers.

In several countries, the design of In-Service education programmes has become completely decentralised and is the responsibility of schools. As a consequence, schools and local education authorities offer training based on the skills and development needs of teachers and schools (Eurydice, 2006, p.52).

The focus on a pan-European context presents additional challenges with respect to designing a ‘one model fits all’ professional development perspective. Earlier in this book the similarities and difference between the participating countries in their design and organisation of science curricula was discussed. Developing an awareness of this diversity in science provision is important for all teachers not just those involved with EuSTD, however this particular group has been actively encouraged to take such a comparative perspective in relation to their own practice. This is particularly significant when one considers the concept of ‘the European teacher’.

EuSTD provides opportunities for science teachers to reflect evaluate and appraise, with guidance, their practice. An important additional dimension of this project is the promotion and engagement in research which is primarily of a trans-national collaborative nature. This is seen as an important step towards a pan-European dimension for the professional development of science teachers and the improvement of science education generally. The development of this project at a European level, that incorporates the best science-related pedagogical characteristics of each country involved, has resulted in a more effective means of addressing some of the current challenges identified by contemporary educational research.

This chapter now moves on to describe and explore the conceptual overview in relation to those examples of curriculum materials used in Level II. This is followed by an elaboration of the distinctive nature of Level III. Concrete examples of those experiences carried out between various project partners are presented in accordance with criteria that will be revealed and explained.

**Articulation of level II and III**

EuSTD is organised in the form of a set of web-based curricular materials (LII and LIII modules) designed to support the professional development of practising science teachers. The core idea is based on the concept of three interconnected levels:

- **Level I:** An overview of the professional development opportunities is initially provided which is then followed by the identification of a teacher’s professional requirements through a ‘needs-analysis’ approach.
- **Level II:** Consists of a menu of individual training modules (E-modules) whose identity has been shaped by the knowledge and understanding of what constitutes high quality science education praxis (these modules reflect the complementary strengths of each European partner).
• Level III: Takes the form of a trans-national collaborative professionally relevant investigative project, conducted by teachers in their own classrooms. Using an action-research methodology and with a focus likely to be determined from one of the LII modules, the teacher will work with at least one colleague outside their national boundary.

Further details of the above can be found in section three of this book.

Involvement of a teacher within EuSTD is dependent on their professional background, and their interest, which determines the number of E-modules undertaken at LII. An experienced and highly proficient practitioner, as evaluated by the LI ‘needs-analysis’ instrument is able to proceed directly to level III.

The philosophy of level II and level III within the context of a European dimension is based on the following rationale. The beginning of the 21st century witnesses an enlarging European Union while at the same time there has never been in modern times a greater need for a scientifically literate society which is crucial for supporting political, economical and social challenges to European citizens’ needs and expectations. Significant and challenging issues such as employment, security, peace and, with growing importance, the sustainable development of the Earth are of concern across Europe. In a ‘knowledge society’ education in general but science education in particular, will be a cornerstone that supports any future response to such critical challenges. Science teachers, and there is a powerful argument for both more teachers and science teaching, will play an vital role in providing future generations of Europeans with relevant education.

A broad range of skills is expected for teachers if they to perform such a function and these aspects were critical is shaping the conceptualization, implementation and assessment of the experience concerned with these two levels. The prerequisite skill set consists of:

• Secure knowledge of the subject area.
• Ability to organise student learning opportunities.
• Effective management of students’ learning progression.
• Ability to deal with student heterogeneity.
• The development of students’ commitment and organisational skills.
• The promotion of parental and community commitment to school.
• The use of new technologies in their daily practice.
• Performance of professional duties.
• Management of their own professional development (Perrenoud, 1999).

The qualitative difference in teacher professional development between level II and level III will be developed below. At level II the E--modules are of an independent but interlinked and related nature that address a range of dimensions of science education that include such themes as cognitive motivation, the nature of science; environment issues and formative assessment.

As mentioned earlier Level III locates professional development in the teacher’s own professional context in which a specific aspect of science education research is carried out through an action research methodology. Collaboration between small groups of teachers (most likely two teachers) operating in different national contexts is a essential element of this development process not least because it moves us closer to the concept
of a European teacher, someone who professional competencies extend beyond that typically associated with their country of residence.

One of the assumptions applied to Level III is the development of a teachers’ capacity to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. Professional competencies such as those related to science processes (recognising scientifically investigable questions, identifying evidence needed in a scientific investigation, drawing conclusions, communicating valid conclusions etc.) and with cross curricular issues (self-regulated learning, cooperation or ability to solve problems etc.) are essential qualities for effective science educational practice.

A wide range of potential areas for research at LIII exist some of which are outlined below.

The development of scientific literacy within a trans-national context: Science plays a very important role in the European Educational Systems. Science literacy gives a strong support for citizenship in a democratic society and science has the potential for improving the economical, technological and environmental sustainability development.

Verification by experience: Verification is an issue very much concerned with the main aims of this project and it is also related both to the research experience of staff members and the collaborative science teachers. The main reason for this relevance deals with the nature of the achievement of a scientific attitude. Therefore this aspect should also be reflected in the designing of the science curriculum materials in science school practice.

Facilitating students’ access to learning: Students’ accessibility to learning in relation to context, terminology, subject specific concepts and so on, should be at the heart of defining and developing teaching strategies in the context of a constructivist approach to science education; the collaboration of teachers from different countries can be of benefit to providing such access. The formulation of effective curricular materials and the selection of appropriate teaching and learning strategies are essential to facilitate learners’ conceptual change from their individual personalised views to a more scientific one. The European dimension of the project provides an ideal opportunity for the dissemination amongst teachers of web-based material that has been previously implemented and evaluated within a reflective framework.

The application of a novel pedagogical technique in any country: A wide range of possibilities exist, however one focus for action research could be the use of an innovative approach to formative assessment that has never previously been employed in either national context. Such a comparative investigation not only alerts individuals to new aspects of professional practice but also facilitates greater trans-national understanding of what are often common professional challenges.

Level III engagement has the additional expectation that participants will engage in a process of synthesis in that there will be an active consideration of their personal and the social development, as well as the environmental dimension and the values which underpin any of the topics. Such criteria direct the choice of research topic such that there must be profitable outcomes for every country involved in the project.
References


4.2

EXAMPLES OF LEVEL II

Introduction

The purpose of this next section is to provide contextual information about specific LII modules in order for the reader to better conceptualise the nature and organisation of these web-based teaching resources.

All LII modules adopted the following common structural elements which were new concepts for some members of the project team. Each module was required to consist of the equivalent of twenty four hours of contact time (typically twelve lots of two hours) and with an additional student study requirement of 48 hours. All modules had clearly specified aims and/or learning objectives that related to a target audience of In-service science teachers practicing in primary and junior secondary schools. Module content was required to be presented in a form that was appropriate for a web-based application.

Each LII module was evaluated through its delivery to the specified target audience in a contrasting national context and this evaluation data used to inform the module review process.

Rather than describe each LII module in unnecessary detail information from two quite different modules will now be provided that enables the reader to grasp a sense of their structure and organisation, expectations of the participants (through the use of exemplars) and the role of the module tutor. Evaluation data will also be provided in order to be able to comment about their effectiveness and identify appropriate conclusions.

An Introduction to the Assessment of Children’s learning in Primary Science

This module was seen as necessary if the assessment practices of teachers was to progress in line with new theoretical perspectives of learning some one which are discussed in this publication. Furthermore it was accepted that improvements in learner assessment methods was critical if pupils (and teachers) we to become enthused about science as traditional summative-based methods often had exactly the opposite impact. This module was planned and organised by the UK team.

Modules aims:

• To gain an overview of assessment processes and practices;
• Develop practitioner knowledge of the purpose of diagnostic and formative methods of assessment;
• Recognise the interrelationship between planning, assessment and curriculum evaluation;
• Develop expertise in planning for assessment;
• Begin to understand how assessment evidence is gathered, recorded and applied;
• Implement formative and diagnostic assessment strategies;
• Reviewing and evaluating participant’s own practice in assessing children.
The exemplar chosen from this module is session 3: **Introducing different formative assessment strategies (1): Effective use of teacher-questioning**

**Learning Objectives for session:**
You will:
- Develop your knowledge and understanding of the use of questioning in the classroom
- Explore the value of questioning as a form of formative assessment

**Content and rationale for session:**
This session is about developing effective questioning techniques and looks at the different types of questions, for example open and closed questions as well as techniques such as ‘funnelling’ and how these can be used as part as a formative assessment strategy in your teaching.

**An example of a task in the session**
You are asked to complete a task involving the use of the techniques illustrated in the session with your pupils and discuss your findings with others within the discussion forums. These professional exchanges of experience form a key process within the module.

**Learning outcomes are identified for the session:**
You can now:
- Use your knowledge and understanding of the use of questioning in the classroom
- Identify the value of questioning as a form of formative assessment

**Assessment for the session**
Assessment is via a e-portfolio developed during the module (very explicit guidance to the participants is provided). From this session the e-portfolio will provide the following evidence:
- Your contribution to the online discussion sessions
- A summary of the advantages and disadvantages of different types of questions
- Evidence and evaluation of your use of the ‘funnelling technique’ within your practice
- A comparison of your own experience of teacher-responses to children’s’ answers (second part of task 2)

**Examples of responses by the teachers while undertaking the module**
As mentioned earlier teachers following the online course completed e-Portfolios as part of the assessment procedure. These were designed to be reflective in nature. Some extracts from these e-Portfolios are shown below:

‘It is so difficult to formulate questions of high cognitive level!’ wrote one teacher, while another found ‘... the implementation of a dynamic debate and questioning between teacher/student, student/teacher and student/student point towards the development of a research attitude in the students and, therefore, to promote the capacity of critical argumentation. ‘A teacher also found that ‘students’ learning may be constrained by the way the questions are formulated.’
As well as the e-Portfolio the courses are designed to engage the teachers in debate within discussion forums. Some of these discussions were designed for individual contribution while others were for each group to contribute as a whole.

Another example from a group discussion identified some of the advantages and disadvantages of open and closed questions. The group devised a table to present these. Please see below:

<table>
<thead>
<tr>
<th>Open Questions</th>
<th>Closed Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is possible for broader discussion to take place so that pupils can give their opinion</td>
<td>It is possible for a more precise response and it is easier to assess.</td>
</tr>
<tr>
<td>Are more suitable for students of higher levels of education with more power of argument and reasoning</td>
<td>Are more suited to students from low levels of education, and so allows the participation of more students.</td>
</tr>
<tr>
<td>Allow a more dynamic and participatory classroom</td>
<td>Allow a greater diversity of type of questions (multiple choice, filling spaces, etc.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are more difficult to assess in the immediate future.</td>
</tr>
<tr>
<td>Not all students are able to respond.</td>
</tr>
<tr>
<td>Are more difficult to elaborate so that everyone can understand.</td>
</tr>
</tbody>
</table>

Such responses are then used by the participants to critically reflect on the use of these types of questions in assessing learners something directly related to the learning outcomes of the module? Of course any analysis is not simply limited to the identified learning objectives.

Discussions were also encouraged within groups so that professional ideas and experiences could be shared. A typical example is shown below:

Communication from Fernanda (A teacher undertaking the module)
Hello group. I’m not sure if this is what it is intended ... but here it goes my attempt:
I’ve chosen a question on a theme in the seventh year about Energy.
"If it would be necessary to build a small power station to supply power for a small town in a forest area, what kind of station do you think that could be more appropriate?"
What kind of energy-producing stations do you know?
What are the energy sources of those stations?
The energy used in that station is renewable or non renewable?
Desired response:
The power station to supply energy would use biomass, since in this forest region; there is a lot of waste resulting from clearing forests.

Did Fernanda receive any responses?

The students were found to be supporting one another as well as moving the process forward as the following example illustrates:

Dear Colleagues:

In this activity it is supposed to choose one of our proposals ...

Girls ... time is short and we have a decision to take.

I particularly liked the proposals of Sandra and Arminda.

Mine, I think, it could be very simple, considering the level of schooling.

I’ll be waiting for your opinions

Thank you very much

Impact of the module on the classroom practice of the teachers

After a trial of the module An Introduction to the Assessment of Children’s Learning in Primary Science teachers in Portugal were questioned about their experience and the affect it had on their classroom practice. The following are extracts from Pombo et al 2009 (unpublished paper) evidence a very decisive reaction from the teachers.

Their responses were overwhelmingly positive. For example over 80% found the collaborative work to be a positive experience while 64% found the development of critical reflection helpful in their classroom teaching. It was found that 78% of the respondents found the tasks within the module to be “professionally interesting”. The international dimension of the module was found by 71% to be a positive experience. It was found that undertaking the module had a profound effect on their classroom practice seeing as 88% of the teachers considered that they started to use a greater variety of assessment methods and tools in their teaching. While 82% say that they are now able to undertake an improved diagnosis of the learning difficulties of their pupils.

Pupil’s World Image and Science Education

This LII module, designed by a team from the University of Wroclaw, is based on the assumption that most pupils’ failures in the teaching-learning process has its cause rooted in the observation that a teacher rarely actively considers what pupils bring into a didactic situation, namely their common, discursive knowledge which is often reflected in the language that pupils use.

For several years we were developing methods of analyzing the statements of pupils on scientific concepts (A. Krajna, K.Sujak-Lesz, Language in science education, Edukacja przyrodnicza w szkole podstawowej, Warszawa-Wroclaw, ISSN 1642-0993, p.35-47 (2000) – in Polish. The course described below has already been incorporated in post-graduate studies for in-service teachers organized at our Institution and has traditionally
been delivered in face-to-face classes. In the frame of this project the course has been transferred, piloted and implemented in a Web-environment using the Moodle-Project-Platform. The title of both the face-to-face and web-based courses is “Pupil’s World image and science education”.

Module’s aims:
The aims of this module are:
- To embed theoretical perspectives (e.g. Cognitive Dissonance, Constructivism) in practical contexts.
- To improve professional skills related to interpreting pupils’ scientific statements.
- Acquainting the participant with the mechanism of using information about pupil’s world image in constructing personal education system.

The exemplar chosen from this module is the session – Pupils’ understanding of the term ‘Maturation’.

Learning Objectives for this session:
You will
- Develop your knowledge and understanding of the role of pupils’ preconceptions in the classroom.
- Develop your skills in defining the pupils’ ideas on concepts or notions you are going to teach.
- Develop your skills in being/becoming a reflective teacher capable of responding to individual needs of pupils.

Content and rationale for session:
The notion of Maturation was the focus of one session. This concept is frequently used in the everyday language, in classes of nature, as well as in humanities in different contexts.

An example of a task in the session
- **Age and number of participants:** 13 years old, 25 pupils from a state junior high school. School that they attend to is situated in Lublin; however most of children in that group are living in small surrounding villages.
- **Task for pupils:** Explain, what maturation is? The model answer being that maturation is long-lasting process, that goal and final effect is achieving by a man biological, social and psychological maturity.
- **Task outcomes:** What follows is the outcome of this work with pupils’ comments grouped according to the following identified categories. What is particularly significant is the range of comments expressed in relation to the key concept of maturation by this relatively small class of 13 year olds.

**Maturation defined as changes in the human body, concerning achieving biological, sexual maturity.**
- Maturation means stimulating hormones in a teenager.
- Maturation, it is growing up, proportions of body change and we become more mature. Girls get a period, boys have their voice changed. We think in different way about boys and girls. We dress as much up to date as we can to impress others. We become more serious.
- Man becomes older. Sings of maturation are e.g. facial hair.
- Going through a stage in life, when facial hair appears, girl get first period. We become grown up.
- Maturation is the fact that severe changes appear in body e.g. girls become women.

**Maturation defined as increasing size of the body, development of the human body.**
- In my opinion, maturation is a growing body.
- In my opinion, maturation, it is the growth of the body, reproduction of cells.
• Maturation, it is the fact, that a man grows all the time, human body is growing up all the time.
• Maturation it is development of the human.
• Maturation is when man is developing and growing up.
• Maturation, it is the change of matter, kind of reproduction of cells.
• Maturation, it is undergoing varied change.

Maturation defined as next stage in life, changing into psychologically mature person.
• Maturation is when I go to the first grade, and then to the third grade. You mature, that is, you do not do stupid things anymore and you become smarter and better in school subjects.
• Brain becomes mature. Man thinks about different things. Man thinks about more serious matters such as: family, work, future. Also body changes. We become taller; have bigger size of shoes and so on. Our interests change.
• It is a stage in human life when he is growing, starts taking some things more seriously. He grows up and his body changes.
• Maturation is in my opinion growing of a human. It is the same way form the pre-school to the third grade of e.g. high school. Or to compare e.g. a nursery school pupil to a third grade high school pupil e.g. child<grown up<old man, e.g. seed<tree<huge tree<fruit.
• Maturation it is growing up from childhood, we become more serious.
• Maturation it is when man becomes older, and becomes more mature than child.
• Maturation it is in my opinion when a human becomes older, more prudent and smarter, makes fewer mistakes.
• Maturation – we become older, smarter, our bones develop.
• To know more words.
• Maturation means that a man becomes more responsible, independent.

Some pupils (six) connect process of maturation with achieving biological maturity. Forming their own definition they point out changes, that they can observe in growing up teenagers. They list specific changes, such as appearance of first period, facial hair or changing of voice in the case of boys. Eight pupils mean by the world maturation generally perceived development of the human body, considering increasing size of the body its main element. Biggest group (11 pupils) associates the process of maturation with changes appearing in human psyche, as ways of understanding of the world and life. Some answers can be assigned to more than one category as when describing maturation in terms of both psyche and building and functioning of human body. Those statements were marked with the asterisk in the original table. Those definitions are closest to the model answer. The rest contains only a part of it, taking under consideration only some chosen aspects of maturation (biological or psychological).
Pedagogical analysis and action for future work about ‘maturation’.

The following are identified as means of enabling pupils to move towards a more fuller scientific understanding of this concept:

1. Showing the film I am maturing, part II: Let us choose together;
2. Work in pairs: pupils receive photos of people in different age and have to state, who is mature in their opinion, and who are adolescent. Photos are then glued to the large sheet of paper, either with the topic: “I am still maturing” or “I am a mature person”
3. Work in groups: pupils receive copies of texts, presenting people in different age, in different situations. Based on their behaviour and made decisions and they state, who can be considered mature, and who is still maturing
4. Work in groups: pupils state criteria of psychological, biological and social maturity. They write down their proposals on the sheets of paper, then, all the sheets are put on the blackboard and analyzed by the whole class. Together pupils try to answer the question: Is maturing long-lasting process and if yes, how long does it take?
5. Pupils formulate one more definition of maturation, using knowledge acquired through the process.

Assessment for the session

Assessment is once again via an e-portfolio developed during the module (very explicit guidance to the participants is provided) that provides the following evidence:

- The participant’s contribution to the online discussion sessions
- A summary of children’s responses including a comparison of your own experience of teacher expectations to children’s perceptions of ‘Maturation’.
- Identification of strategies that can more effectively move a pupil to an improved scientific level of understanding.
- Evidence and evaluation of reflective practice
4.3

EXAMPLES OF LEVEL III

Eva Trnova, Arminda Malho, Josef Trna and Luis Marques

Action-Research as the methodological base of level III

The idea of using research in a "natural" setting to change the way that the researcher interacts with that setting can be traced back to Kurt Lewin, an educator social psychologist whose work on action research was developed throughout the middle of XX Century, in the United States. Lewin is credited with coining the term "action research" to describe work that did not separate the investigation from the action needed to solve the problem (McFarland & Stansell, 1993, p.14).

Traditional educational research has, so far, limited usefulness for classroom teachers, despite the attempts which have been made during the last decade (Costa et al., 2000; Hammersley, 2003). When some educators talk about teacher research, or teaching as research they envision teachers extending their role to include critical reflection upon their teaching. Some examples of teaching as research include educators who wish to undertake research in their classrooms or schools for the purpose of improving teaching, to test educational theory, or to evaluate and implement an educational plan. Teacher researchers have adopted the label "action research" to describe their particular approach to classroom research.

The project teams’ experience concurs with Cohen, Manion and Morrison (2004), when they argue in favour of a style of research that has received rather more publicity over the years than most other methods in the social sciences. In fact, action research is known by many other names, including participatory research, collaborative inquiry, emancipator research, action learning, and contextual action research, but all are variations on a theme.

This method marries well with teachers’ activities and concerns, because it is a small scale intervention about the functioning of the real world and is a quite close examination of the effects of such intervention. Also, it contributes to theory of education, as well as practice. The method is a cultural innovation and it is inevitably threatening to the traditional professional cultures of both teachers and academic teacher educators. As a form of mutual professional learning it requires a transformation of both school and academic cultures (Elliot, 1997, p.45). Therefore it seems possible to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction.

Put simply, action research is "learning by doing" - a group of people identify a problem, doing something to resolve it, seeing how successful their efforts were, and if not satisfied, trying again. The emphasis on scientific study, which is to say the researcher studies the problem systematically and ensures the intervention is informed by theoretical considerations, separates this type of research from general professional practices. The diagram in Fig. 5 demonstrates this process:
A particular action is conceptualized and applied, structuring routines for continuous confrontation with data. Identification of the question to be tackled is the starting point, and this question should be concise, meaningful and doable in the context of the daily work.

The collection of data is an important step in preparing the action itself and multiple sources of data are used to better understand the scope of happenings in the classroom. Three types of selection have to be taken into account: to select the data that are most appropriate for the issue being researched, to select the methodology for collecting data and to select the way they should be structured. Much of the researcher’s time is spent on refining the methodological tools to suit the exigencies of the situation, and on collecting, analyzing, and presenting data on an ongoing, cyclical basis.

A plan of action based on the information from the data collection and review of current literature, will allow the teacher to make a change and to study that change. As with any experiment, if several changes are made at once, it will be difficult to determine which action is responsible for the outcome. So, it is crucial to develop a time-line to gather evidence or data to examine what you are trying to accomplish/resolve/do in light of "what you do not know yet". Therefore, it is relevant to take decisions about the evidence to be collected. Evidence includes such things as questionnaires/surveys, observations (video or written notes), collaborations (i.e. video or audio tape of meetings, peer coaching) interviews, tests and records, student work, video and audio tape transcripts, personal journal, library readings, etc.

Action, in *latum sensum*, is something which is central in the teachers’ activity, but the reflection should be in the core of their professional development. Nevertheless if it was no longer simply a matter of producing materials for teachers to test in the classroom, it was also a matter of fostering the development of teachers’ capacities for self-reflection (Elliot, 1997). The principle of reflective critique ensures people reflect on issues and processes and make explicit the interpretations, biases, assumptions and concerns upon which judgments are made. In this way, practical accounts can give rise to theoretical considerations.
Another aspect which should also be stressed is the perspective that participants in an action research project are co-researchers. The principle of collaborative resource presupposes that each person’s ideas are equally significant as potential resources for creating interpretive categories of analysis, negotiated among the participants.

From the interaction between practice and reflection (see Fig. 5) in action research, theory informs practice and practice refines theory in a continuous cycle. In any setting, people’s actions are based on implicitly held assumptions, theories and hypotheses, and with every observed result, theoretical knowledge is enhanced. The two are intertwined aspects of a single change process. It is up to the researchers to make explicit the theoretical justifications for the actions, and to question the bases of those justifications. The ensuing practical applications that follow are subjected to further analysis, in a transformative cycle that continuously alternates emphasis between theory and practice.

**Action Research in Science Education**

As with the LII modules the intention of this next section is to provide contextual information about this LIII module, jointly designed by teams from the Czech Republic and Portugal, in order to better conceptualise the nature and organisation of this web-based teaching resource.

Participants are guided to develop their knowledge, understanding, teaching and diagnostic skills of action research in science education.

**Modules aims**

- Guidance in the educational skill how to use action research in science education especially by motivation
- To gain an ability to self-evaluate the application of action research in science education, in the context of a peer supervision.

**Context**

What has been written earlier helps the understanding of the context of Level III as an means of energising teacher’ generally suspicious and critical attitude towards educational research. The topic selected by participant teachers from Czech Republic and Portugal, ‘photosynthesis’, has been used specifically in order to:

i. Identify the concise problems related to how to motivate the students to learn about obtaining energy: *photosynthesis and chemosynthesis* and how to promote the development of skills in terms of concepts, procedures, values and attitudes, concerned with such a focus.

ii. Enable the principle of reflective critique concerned with both the activities and experiences which have been planned, such as those related to factors influencing the rate of photosynthesis.

iii. Improve interaction among students, between teachers and learners and between science teachers (at least two); strategies designed to stimulate the collaborative work were critical.

iv. Develop a broader, more European dimension through a trans-national focus such as photosynthesis in order to begin to challenge students’ assumptions, attitudes and values as far as the environment is concerned.
Module structure and organisation

The requirement for bilateral cooperation in this module was addressed through collaboration among teachers and students from Portugal and the Czech Republic. Both teams were motivated by the desire to collaborate in upgrading teaching and learning through the application of new educational methods including those of an experimental nature. Students were encouraged to become cognitively and emotionally involved in the process of teaching and learning because they shared a common interest in any elaboration of teaching and learning materials. The experiences from this action research will be presented below.

The module team identified the following steps were essential in engaging effectively with this LIII module:

1. Topic selection (Agreed with module tutor)
2. Selection of students (not simply limited to those that had completed one or more LII modules)
3. Collaboration schedule (agreed across all parties)
4. Use of Information and Communication Technologies (web-based communication being essential given the international nature of this work)
5. Elaboration of materials for teaching and learning
6. Reflection

The examples of these steps are now in the form of both specific materials and examples drawn from e-portfolios.

1. Topic selection

Not all science topics are equally suitable for action research so the following topic-selection criteria were applied: position of the topic in the national curricula, importance of topic for students’ development, and interest for students.

The relevance of the position of the topic in the national curricula was a particularly important factor as it should belong to the science curricula of both countries i.e. the location with respect to the pupils’ age range should be similar. It was on this basis that through comparisons of both the Portuguese and Czech Republic curricula the topic “photosynthesis” was selected (see below).
**Extract from the Portuguese curriculum**

<table>
<thead>
<tr>
<th>Unit 1 - GENERAL MATERIAL</th>
<th>Extract from the Czech curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collection of material by heterotrophic beings.</td>
<td>GENERAL BIOLOGY</td>
</tr>
<tr>
<td>1.1 Single-cell vs Multi-cellular organisation.</td>
<td>Expected Outcomes</td>
</tr>
<tr>
<td>1.2 Ingestion, digestion and absorption.</td>
<td>The pupil shall:</td>
</tr>
<tr>
<td>2. Collection of material by autotrophic beings.</td>
<td>- distinguish living from non-living systems on the basis of their typical properties.</td>
</tr>
<tr>
<td><strong>2.1 Photosynthesis.</strong></td>
<td>- compare significant hypotheses on the origin and evolution of living systems on the Earth.</td>
</tr>
<tr>
<td>2.2 Chemosynthesis.</td>
<td>- explain the arrangement and function of the structural components and life manifestations of prokaryotic and eukaryotic cells.</td>
</tr>
<tr>
<td></td>
<td>- explain the significance of the differentiation and specialisation of cells for multicellular organisms.</td>
</tr>
<tr>
<td></td>
<td>- deduce the hierarchy of recent organisms based on his/her knowledge of their evolution.</td>
</tr>
<tr>
<td></td>
<td>- explain principle of photosynthesis and evaluate plants as the primary producers of biomass.</td>
</tr>
</tbody>
</table>

2. **Selection of students**

The main conditions for selection of pupils are comparable age and ability. They need to be approximately at the same age because the requirement for cooperation. Pupils need also to have a reasonable capacity to both communicate in English and use ICT. Portuguese pupils from the first year of level III and the Czech students of the first year of grammar school were selected for being most suitable for this work; both groups are at the beginning of the secondary school and at the age 15-16 years.

<table>
<thead>
<tr>
<th>Information</th>
<th>The Czech students</th>
<th>The Portuguese students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>15-16 years</td>
<td>15-16 years</td>
</tr>
<tr>
<td>Position at school</td>
<td>First year of grammar school</td>
<td>first year of level III</td>
</tr>
<tr>
<td>Ability to communicate</td>
<td>English</td>
<td>English</td>
</tr>
<tr>
<td>Ability to use ICT</td>
<td>PC, Skype, ICQ, e-mail</td>
<td>PC, Skype, ICQ, e-mail</td>
</tr>
</tbody>
</table>

3. **Use of Information and Communication Technologies (ICT)**

Effective communication strongly influences collaboration between teachers and students. In the case of an international collaboration it is necessary to use 'on-line' technologies. Consequently most communication for both teachers and pupils was via email, Skype, ICQ or similar technology. Video-conferencing was not used and face-to-face meetings were rare.
The example of Skype communication between teachers:

Teacher Arminda:
"[...] I’m sending you the first materials I have prepared. [...]I’m sending you a reduced version of the Portuguese Biology syllabus, adopted from the Ministry of Education. I’m also enclosing a draft of the pre test. Is it possible for you to have a look at it and tell me what do you think? I’m also sending you a summary with the main aims of our meeting in Aveiro. Do you agree with it? Please, change or add whatever you like.
Teacher Eva:
"[...] I agree with your prepared materials and I’m sending you some next new materials. I have found very good materials in English version about experiments. They are in the attachment. I hope that you have received my first e-mail. Please write what next is necessary to do. [...]"

The example of Skype communication between students:

"[11:07:20] Andre: Yes I already told you that we are making some experiences with plants
[11:08:13] André: We put some plants on a cup and we smash them, and we add some alcohol!
[11:08:59] André: We filter the mixture to another cup and put some chromatography paper.
[11:09:31] André: And we watch the results, the colours that were formed on the paper.

The example of email communication between students:

"Hi Ana, Diana and Cátia!!!
I am Karolina but friends called me Kari. I am from the Czech Republic and I live in Kunštát (small city in the Czech Republic). I have gone for five years at Gymnasium Boskovic. Would you like to know something about me??? Write me what you like doing or you write what you want :-) ...Excuse me but I cannot speak English very well.
I study French too (I like French :-)... So I will be happy if you write me : -)!!!
That’s all...Goodbye Kari."

4. Collaboration schedule
Teachers have to prepare schedule of their and students’ activities in action research. The table below provides some indication of both the periodicity and purpose of joint contact; not all detail is included.
<table>
<thead>
<tr>
<th>Date</th>
<th>Objectives/ Questions</th>
<th>Contents</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. 3.</td>
<td>What does each student already know about this topic? What strategies are used to obtain material for autotrophic beings? How do autotrophic beings get the matter responsible for their growth?</td>
<td>Collection of material by autotrophic beings.</td>
<td><strong>Activity 1</strong>&lt;br&gt;Pre-test. <strong>Activity 2</strong>&lt;br&gt;Analysis, interpretation and research, discussion and debate; paper and pencil exercises.</td>
</tr>
<tr>
<td>3. 3.</td>
<td>What are the main autotrophic beings? Which characteristics of photoautotrophic beings enable them to convert the radiant energy into chemical energy? What photosynthetic pigments exist in plants?</td>
<td>The plants and other autotrophic beings. The chloroplasts are the organelles where photosynthesis takes place.</td>
<td><strong>Activity 3</strong>&lt;br&gt;Analysis, interpretation and research, discussion and debate; laboratory work: Observation of chloroplast. <strong>Activity 4</strong>&lt;br&gt;Analysis and interpretation of information, laboratory work: &quot;Extraction and separation of photosynthetic pigments.&quot;</td>
</tr>
<tr>
<td>5. 3.</td>
<td>What is the significance of different visible light radiation on photosynthesis?</td>
<td>Details omitted.</td>
<td>Details omitted.</td>
</tr>
<tr>
<td>9. 3.</td>
<td>What is the importance of autotrophy’s beings at the ecosystems level? – What is the relationship between the materials used in photosynthesis and the resulting products?</td>
<td>The process of photosynthesis: an overview</td>
<td><strong>Activity 6</strong>&lt;br&gt;Analysis, interpretation and research, discussion and debate; paper and pencil exercises (worksheet).</td>
</tr>
<tr>
<td>12. 3.</td>
<td>Which factors influence the rate of photosynthesis?</td>
<td>Factors that influence photosynthesis.</td>
<td><strong>Activity 9</strong>&lt;br&gt;Analysis, interpretation and research, discussion and debate; investigative path.</td>
</tr>
<tr>
<td>16. 3.</td>
<td>How does chemosynthesis occur? Chemosynthesis vs. Photosynthesis - What are the similarities and differences?</td>
<td>Details omitted.</td>
<td>Details omitted.</td>
</tr>
<tr>
<td>17. 3.</td>
<td>What does each student knows about this topic?</td>
<td>Details omitted.</td>
<td>Details omitted.</td>
</tr>
</tbody>
</table>

5. The elaboration of materials for teaching and learning
All the materials were prepared by the two cooperating teachers as part of their engagement with the action research process. It is possible to create a wide variety of resources such as power-point presentations, videos and worksheets one of which is provided below. This level of detail is necessary to convey a sense of the high levels of commitment and cooperation required.
10th year of schooling  
Academic Year 2008/2009  
Biology and Geology  
Name: ____________________________________________ No.  
___ Class B  

Worksheet  

How do autotrophic beings get the matter responsible for their growth?  

Introduction  
Acquiring matter and energy is carried out in many ways by living systems. Autotrophic beings, living beings capable of producing the organic matter they need for their survival, can perform this production activity by using light or chemical energy as an energy source to synthesize organic matter from mineral matter. Autotrophy, therefore, involves two processes: photosynthesis, used by photoautotrophic beings (for example green plants), and chemosynthesis used by chemosynthetic beings (for example sulphur bacteria).  

Activity 1  
As long ago as ancient Greece, it was known that fertilized soil allowed the growth of plants, believing that this only depended on nutrients that they get from the soil.  

In a posthumous publication (1648) Van Helmont describes an experiment which attempts to explain this hypothesis.  

He placed a small 2.268 kg sprig of willow in a vessel containing 90.718 kg of dry soil (both weighed very precisely). He put water (pure rainwater) on the young plant regularly during
five years. After this time he weighed the plant again, after properly cleaned the plant (get rid of all the earth - soil). He found that it weighed 74.389 kilograms. Weighing the earth (soil) in the pot, he found that it had only decreased by approximately 56.7 g. From these results he concluded that the total increase the weight of the plant was mainly due to the water that plant received, which would have made all other elements necessary for the growth of small willow.

**Tasks:**

1. **Do you think the data supports the original hypothesis? Justify your answer.**

2. **Van Helmont inferred from the data he collected that the growth of plants is solely due to the addition of water. Examine critically the conclusion drawn by Van Helmont.**

3. **Identify the variables that were not monitored during this experiment.**

![Fig. 6 Van Helmont experiment](image)
Activity 2

A *Quercus* spp., a eucalyptus plantation (*Eucalyptus* spp) and a pasture (*Vicia* spp.; *Bromus* spp.) are all being assessed by Portuguese investigators to identify which of these offers the best carbon dioxide retention (CO₂), the gas which most contributes to the greenhouse effect.

The forest's ability to retain CO₂ has been called a "carbon sink" under the Kyoto Protocol to combat climate change. Plants (trees) absorb CO₂ by photosynthesis carried out by plants that, unlike humans and animals, retain carbon dioxide and release oxygen. (Adopted from [http://www.agroportal.pt/x/agronoticias/2005/02/14d.htm](http://www.agroportal.pt/x/agronoticias/2005/02/14d.htm))

Analyse Fig. 7 and 8.

Primary Production is the amount of organic matter that is produced by autotrophic beings from solar energy (photosynthetic organisms) or chemical energy.

Gross primary production (PPB) - is conversion rate of CO₂ into organic carbon per unit area.

The Net Primary Production (PPL) - is all the energy that producers store from the photosynthesis (PPB) minus what they spend on respiration (R) $\text{PPL} = \text{PPB} - R$.

The efficiency of photosynthesis is converted to radiation incident to PPL divided by the total incident radiation.

The general formula of photosynthesis is: $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$ and for each gram of C assimilated, 39 kJ of energy are stored.

\[(2)\]
Fig. 7 Gross Primary Production (PPB) worldwide registered between June and July 2000.

Fig. 8 Portugal and the Czech Republic geographical location.

Tasks:
1. Compare the PPB in the countries of the world registered in Figure 2.
2. Mention some of the factors that could explain the differences observed in Northern and the Southern Hemispheres.
3. Analyse the Portuguese and Czech Republic cases specifically. Collect, organize and analyze critical information on the similarities and/or differences in PPB for the period considered in the picture.
4. It was found that CO2 absorption of is 3-4 times higher in eucalyptus forests in Portugal However, researchers believe that Portugal should choose to have various types of forest. Discuss the appropriateness of the measures that are being put into practice by Portuguese scientists.

6. Data generation and analysis

(i) Reflection
Continuous ongoing reflection is an essential element of the action research process. It is necessary to find if the suggested hypothesis of the action research can be supported. Many data generating methods are available such as through the use of questionnaires, observations, interviews, tests, students’ and teachers’ portfolios including e-portfolios and video recording. This data can then be used to assess the success of the action research. The methodology of this action research project was based on a pre-intervention test, intervention and post-intervention test data gathering set of instruments.

(ii) Pre-test and post-test
Pre-test data was gathered about what students already know about the learning focus in order to ascertain those changes in students’ knowledge and skills. Below is one example of pre-test and post-test that focused on one aspect of this work.

Pre-test
Instructions for completing this form:
Fill in the following table on the theme of "photosynthesis", indicating it is considered that the statement is true or false and their justification. This activity aims to diagnostic help your teacher to know you a little better, on what you know, the general and specific skills that you developed in previous years and the problems about the issue that is now beginning.

<table>
<thead>
<tr>
<th>Statement</th>
<th>True / False</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>In winter, most plants survive on the reserves that accumulated during the summer.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pre-test findings:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Correct answers (%)</th>
<th>Correct answers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In winter, most plants survive on the reserves that accumulated during the summer.</td>
<td>56,2</td>
<td>44,4</td>
</tr>
</tbody>
</table>

Post-test

<table>
<thead>
<tr>
<th>Statement</th>
<th>True / False</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The plant stores glucose for later use in seeds, roots and fruits.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post-test findings:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Correct answers (%)</th>
<th>Correct answers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The plant stores glucose for later use in seeds, roots and fruits.</td>
<td>87,4</td>
<td>81,5</td>
</tr>
</tbody>
</table>

Assessment:
According the pre-test findings students of both countries had difficulty to recognize the lowest activity of photosynthesis during the winter. Therefore we aimed at these problems during explanation. Post-test findings showed that students were more successful in solving these problems.
(iii) Questionnaire

The questionnaire, while it has both advantages and disadvantages, is a useful tool for gathering a wide range of pre-determined areas of interest. Students completed such a questionnaire that focused on their reflections on this innovative bilateral collaboration. Their answers indicate very high levels of both motivation and engagement with the educational process; they learnt a great deal.

**Answers of the Czech students:**

**Question: In the statements listed below are some of the aspects related to the activities shared with your Portuguese colleagues. Choose the option which best expresses your opinion.**

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Partially Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fact that various activities were undertaken in partnership with Portuguese colleagues increased your interest in studying this topic.</td>
<td>9,52%</td>
<td>2</td>
<td>38,10%</td>
<td>28,57%</td>
<td>6</td>
</tr>
<tr>
<td>This partnership helped you to better understand certain aspects on this topic.</td>
<td>0,00%</td>
<td>0</td>
<td>28,57%</td>
<td>6</td>
<td>47,62%</td>
</tr>
<tr>
<td>You would have achieved the objectives of this topic better by interacting only with your classroom classmates.</td>
<td>28,57%</td>
<td>6</td>
<td>28,57%</td>
<td>6</td>
<td>28,57%</td>
</tr>
<tr>
<td>Distance sharing allowed you to develop skills in the use of English.</td>
<td>0,00%</td>
<td>0</td>
<td>14,29%</td>
<td>3</td>
<td>47,62%</td>
</tr>
</tbody>
</table>

**Answers of the Portuguese students:**

**Question: In the statements listed below are some of the aspects related to the activities shared with your Czech colleagues. Choose the option which best expresses your opinion.**

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Partially Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fact that various activities were undertaken in partnership with Czech colleagues increased your interest in studying this topic.</td>
<td>3,70%</td>
<td>1</td>
<td>29,63%</td>
<td>8</td>
<td>51,85%</td>
</tr>
<tr>
<td>This partnership helped you to better understand certain aspects on this topic.</td>
<td>7,41%</td>
<td>2</td>
<td>33,33%</td>
<td>9</td>
<td>40,74%</td>
</tr>
<tr>
<td>You would have achieved the objectives</td>
<td>33,33%</td>
<td>9</td>
<td>51,85%</td>
<td>14</td>
<td>3,70%</td>
</tr>
</tbody>
</table>
of this topic better by interacting only with your classroom classmates.

Conclusions of the action research process

All materials such as tests, questionnaires, observations, interviews, students’ and teachers’ portfolios, and video recordings, indicate that students learnt with interest, and their knowledge and skills are better than would be expected using classic methods. On this basis this action research project produced very positive outcomes for both groups of children and the two action researchers. This confirms the a fundamental belief by the EuSTD team that in general terms international cooperation of this nature can make a significant contribution to improving the quality of science education. Such action research engages both teachers and pupils in ways not typically experienced but it not just the novelty value that is important. This development can contribute to reducing the gap between educational research and the development of curriculum materials and methods for school practice (Hammersley, 2002; Costa et al, 2000). In fact the education research dimension of curriculum development materials is an important feature for all science education innovations and, obviously, for all project content. This much more about presenting new ways of working that can genuinely move the education profession towards a new concept, that of the European Teacher.

References


