PROFILES

Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science

Bolte, C., Holbrook, J., Rauch, F. (eds.):

Inquiry-based Science Education in Europe: Reflections from the PROFILES Project

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Inquiry-based Science Education in Europe: Reflections from the PROFILES Project

CONTENT

PREFACE

This book provides an insight into the PROFILES project; its aims and objectives as well as about some of the activities initiated by PROFILES partner institutions. In particular, the book gives a picture of some experiences colleagues underwent within the first period of the projects lifespan and invited experts provide insights into special issues and tasks PROFILES is promoting to foster cooperation and support on a large scale in Europe as well as across European borders.

Chapter 1 provides different perspectives related to the term Inquiry-based Science Education (IBSE), on current IBSE practice(s) and on developments within the field of the IBSE movement worldwide (see keynote presentation by Peter Gray - Chapter 1.1.1 and the co-keynote statement of Ilmars Rikmanis, a Latvian teacher, in Chapter 1.1.2). In addition, this Chapter offers up-to-date indicators on Teacher Continuous Professional Development (CPD), as well as perspectives on how to enhance teacher ownership (see keynote presentation of Shirley Simon in Chapter 1.2.1 and the co-keynote statement of Funda Tunaboylu, a Turkish teacher, in Chapter 1.2.2). This chapter also focuses on how to foster and evaluate student gains to enhance their Scientific Literacy by means of more innovative Inquiry-based Science Education practices (the keynote presentation by Olaf Köller in Chapter 1.3.1 will, unfortunately, be published in the next PROFILES Book; see the co-keynote statement of Chrystalla Lymbouridou from Cyprus, in Chapter 1.3.2).

After an introduction into the PROFILES project and its philosophy (Chapter 1.4.1), the project's internal monitoring team presents in four lectures their most recent findings in the field of stakeholder views on IBSE (see Chapter 1.4.2 by Theresa Schulte & Claus Bolte) and on the setting up of the PROFILES innovative learning environments (see Chapter 1.4.3 by Jack Holbrook & Miia Rannikmae), as well as provides insights into the development of teacher preparations through Continuous Professional Development and the moves towards establishing evidence for Teacher Ownership of the PROFILES ideas (see Chapter 1.4.4 by Avi Hofstein & Rachel Mamlok-Naaman) and the involvement of stakeholders into IBSE networks (see Chapter 1.4.5 by Franz Rauch & Mira Dulle).

Of special significance are the contributions by project partners and the involvement of their highly motivated teachers, presented within the interactive poster sessions, which strongly enrich this book (Chapter 2). The presentations reflect the poster contributions of all PROFILES Consortium partners and include a large range of good practice examples, experiences and research results in the field of science education, CPD operations and the classroom interventions using PROFILES type teaching modules.

In Chapter 3, the ten workshops, presented in the PROFILES conference from 24th – 26th September 2012 in Berlin, Germany, go into further depth on specific PROFILES related topics: against a background of the Bologna Process, Chapter 3.1 seeks to elaborate the meaning of learning outcomes within the PROFILES teaching modules. Chapter 3.2 gives an insight into the statistical analyses of survey data via R-Commander seen as very appropriate in analysing e.g. the PROFILES Delphi Study and other data collected in the context of PROFILES or other studies and interventions.

The project partners from Turkey, Finland and Cyprus show examples how information and communication technology (ICT) can support PROFILES science teaching and learning via different programmes and tools, like: including robotics in PROFILES modules (Chapter 3.3), using social software in pre-service teacher education (Chapter 3.4) and including WebQuest as a focus for student learning via IBSE (Chapter 3.9).

Chapter 3.5 identified an interdisciplinary Science-Technology-Society (STS) approach to science teaching in line with PROFILES philosophy. A focus on the development of classroom teaching modules meeting the intentions of PROFILES, is highlighted in Chapter 3.6, while Chapter 3.7 focuses on the potential of action research to overcoming issues in developing exemplary practices in the implementation of PROFILES teaching. Chapter 3.8 details the inclusion of experimentation within different levels of Inquiry-based Science Education (IBSE).
Chapter 3.10 throws light on the need to establish evidence of teacher ownership and leadership which goes beyond levels of self-efficacy in utilising PROFILES teaching modules.

The last chapter includes critical statements regarding implementation of best practices in IBSE related learning environments within PROFILES from an outside observer (see statements and recommendations from the PROFILES External Evaluator, Wolfgang Gräber, in Chapter 4.1).

The PROFILES Consortium as a whole and the organizer of the "1st PROFILES International Conference on Stakeholders Views" regarding Inquiry-based Science Education, as well as the editors and authors of articles within this "PROFILES Book" wish to assure you of many interesting insights and look forward to your continuing interest in the further developments within the PROFILES project. In the next PROFILES Newsletter you will be able to read more about conference impressions from Peter Childs, the PROFILES Conference observer and critical discussant.

In the name of all authors of this PROFILES Book we wish you interesting insights regarding IBSE in Europe in general and the cooperations with the PROFILES project in particular.

Yours,

Claus Bolte, Jack Holbrook, Franz Rauch and Mira Dulle

CHAPTER 1: SUCCESSFUL IMPLEMENTATION OF INQUIRY-BASED SCIENCE EDUCATION AND SCIENCE TEACHERS CONTINUOUS PROFESSIONAL DEVELOPMENT

1.1 INQUIRY-BASED SCIENCE EDUCATION IN EUROPE

1.1.1 Inquiry-based Science Education in Europe: Setting the Horizon 2020 Agenda for Educational Research?

Peter Gray – Norwegian University of Science and Technology & the S-TEAM Project, Norway

Introduction

The numerous inquiry-based science and mathematics projects, including PROFILES, Pathway, PRIMAS, Fibonacci, ESTABLISH, SAILS and S-TEAM initiated by the EC are now mostly beyond the mid points of their various trajectories, and will finish more or less as Horizon 2020 begins. As project participants, we know many things about IBST, and have begun to develop a shared understanding of its role in promoting better engagement with science, technology engineering and mathematics (STEM) in schools. As a research community, we are now at a crucial stage in the evolution of European research and development on science education, with the shape of Horizon 2020 being argued over by its many stakeholders. Education has not, until now, played a very significant role in the construction of Horizon 2020, but, as I will argue below, it should be a fundamental part of the strategy.

Horizon 2020 is currently of interest mainly to potential beneficiaries of research funding, but in order to produce real progress and to meet the various EU priorities regarding 'Responsible Research & Innovation', etc., Horizon 2020 needs to be brought into the public consciousness. This can usefully be done in schools, since the 'Societal Challenges' identified in the programme are increasingly the focus of attention in curricular areas ranging from natural science through scientific literacy, to citizenship and moral philosophy. Horizon 2020 could act as a 'gathering' mechanism to help these curriculum subjects to work together. Before we move to Horizon 2020 projects, however, we need to maximise the learning from our collective participation in Framework Programme Seven, Science in Society and related activities. This is of interest because Horizon 2020 will require interdisciplinary collaboration, probably on a larger scale than FP7.

In Horizon 2020, funding will be focussed on the following challenges:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture, marine and maritime research, and the bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Inclusive, innovative and secure societies;
- Climate action, resource efficiency and raw materials.

These can, I argue, form the basis of a new scenario for STEM education in Europe.

On the way to outlining such a scenario, I will first preview the synthesis of available findings from current STEM education projects in FP7, which will be created for the forthcoming (December 2012) INSTEM project, a Comenius project funded by the Lifelong Learning Programme. Preliminary results indicate that projects have a general sense of frustration with the short-term nature of EU actions in this area. The overall aim of spreading IBST is widely shared across national education systems, but the limiting factors are favourable conditions for teacher development activity, and lack of overall coherence between pedagogy, curriculum and assessment within these national systems. Naturally, there are variations between and within national systems at all levels.

Within this general agreement, there are many differences in the overall approaches taken by STEM education projects, particularly in terms of their interaction with national systems. For example, the role of the German SINUS programme in providing a basis for subsequent projects in IBST, such as Mind the Gap, Fibonacci and S-TEAM, is well known. In the case of EU-funded projects, however, we need to move beyond action at the national level, to action within a European space for educational research and development.

There is a European policy 'envelope' within which STEM education has been seen primarily as a tool to improve economic competitiveness, and secondarily as a route to the democratic involvement of citizens in scientific and techological decisions. The traditional academic attitude to the relationship between education and the economy has been one of resisting instrumentalism and of promoting a broader concept of education, perhaps best captured by the term '*bildung*'. At the same time, there has been a tendency within academia to uncritically accept the concept of the 'knowledge economy', and to promote a discourse of accelerating change and the accompanying need for urgent reform.

The pace of change in education is, however, (un)surprisingly slow, given the mass and complexity of the systems involved, and in fact a recent call for research into change processes within education systems (SSH.2012.1.1-1. *Challenge: Education systems in the 21st century*) indicates the frustration felt within the EC at its inability to catalyse educational reform. There is, therefore, an opportunity to create a more forward thinking and better informed concensus on future actions in STEM education. This requires a perspective on change processes which takes into account resistance and the variety of drivers for change, beyond the technology cycles exemplified by endless versions of Windows, or the Volkswagen Golf.

The conference presentation will also include a brief report on the findings of a workshop series at ECER 2012 (Cadiz) set up by EERA (European Educational Research Association) to consider how social science and humanities can contribute to the Horizon 2020 programme. One suggestion which may well emerge from the workshop is that school science and mathematics should become more closely engaged with real world research. In S-TEAM, we have experience of initiatives using narrative or drama to increase pupil engagement with science. in these narratives, engagement is increased because pupils gain ownership of the results of scientific activity and recognition for their scientific contribution. When school science has effects in the world, both the social and intellectual benefits of schooling are increased. This is not the only possible way forward, however, and I will suggest several posible scenarios as to how the STEM education community can contribute to future progress. Firstly, however, I will discuss the initial synthesis of project results resulting from the activities of ProCoNet and the INSTEM project.

Synthesis of available findings

At this stage, the findings are provisional. Nevertheless, we have a number of possible recommendations, which have evolved during discussions in ProCoNet and elsewhere.

1. The move to inquiry-based science teaching methods, and associated improvements in the quality of teaching, need properly aligned curricula and assessment systems that specifically support inquiry, to allow teachers to work creatively with pupils across topic areas and to exercise pupils' imagination and curiosity. In other words, classroom and school environments as a whole should support inquiry, especially in science but also in mathematics and across the curriculum generally.
2. The support of colleagues and school management together with collaborative inquiry into practice is necessary for the effective implementation of inquiry-based science teaching.
3. Authentic inquiry happens when pupils are looking for answers to questions owned and, where possible, formulated by themselves. Inquiry can thus make a difference to pupil motivation, but the open-ended nature of inquiry needs to be carefully adjusted to the desired outcomes, the need for teacher support and the constraints of existing curricula and assessment systems.
4. Inquiry achieves better understanding of ideas or concepts, and better develops a range of intellectual and practical capacities, but may take more time than traditional methods. Changes to systemic practices, including curriculum design and assessment methods, will be required, but small-scale demonstrations of the effectiveness of inquiry can help to bring about these changes. Teachers should be prepared to experiment with their own practice, and should not see inquiry as an all-or-nothing activity, but as part of a repertoire of actions directed towards improved pupil outcomes.
5. Inquiry is embedded in specific situations and is multi-dimensional. Teachers should be able to select appropriate dimensions of inquiry, in order to facilitate understanding, learning and engagement amongst all pupils.
6. Science content knowledge and pedagogical process knowledge (PPK) are equally important for the implementation of inquiry-based science teaching. In addition, it is vital that science teachers are conversant with the nature and history of science, since the nature of inquiry is as complex as the nature of science itself.
7. Science teachers also need pedagogical content knowledge (PCK) and pedagogical process knowledge (PPK) to support, for example, argumentation, experimentation, dialogic teaching, motivation, use of innovative, cross-curricular methods such as drama and narrative, and cross-curricular working in general.
8. Teachers' values, beliefs and the purposes of education are sometimes in conflict, but inquiry provides a basis for resolving these tensions.
9. More priority should be given to collaborative teacher professional development activities, which should be part of a coherent professional development structure aimed at improving teaching quality, educational outcomes, pupil engagement and teacher retention.
10. Professional development should be coherent with initial teacher education and should be seen in a context of lifelong learning for teachers, rather than just being about imparting information.
11. Professional development should be conducted in teachers' professional contexts, and should be empowering for teachers, who should be able to change their practice as a result.
12. Initial teacher education should itself be inquiry-based, and should give pre-service teachers the possibility of conducting their own inquiries into practice.
13. In a globalised and increasingly mobile world, there needs to be more attention to learning from other educational systems, in

order to avoid wasted or duplicated effort and to increase educational mobility.

14. Educational interventions should be research-based, sustainable and should reflect the length of time spent by pupils in the system, typically from 11-13 years.
15. There should be stronger coordination between research and development projects, and better use should be made of results and experience across research project clusters in particular topic areas.

These recommendations are of course quite general, because it is neither appropriate nor useful to impose detailed recommendations on teachers at the level of specific topics, or in the form of 'tips' for good inquiry-based teaching practices. The exact form of inquiry implementation will inevitably vary across and within national contexts.

National differences

Here we have to clarify the role of action at the European level versus action at national level. Most European countries are engaged in continuing reform of some or all aspects of their education systems. These reforms may or may not include elements of inquiry-based science and mathematics education. There is a trend towards opening up the science curriculum to more varied teaching methods and topics, with the use of 'core concepts', 'key ideas' and so forth. As researchers with interests in inquiry-based methods, we should engage with these national reforms, but we also need to pursue a European agenda. The policy envelope for this agenda is a general increase in innovation, creativity, imagination and at the same time increased engagement with science and mathematics. We need to pursue it because the real societal challenges identified by the EC can only be addressed by a paradigmatic shift in attitudes and capacities across the entire population, from a passive to active mode of education, based on the capacity for inquiry and democratic participation.

What this would really mean in practice is a more open education system with the capacity to develop in different directions. At the moment, there is little sign of coherent negotiation between national school assessment systems, national higher education systems and the European institutions which could coordinate such action. A project to research the role of formative assessment in STEM education has just been negotiated, but is unlikely to produce significant results before 2014 at the earliest.

Who are the stakeholders in such a project? Industry, SMEs, the public sector and civil society employers, as well as 'European society' in general, all have an interest in a more flexible and productive education system. The main barrier, as we see in national contexts as well as in the European arena, is the reluctance of politicians to take risks with what they see as the measurable results of current systems, with percentage increases or decreases in achievement, attainment or 'value added'. We need to research ways of protecting students from the effects of change, and from ending up in a free-fall situation where they have done interesting and engaging things at school, without recognition of their skills and achievements.

Future Scenarios

There are essentially three possible scenarios for the future of European (and indeed, global) education:

Scenario 1 is business as usual, with tensions between progressive and conservative tendencies, a confusion of purposes, aims, objectives and outcomes and a disillusioned and demotivated student population. This is the scenario which the EC wishes to address, but is limited in its scope due to the legal restrictions on its powers in relation to national education systems.

Scenario 2 is a gradual acceleration of the implementation of new methods, adoption of new technologies and responsiveness to difference and student voice. This scenario is the emerging picture from our work with EU projects, but is insufficient in itself to address wider societal objectives, as can be seen in the sub-texts of current and emerging EU programmes, including Horizon 2020.

Scenario 3 is a complete rethink of the purposes of education, based on the principle that learning, life and work have become part of a whole being-in-the-world and that the purposes of education and the emergence of new, sustainable societies are convergent. This scenario may seem somewhat over-ambitious, especially to those of us who have worked directly with schools and teachers in STEM projects. The point, however, is that the current passive mode of education, in which students are 'prepared' for the so-called 'world of work' is demonstrably failing to provide them with opportunities to be innovative now, as opposed to sometime in the (for them) distant future. An active mode of education sees students as sources of innovative thinking. This is not the same as a purely constructivist view of education, which is counter-productive, at least in relation to science. Innovative thinking builds on a strong foundation of existing knowledge but requires an opening or openness rarely found in current education systems.

Scenario 3 would be based on the idea that active inquiry and real-world research, suitably evaluated and documented, would be the best basis for both student outcomes and future societies. By 'active inquiry', I mean students agreeing on the object of inquiry, developing methods, observing results and arguing for conclusions, in line with the concept of 'responsible research and innovation' currently promoted by the EC. By 'real world research', I mean finding the causes of, and solutions for, current problems, whether at local, regional, national, European or global level. This would require extensive collaboration between students, schools, universities and other research organisations, industry and policymakers, which in itself would provide learning experiences.

Although Scenario 3 is in itself a policy change, it also requires policymakers to step back and recognise that risk cannot be removed from education, either by continual policy changes or, more specifically, by continual testing. In fact, as current projects are finding, both of these increase rather than decrease the risk of poor educational outcomes. By coupling the Horizon 2020 challenges directly to education systems in Europe, we can increase the available research and innovation capacity by a huge factor, whilst simultaneously increasing student motivation, engagement and achievement. The real risk lies in doing nothing!

1.1.2 Teachers Views on Inquiry-based Science Education

Ilmars Rikmanis – Riga State Gymnasium No 1; Jazeps Logins and Dace Namsone - University of Latvia, Latvia

Introduction

In skilfully planned and implemented inquiry-based science education, students play an active part in the learning process; they are an important part of it. In this way, student-centred education can be implemented. Students develop and improve not only their process skills, but also their cognitive learning and communication and cooperation skills. However, there are a few difficulties to be faced when putting inquiry-based science education into practice in schools. According to the opinion of colleagues, the most critical difficulties are:

- lack of teacher competence in inquiry-based science education
- teacher concerns that they could fail by doing something new

With these in mind, it is felt important to find out how well a teacher, having no work experience and a teacher with extensive work experience, can implement the inquiry-based approach, what are the benefits of this approach and the difficulties encountered.

The module “Water I Use in Daily Life” and its implementation

An inquiry-based approach was put into practice in Latvia, by implementing the PROFILES module “Water I Use in Daily Life”. This grade 8 chemistry module, comprising 5 lessons, was created based on PROFILES project guidelines (Holbrook, 2011). The main points of the module are outlined in Figure 2.

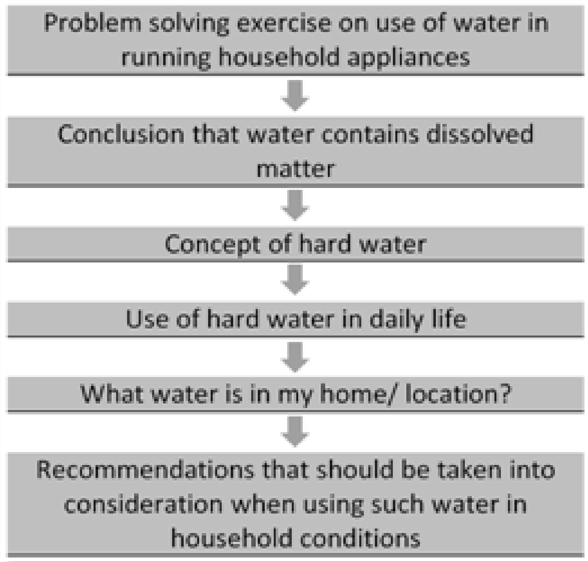

Figure 2. Main points of the module

<u>Lesson 1:</u> Students interact with the scenario about steam irons and formulate a possible explanation based on an assumption that matter is dissolved in water and this can influence the functionality of household appliances. In groups, students plan a laboratory investigation to test the assumption.

<u>Lesson 2</u>**:** Students undertake the experimentation and draw conclusions based on the results.

<u>Lesson 3</u>**:** Students comprehend and interpret a provided text and debate the essentials when

Figure 1. Module realisation in Riga State Gymnasium No. 1

Figure 3. Comparing hardness of water samples

using hard water in households. Students distinguish between hard and soft water and discuss their use in daily life.

Lessons 4 and 5: Students plan a laboratory investigation to determine the type of water (hard or soft) in the students' homes. Students have been guided that finding whether the water is hard or not can be undertaken using soap solution (Figures 1 and 3).

Students make recommendations on how the water in their homes can be used.

First author, Ilmars Rikmanis, a new teacher, taught the above mentioned module in two grade 8 classes and compared her results with the results of six other teachers having extensive work experience. The comparison was based on student observations, students' written evaluation and a student survey.

Results and discussion

Results from the student survey (Figure 4) show that more than 70% of the students worked with interest in these lessons and more than 90% of the students saw the module's connection with real life. Thus, it is understandable that almost 90% of the students said they would like to learn other topics this way as well.

The students felt that inquiry-based learning had stimulated their interest, leading to increasing students' knowledge in the subject. Even students with low grades shown interest. As can be seen from a teacher's comment:

"Another benefit – students' attitude towards chemistry itself has changed, because working this way shows that underachievers can do and finish their work. Four schoolboys even attended a consultation with a desire to learn about writing formulas correctly!"

Analysis of students' worksheets and self-evaluation sheets shows a very important benefit of IBSE for students – inquiry-based learning has really improved their process skills.

From students' self-evaluation (Figure 5) we can see that, after the module, students evaluate their process skill much higher than before – they feel their skills have improved. The stu-

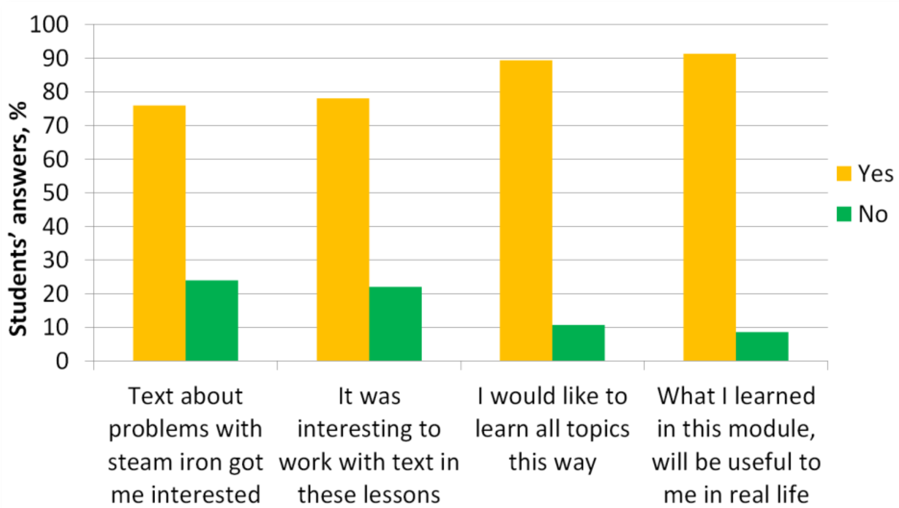

Figure 4. Results of the student survey

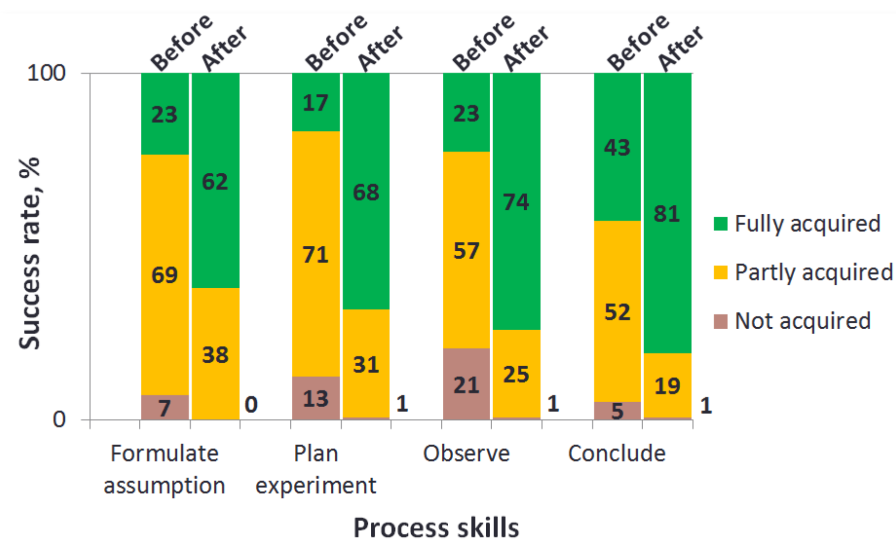

Figure 5. Student self-evaluation before and after the module

dents feel more certain about their abilities, feel safer solving inquiry-based issues, seemingly because they realize that they are able to do it!
94% of the students recognize that it is easier to work in groups, and 86% of them think they divided responsibilities within the group successfully. For example, a student said: *"Together we could figure out, understand and do everything!"* Nevertheless 6% admitted that it was difficult to work with students to whom they did not relate. For example: *"It was difficult to work with people with whom you don't get along with very well, but it was good for me and gave me experience."*

When comparing the given results with those from teachers having an extensive work experience, no substantial differences appeared – all results were similar.
As for the main problems when using PROFILES modules in Latvian schools, one can identify the limited lesson time (only 40 minutes) and only a few lessons per week – in grade 8 there are only 2 chemistry lessons per week. A solution when the module is implemented is that; the lessons can be planned using the module as 2 + 1 + 2 lessons, or the module can be implemented during a science day, for example, as part of the project week. During a science day, it is possible to carry out all the module activities with no rush.

Conclusions

PROFILES type Inquiry-based science education develops students' process, learning, communication and cooperation skills. And very importantly – it increases their motivation in science lessons.
New teachers are able to carry out PROFILES-type inquiry-based science education, as well as teachers with extensive work experience, because for both groups of teachers, it is a new approach and often neither group has the necessary competencies. Also, new teachers have fewer inhibitions in implementing an inquiry-based approach, because to them any approach is new and they are less reluctant to change approaches. The main obstacle in carrying out inquiry-based education is time. There are just a few lessons a week and that is not enough for students to gain sufficient meaningful experiences. Therefore, the best solution is to organise science days during which the PROFILES inquiry-based module approach can be firmly initiated.

References

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1.2 CONTINUOUS PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS

1.2.1 Effective Continuous Professional Development in Science Education

Shirley Simon – University of London, UK

Abstract
Teachers often try out new idea to enhance their students' engagement and learning in science, but changes in practice may not be sustained unless accompanied by fundamental changes to underlying beliefs and values. In this paper I address the issue of teacher learning, what it means, what factors are involved, and what practical strategies can be put in place to make it happen. Drawing on examples from my own research I provide scenarios for learning that can form part of a wider agenda to enhance effective professional development in science education.

Introduction
In recent years both in the UK and globally there have been concerns about the quality of science teaching in schools and its impact on the uptake of science by young people going on to further and higher education (Millar & Osborne, 1998; Osborne & Dillon, 2008). The problem of young people's declining interest in science was highlighted in the data of the Norwegian Relevance of Science Education (ROSE) project (Sjøberg & Schreiner, 2005), in which the attitudes of students aged 15-16 years towards school science were surveyed in over 20 countries. The study showed an increasingly negative response to the question 'I like school science better than other subjects' the more developed the society. In the UK there are funded initiatives to support the Continuing Professional Development (CPD) of science teachers through various initiatives, emphasising the role of senior and experienced teachers in modelling practice, and of schools communicating with other schools to share best practice. There are also nine Science Learning Centres that were set up in England in 2004 to promote the professional development of science teachers in each region of the country. The Centres are part of a government initiative to enhance science teaching and learning and offer CPD courses for teachers. Whatever the initiative and its location, an on-going concern is to examine what makes CPD effective.

From many years of research undertaken with science teachers I have found that unless teachers really want to change, or really value how a particular change can make their and their students' experience more worthwhile, they will not alter how they perceive themselves as science teachers or radically change their practice. My work with teachers in developing practice began with a major project undertaken at King's College London, where I worked with Alister Jones, Paul Black and other colleagues. The project was called the Open Ended Work in Science project, or 'OPENS' (Jones, Simon, Black, Fairbrother & Watson, 1992), and came about after changes in the English national curriculum for science introduced investigative or inquiry-based learning as a significant component to be assessed across the age range from 5 to 16 years. In the OPENS project the research team worked alongside teachers from nine secondary schools to produce materials and develop good strategies for teaching inquiry. We quickly ascertained that every teacher was different in terms of experience with inquiry, beliefs about teaching and learning, and values. We needed to explore each existing situation to negotiate a starting point for development, and plan with individual teachers how they would try out new approaches in their teaching of science. We also encouraged teachers to reflect on and evaluate the changes and outcomes of their practice.

Working with these teachers on the OPENS project alerted me to the need for establishing starting points, individual differences and the value of shared reflection in a professional development context.

In the 20 years since this project I have discovered from reading the international literature that similar issues occur globally, and that teacher learning is a complex process that has been theorised and modelled by many authors. In this paper I draw on particular studies that have helped my own work with science teachers, to show how I have interpreted and understood teacher learning in my research and how research informs effective professional development. In my view there is a need to consider teacher learning from both a cognitive and situated perspective, in order to take into account individual learning processes as well as social and contextual influences. I have come to conceptualise teacher learning as a complex combination of the individual teacher's knowledge growth, the professional teacher practicing in a particular setting and the social teacher working collaboratively with others in that setting.

The focus of CPD in science education can be categorised broadly into subject knowledge enhancement, management of practical work, pedagogic approaches and leadership. The importance of subject knowledge for both primary and secondary teachers cannot be understated and there are many studies to show how confidence in subject knowledge underpins the ways in teachers interact with students, including one I carried out in the early 1990's (Osborne & Simon, 1996). However, most of my own research has centred on developing pedagogical approaches that address aims other than the learning of science content; research and development such as that cited above has focused on goals relating to science inquiry and its practice, and more recently my work has concerned the process of argumentation as a means of developing epistemological reasoning. Both of these aspects of science education come under the umbrella of what is known in the English curriculum as 'how science works'. Working with communities of science teachers in school departments has also led to a focus on issues of leadership and the impact of school culture on the effectiveness of CPD.

The role of theory in effective teachers' professional development has been of particular value in the initiatives I have experienced or developed. Pedagogical practice that is underpinned by a deep understanding of teaching, learning and classroom environments has been of particular significance in my work, as demonstrated in the following section.

Theoretical background

In the late 1990s I became involved in the professional development of teachers as part of a major innovation called Cognitive Acceleration in Science Education (CASE). Whilst working on this project with Philip Adey I learnt to appreciate the value of having good theoretical foundations to new teaching initiatives. CASE drew on a theoretical base derived from the work of Piaget and Vygotsky, being underpinned by conceptions of students' reasoning in terms of Piaget's stages of development (Shayer & Adey, 1981) and the social construction of knowledge. The CASE team designed science curriculum materials to promote formal operational thinking (Adey, Shayer & Yates, 1995), and a professional development programme to support teachers as they attempted to use the materials to promote cognitive conflict and social construction of reasoning. The development program involved university based workshops, in which teachers were introduced to the theoretical base, engaged in activities to experience cognitive conflict and construction, and shared with each other reflections on practice. As a CASE trainer I became aware that teachers' who optimised the implementation of the CASE activities were those who had a good grasp of the theoretical basis for the initiative; they would set up cognitive conflict appropriate to the activity and their students, and encourage classroom dialogue and peer interaction that promoted the social construction of reasoning.

The importance of theory in developing teachers' practice also featured in my work on argumentation in science education with Jonathan Osborne and Sibel Erduran, which I began in 1999. In this work we drew on the analytic framework developed by Toulmin (1958). His model of argument, referred to here as Toulmin's argument pattern (TAP), included the essential elements of argument as claims, data, warrants and backings. We used TAP as a framework for analysing the components of arguments occurring in classroom discourse and hence the quality of argumentation (Erduran, Simon & Osborne, 2004; Osborne, Erduran & Simon, 2004a; Simon, Erduran & Osborne, 2006). The application of TAP was underpinned by the assumption that the more elements of TAP that were present in the dialogue, the better the quality of argumentation. Claims supported by grounds including data, warrants and backings were deemed to represent more complex hence more sophisticated arguments. Moreover, argumentation including rebuttals, where the data or warrants were opposed, was seen to foster the process of justification and elaboration of evidence. We also generated a scheme where argumentation was assessed in terms of levels, which illustrated the quality of opposition or rebuttals in students' small-group discussions. The presence of a rebuttal was a significant indicator of quality of argumentation as rebuttals force students to evaluate the validity and strength of arguments. The focus was on those episodes of student-student dialogue where there was a clear opposition between students, and the nature of this opposition was assessed in term of the strength of rebuttals offered.

Professional development materials building on this research (Osborne, Erduran & Simon, 2004b) included teaching activities, strategies for small group discussion, lesson planning, and evaluation of student outcomes. One deliberation that occurred in working with teachers was how they might respond to the introduction of Toulmin's definition of argument. Having used TAP as an analytical tool for research purposes, it was envisaged that teachers' understanding of argument might be enhanced if they too used TAP as an analytical tool. Some teachers found that using the Toulmin perspective on argument helped to inform their pedagogical strategies (Simon, 2008). For example, one teacher introduced the meaning of argument by presenting students with two arguments, one involving a simple claim, the other a claim supported by evidence in the form of data and warrant. She asked students to judge which of the two arguments was the stronger and why. The students focused on the existence of reasons and the teacher used their responses to highlight the importance of evidence in argument. The analytical process had helped her to conceptualise argumentation in a way that informed her practice.

These examples from my research with initiatives in science education have stimulated questions about the nature of teacher learning and teacher change, which resonate with those posed by Bell and Gilbert (1996) about teacher development and which other authors have taken up:

"What is the nature of teacher development?
What factors help and hinder teacher development?
What model of teacher development can be used to plan teacher development programs and activities?
What teacher development activities promote growth?" (Bell & Gilbert, 1996, pp. 9-10)

The following sections highlight some key models and ideas that I have found particularly influential in understanding the nature of and conditions needed for teacher learning. Insights provided by applying such models have helped to highlight ways in which the development of specific practices can bring about change, hence inform professional development programmes.

Teacher development models

Bell and Gilbert based their model on a view of learning that takes into account human development and the development of self-identity, social constructivism, and reflective and critical enquiry. The model portrays teacher development as taking place in three intertwined domains, the personal, professional and social, and identifies how progress occurs in each of these three domains. What makes this model so relevant and enduring is that it arose from a study where teachers *reconstructed* their understanding of what it means to be a science teacher in fundamental ways.

The first stage of development occurs when teachers begin to see an aspect of their teaching as problematic (personal) and practicing in isolation as problematic (social), so they are motivated to seek out and try out new ideas in their practice (professional). As they progress in their development teachers deal with feelings and concerns that come about as they behave differently, for example loss of control, insecurity in subject knowledge, or uncertainty about how to intervene, and begin to change their ideas of what it means to be a science teacher (personal). They also begin to see the value of collaborative ways of working (social) and have confidence to develop their own ideas for classroom practice (professional). Progressing further in their development teachers feel empowered through increasing confidence (personal), they initiate or seek out collaboration (social) and eventually facilitate new kinds of professional development activities (professional). The notion of progression in this model can provide a basis for teachers to evaluate their learning within each domain, and how the three domains are intertwined. In an account of how particular teachers developed in the study, Bell and Gilbert identified the process of reflection as a key condition for progression. Reflection has become an integral part of many other models, for example as a fundamental process for stimulating change, as in Clarke and Hollingsworth's Interconnected Model (2002). In this model, Clarke and Hollingsworth created a cyclic version with different entry points, where change is seen to occur through the mediating processes of reflection and enactment in distinct domains: the personal domain (teacher knowledge, beliefs and attitudes), the domain of practice (professional experimentation) and the domain of consequence (salient outcomes). In addition, the external domain provides sources of information, stimulus or support.

Conditions for Teacher Learning

I have also found the work of Hoban (2002) particularly useful in considering what is needed to bring about teacher learning. In arguing for the notion of a professional learning system, Hoban identifies eight conditions that are needed to bring about teacher learning. These include:

- a conception of teaching as a dynamic relationship with students and with other teachers where there is uncertainty and ambiguity in changing teaching practice,
- room for reflection in order to understand the emerging patterns of change,
- a sense of purpose that fosters the desire to change,
- a community to share experiences,
- opportunities for action to test what works or does not work in classrooms,
- conceptual inputs to extend knowledge and experience,
- feedback from students in response to ideas being tried, and
- sufficient time to adjust to the changes made.

An evaluation of whether or not these conditions for learning are present in the context of an innovation can provide the basis for planning work with teachers. As Hoban points out, on their own, each condition is unlikely to sustain teacher learning, it is the combination of conditions that is important.

High Leverage Practices

Teachers' interpretations of the intended curriculum are determined by their own beliefs and values. Such interpretations have implications for teachers' enactment and the 'curriculum in practice'. The default position is often a focus on the development of conceptual understanding at the expense of other, newer, curriculum goals. How can professional development overcome the obstacles to interpretation and enactment so that intended learning goals are realised?

Professional development programmes that have focused on the introduction and implementation of high-leverage practices (HLPs) in teacher education (Windschitl et al., 2010) have been based on an evidence-informed system of learning opportunities, tools, and formative assessments tailored to the needs of novice teachers. Such systems and tools can be designed to foster effective pedagogy over time. The work has been motivated by the perceived need to shift the emphasis from instructional procedures and management strategies in preparing new teachers, towards valued classroom practices that focus on student thinking and learning. HLPs are grounded in important learning goals for students, in research on students' learning and how novices learn to teach. Windschitl et al. (2010) envisage HLPs to be core to ambitious teaching. My work with in-service teachers suggests that this perspective rests on a view of 'good teaching' that is more than a set of behaviours learnt through the accumulation of on the job experience, it is a product of specialised knowledge. HLPs are instructional routines that make students' thinking visible, so they are practices that enhance students' learning from a particular set of instructional strategies, and that help teachers learn about effective teaching through their practice.

The identification of HLPs begins with the learning goals for students. For example, in the teaching of argumentation, specific goals have been identified over many years of research and curriculum development (Erduran & Jiménex-Aleixandre, 2008; Khine, 2011). Depending on the design of the activity, opportunities can be provided that enable students to consider and evaluate evidence, construct an argument which relates evidence to theory, examine whether evidence supports theory, generate counter-arguments, evaluate their own and others' arguments, work in groups to evaluate and present evidence, and learn to oppose a counter theory by constructing counter arguments and providing an explanation for why another theory is not plausible. My research in this area has shown that three key aspects of argumentation pedagogy to address these goals have consistently presented challenges for teachers in optimising the potential of argumentation activities: planning and organisation of small group discussion, adopting a teaching role for introducing and sustaining small group discussion that scaffolds argumentation processes such as justification of claims and counter-argument, designing and interpreting argumentation materials that can be used in lessons. These three aspects of argumentation pedagogy can form the basis of HLPs that teachers can use to achieve the learning goals of argumentation. How these and other features of CPD can be sourced and utilised is covered in the next section.

Sources of CPD

As mentioned earlier, the Science Learning Centres in England provide CPD courses for teachers, and these address a range of needs, including subject knowledge enhancement, technical aspects of teaching science such as practical procedures, or more fundamental pedagogical practices, such as formative assessment. Courses may be just one day, or two to three days over a period of time with teachers taking ideas and activities to try out in their schools so that they can reflect and subsequently feed back ideas to colleagues on the course. A model of professional development that entails teachers coming out of school to attend short courses may be limited in its impact on pedagogy, even though such a model is financially and organisationally the most viable. Recently the Centre based in London has initiated outreach activities in schools, in response to science departments requesting such support whilst they attempt to initiate fundamental changes in practice, such as assessment, and these are tailored to be more relevant to teachers' contexts and needs. Small-scale research studies into the impact of outreach courses suggest that they are particularly effective in engaging teachers' interest and willingness to try new instructional practices.

CPD that is relevant to communities of science teachers working in schools and supported by strong leadership was found to be effective in an interview study I conducted with colleagues in 2009/10 (Simon, Campbell, Johnson and Stylianidou, 2011). The research set out to investigate the features in schools and science departments that were seen as effective in contributing to the CPD of early career science teachers. Ten schools took part in the study, selected on the basis of their reputation for having effective CPD practices. To gain different perspectives from within the organisations we conducted interviews with senior members of staff, heads of science departments and early career teachers. A thematic analysis of the interviews revealed a wealth of practice, which included a focus on broadening experience beyond the classroom, having an open, sharing, non-threatening culture and systemic procedures for mentoring and support that involved ring-fenced budgets. The schools also deployed staff judiciously in critical roles that model practice and motivate early career science teachers. Early career teachers were concerned primarily with their overall development as teachers, though some science-specific examples such as observing practical work and sessions to address subject knowledge were seen as important. Studies of how departments operate socially (Siskin, 1994) suggest that quite different environments can exist, ranging from collaborative working and a commitment to shared goals, to split departments where groups of teachers have conflicting aims.

To promote effective CPD for science teachers, a key source that I have found to be particularly influential is the use of video. In the early OPENS project on science inquiry I helped to produce video material that became part of an in-service package, and found that specific pedagogical practices could be very quickly understood and debated with teachers if portrayed in a filmed classroom setting. I became more convinced of the value of video later when taking part in developing the argumentation in-service raining package and video, called IDEAS (Osborne, Erduran & Simon, 2004b). I am now currently developing more film-based materials for CPD on a website based on the aforementioned HLPs, which will be the focus of three professional development units: the planning and organisation of group-work, the teacher's role in argumentation, and the design and interpretation of materials. The development of the film material and subsequent professional development tasks has involved close collaboration between teachers in the schools associated with the project, a specialist film production company and the project leaders. A key feature of using films of teachers in effective professional development is the use of naturalistic teaching settings (Hatch & Grossman, 2009) and so this is an important aspect of the website. The nature of filming in a naturalistic setting is always problematic, and three filmed lessons were required in order to capture a sufficient range of elements of group-work and argumentation that were essential to the successful design of the professional development tasks. The three teachers involved in this stage of the project had taken part in previous projects related to argumentation and were well versed in the skills needed to establish and maintain effective argumentation activities in science lessons and were familiar with much of the literature and resources that support this pedagogy.

Conclusions

A major question relating to the topic I have presented here is how can we know whether CPD has been effective? My main concern over the years has been to answer this question through the behaviours of the teachers themselves, for example, as shown in Simon et al. 2006. However, it is clear that any real impact must be evidenced in how the CPD has influenced student outcomes. Adey and Shayer devoted many years to establishing evidence for the effects of cognitive acceleration (Adey & Shayer, 1994; Adey, 2004). Their evaluation of professional development was not focused on individual teacher learning, but on sustained implementation by science departments. Such an enterprise requires many resources, and yet still does not provide a direct causal link between CPD and student outcomes. A conversation with Lee Shulman (November 2010) helped to convince me that the distance between CPD and student outcomes is so great that direct links are very difficult (if not impossible) to establish. I remain convinced that the best way to judge the impact of CPD is through the behaviours and perspectives of teachers, using analytical tools such as that of Clarke and Hollingsworth to measure growth in different dimensions (personal, professional and social), and particularly in changes of salient outcomes, that is what teachers value as outcomes of practice. Factors influencing individual teacher learning become apparent through close contact with teachers, and include motivation to want to change, an understanding of the theoretical basis of a new curriculum materials and teaching approach, and an appreciation of perceived benefits for students.

Finally, one aspect of science learning that I have kept in mind and communicated to teachers on many occasions during CPD programmes is that of enthusiasm for the subject. I conclude with two quotations that have enthused my own science education journey that began 40 years ago, one for primary science and one for secondary chemistry:

“We started the year with a 'Seaside Room'. Ready beforehand were displays of shells, pebbles, and sand; aquaria with live crabs and sea anemones; seaweeds; boxes and tables for collections made during the summer holidays; drawing materials, paper for labelling and a selection of named specimens, reference books and pictures.” (Conran, 1983, p. 18)

“Dorothy and her fellow students made solutions of alum and copper sulphate from which to grow crystals. Over the days that followed they watched as the solutions slowly evaporated. Gradually the crystals appeared, faceted like jewels, twinkling in the light. Dorothy was enchanted. ‘I was captured for life’, she later wrote, ‘by chemistry and by crystals’”.

(Ferry, G. (1998) Dorothy Hodgkin, A Life, p. 8)

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1.2.2 Being a PROFILES Teacher: A Teacher's View on Teacher Training and Continuous Professional Development

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Recently, in parallel to developments in science education, we, as teachers, have reconsidered and revised our understanding of teaching and learning science. One of the innovative projects that guide us in this reconsideration and revision is PROFILES. The project has extended our vision in terms of teaching science and technology. It has contributed to our profession by means of scientific and active learning.

The value of the project, I think, lays its efficiency in adapting a teaching method that is in coherence with the changing goals of science education. The teaching method not only has shifted our teaching from direct teaching and passive learning to active and inquiry-based teaching, but has also encouraged us to be creative science teachers.

The pace of developments in the area of science is not easy to keep up with and to teach to our students. I think, in the PROFILES project, we experience the most recent science education reform while learning through continuous professional development programmes for teaching in our classrooms according to PROFILES. I believe that if we expect our students to be scientifically literate citizens, we should promote the applications of the project in science education.

One of the important gains of the project I have realized is that during PROFILES modules implementation, I do not only guide students to achieve cognitive, but also attitudinal learning outcomes in science teaching. The project emphasises the use of science process skills. Through these skills, inquiry-based science teaching, and socio-scientific scenarios, students have an opportunity to gain a meaningful understanding of the nature of science.

The teaching methods we are encouraged to use in the PROFILES project help students to learn how to be persons who can realize up-to-date information, use this information and his/her knowledge effectively, and think critically rather than having to content himself/herself with one source of knowledge (textbook) and try to memorize information. The results of the science exams in our classrooms support this, such that my students have learned how to search for information and generate solutions to the problems they face. These gains have been reflected in our science classroom and students suggest they enjoy what they now learn in science.

Recent developments in science education, as well as the PROFILES project, require the science teacher to design an interactive learning environment. During the PROFILES modules development and implementation, we teachers can achieve this through searching for socio-scientific contexts in local and in global, situations so that we can enhance students' comprehension and learning. Some teachers complained it took too much time to utilize modules, but I think, the allocated time for modules is appropriate to be able to implement them effectively. To use the time effectively and to implement the modules completely are both important for the promotion of the targeted skills and for the long-term learning. Additionally, it allows students to participate in the lesson, as well as increase their reading and searching abilities. Modules also bring up socio-scientific issues which students find familiar, but have not thought about much. The socio-scientific issues are valuable because through socio-scientific issues, students face real life issues in which they can use their newly gained science knowledge to reflect further on these issues. This activity increases students' interest and motivation and students become active learners.

In the PROFILES project, the selection and design of visual materials for science teaching is as important as the use of them. All the activities in the modules are prepared in line with the teaching goals and objectives of the curriculum, which allow our students to practice and operate their science knowledge. The inquiry-based science teaching, advocated within project modules, reinforce the use of up-to-date information and reflect real-life. They provide approaches to the science topics we teach which are concrete and related to life. Moreover, they promote learning through steps which begin from the easy and familiar and progress to the hard and critical issues. Modules were designed in our case such that they are appropriate for the students' developmental characteristics, their level of material use and the school's socio-economic context.

The PROFILES project enhances most of our skills as science teachers. For example, during continuous professional development workshops, our creative thinking, problem solving and designing socio-scientific learning environment abilities are supported intensively. During the implementation of the modules in our science classrooms, I have realized that the most important task to promote long-term learning is to create a high quality learning environment. In these learning environments, students' intrinsic motivation to learn science increases. The number of students who participate in small group discussions and brain storming increases considerably. I observe that my students' abilities such as decision making and scientific inquiry have improved.

I believe that the PROFILES project should be disseminated and implemented to keep pace with the recent developments in science and science education. The project reinforces awareness of the need for science education. I have realized that the project is constructivist in nature and enhances students' active participation. More important still, the project is open to developments and innovations. It allows one to integrate new and innovative ways of teaching and learning science into the modules in an organized and proven-to-be effective way.

The visual materials that we used in PROFILES modules, as well as the teaching methods and techniques, are selected and implemented to increase students' intrinsic motivation and meaningful learning. One of the most valuable parts of the PROFILES modules is the scenario. The scenario draws the attention of the students to a real life issue and asks them to argue based on evidence, with the science evidence gathered in diverse ways such as search, data collection, observation etc. Students can study on a socio-scientific problem: search about it, make inference on solving the inherent scientific question based on observation and experiments, discuss and conclude. Students also learn to engage in socio-scientific argumentation in the PROFILES project. While arguing, they use tables, diagrams, graphs and visuals to support their arguments. The argumentation process encourages students to further engage in learning science.

Students' academic achievements and perceptions of inquiry-based learning are assessed through surveys. According to the data obtained after PROFILES application, science and technology lesson have become enjoyable and inquiry-based learning skills in students have increased. The PROFILES project enables student to be more active than even his/her teacher in the learning process. Thus, during the learning process students are in constant communication with other students and take on more responsibility for their learning.

The limitations of the project in terms of science teaching are, I think,

a) the time allocation for a topic in the curriculum is not the same as in the project;

b) the questionnaires are too long and time consuming for students to complete. My students complained about the number of choices in the questionnaires, and the existence of similar questions. I think these complaints should be taken into consideration since it would affect the results. The questionnaires should be adapted to the age and developmental levels of the students so that we can get more accurate and reliable outcomes.

My recommendations is to have a teacher's guide, where all modules are collected in a book and all other modules from different countries in the project might be in the same book to increase the diversity of modules. By this way, the project applications might be disseminated.

Through the PROFILES project, I believe, science education in our classrooms is more interesting and active since it increases attention and motivation of students. It is an important project for the achievement of scientific literacy.

1.3 TOWARDS RELEVANCE, STUDENTS (INTRINSIC) MOTIVATION, LEARNING OUTCOMES AND GAINS

1.3.1 Towards Relevance, Students (Intrinsic) Motivation, Learning Outcomes and Gains

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(To be added.)

1.3.2 Students' (Intrinsic) Motivation, Learning Outcomes and Gains

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The goal of science education is to enhance all students' scientific literacy. This includes going beyond the grasping of science concepts and understanding the nature of science, and towards realizing the relevance of science and technology to their lives and the will to continue their science study in school or beyond (National Research Council, 1996). Students' motivation for learning and continuing to learn science therefore falls within the issues that research in science teaching should address. Failure to develop children's interest in science will disempower a generation of children in an era when scientific knowledge is at the foundation of our culture (Watters & Ginns, 2000).

Motivation is defined as the internal state that arouses, directs and sustains students' behaviour toward achieving certain goals (Gynn et al., 2006). Intrinsic motivation for learning, as differentiated from extrinsic motivation, refers to the general state, whereby students learn for their own sake, rather than as a means to an end that is not directly related to learning. In this sense, intrinsic motivation could be described, as Brophy (1988) defines, as *"a student tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from them"* (p. 205).

Students' motivation has been found to play an important role in their conceptual change processes, critical thinking, learning strategies and science learning achievement (Lee, 1989; Lee & Brophy, 1996; Pintrich et al., 1993; Napier & Riley, 1985; Garcia & Pintrich, 1992; Kuyper et al., 2000; Wolters, 1999, as cited in Tuan et al., 2005). However, studies suggest that students begin school with enthusiasm, but gradually settle into a dull routine in which interest centres on minimizing the ambiguity about precisely what must be done and risk (Brophy, Rohrkemper, Rashidfi & Goldberger, 1983; Harter, 1981; Lepper, 1983, as cited in Brophy, 1983). This image is compatible with recent studies that suggest that students are unwilling to work hard towards achieving scientific understanding and spend their time and effort focusing on memorizing science vocabulary, or factual information, rather than trying to achieve conceptual understanding. They rely on inadequate explanations of science concepts, distort scientific knowledge to fit their existing knowledge, mindlessly answering questions and even copy answers from their texts or peers (Barlia, 1999).

Self-perceptions of ability, effort, goal orientation, task value, self-efficacy, test anxiety, self-regulated learning, task orientation and learning strategies have been identified as motivation factors by several studies (Garcia, 1995; Garcia & Pintrich, 1995; Nolen & Haladyna, 1989; Pintrich & Blumenfeld, 1985, as cited in Tuan et al., 2005).

Goal orientation of students has been identified as one of the key constructs, within the self-regulatory system, that contributes to a student's overall motivation. Students with learning goals tend to be intrinsically motivated, seeking understanding and a mastery of science content and skills, whereas students with performance goals tend to be extrinsically motivated, seeking to earn the highest grades and impress their instructors (Cavallo, Rozman, Blinkenstaff & Walker, 2003, as cited in Gynn et al., 2006).
The challenge for science education therefore is to find those ways that would engage students in the learning process, with a perception that they are doing something valuable and meaningful for themselves, and that they have the ability to do it successfully. As Tuan et al., 2005 cite: *"When students perceived that they are capable, and they think the conceptual change tasks are worthwhile to participate in, and their learning goal is to gain competence, then students will be willing to make a sustained effort and be engaged in making conceptual change."* (p. 641)

Learning environments, based on constructivism, might address a range of the above requirements. If each learner, individually and socially, constructs meaning, as he/she learns, then he/she does not passively absorb information, but rather, is engaged in meaningful learning by actively creating and modifying his/her knowledge structures (Palmer, 2005). Instructional strategies, based on constructivist theories therefore, are at least compatible, at a theoretical level, with initiatives aiming to encourage students to set and pursue goals for themselves and give them some degree of control over what they learn and how they learn it. This thus affects goal orientation, task value, self-regulated learning and task orientation aspects of motivation.

Inquiry-based learning environments are such environments. Inquiry-based learning refers to a learning process in which students are engaged (Anderson, 2002) and is defined as an active learning process: *"something that students do, not something that is done to them"* (National Science Education Standards, NRC, 1996, p. 21). Inquiry and constructivist teaching approaches therefore, share many educational objectives, such as emphasizing student construction of concepts and the relationship between student acquisition of concepts and the concepts' development in the history of science (Abd El Khalick et al., 2004) and promise the fostering of motivation for students in terms of self-regulated learning.

Still, there are challenges related to students' active engagement, in terms of their willingness to do so. The value of science learning is a great challenge that science education has to address to foster students' motivation. Problem solving and the relevance of science knowledge in students' daily lives are included, among others, as unique features that highlight the value of science learning (American Association for the Advancement of Science 1993; NRC, 1996).

A primary conception of the relevance of scientific knowledge and students' lives is one of utility: learning environments that promise to connect scientific knowledge as a source that can solve everyday problems in students' lives, or which might explain several phenomena that students confront in everyday lives, might be able to develop students' value of science learning. However, the challenge is to find the right balance between a 'broad intellectual understanding of the natural world and the scientific way of thinking on the one hand, and the utility of science for effective living on the other.' In the history of science education, such as in the early years of the 20th century, there have been movements in which curriculum developers had gone too far in making subject matter 'relevant' and had forgotten the fundamental reason why science was being studied - which was to provide a broad understanding of the natural world and the way it affected people's personal and social lives (DeBoer, 2000).

Another conception of the relevance of scientific knowledge to student's lives is one of citizenship: students need to understand scientific concepts related to contemporary controversies that affect their lives, but also conceptualize the nature of science as a human enterprise that produces entities affecting the natural environment, their health and society in general. This inevitably infuses other areas into science lessons, as different social domains impinge upon the decision making: religion, science, ethics, politics, law and others (Aikenhead, 1985).

Science teachers usually spend more time in transmitting facts and regard values as being out of the scope of science teaching (Levinson & Turner, 2001). Thus, traditional science instruction has given a false impression of science as the unproblematic collation of facts about the world and makes controversies between scientists (historical or contemporary) look puzzling (Driver et al., 2000). However, there is a need for a functional scientific literacy model, which should include personal, cognitive and moral development, since a cultural perspective towards education underscores the necessity to appreciate students as moral agents who are intimately involved with their own cultural, natural and technological environments (Zeidler et al., 2005, p. 365). This perspective could also promote students creating the link between science and their lives and also enable them to appreciate the value of being scientific literate in a 'society of risk.' Again, the challenge of finding the balance between infusing ethics and morals in science education, while still achieving the science education fundamental goals related to explaining the natural world, is a complex issue of pedagogy – out of the scope of this paper.

Summarizing, student motivation has been identified as a factor affecting their conceptual change processes, critical thinking, learning strategies and science learning achievement. Motivation is affected by self-perceptions of ability, effort, goal orientation, task value, self-efficacy, test anxiety, self-regulated learning, task orientation and learning strategies. Science learning environments, such as inquiry-based learning environments, which actively engage students in the learning process and provide them the space of self-regulating the process, might affect students' motivation factors. Furthermore, students might find science valuable and be motivated to learn, if they engage in problem solving activities where science's utility in their everyday live is evident. Finally, socio-scientific controversies, which encompass morals, ethics, politics and other societal factors, might enable students to create the link between science and several issues that confront us as current or future citizens.

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1.4 INSIGHTS INTO THE PROFILES PROJECT

1.4.1 Introduction into the PROFILES Project and its Philosophy

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What is PROFILES?
PROFILES is one of a number of European FP7 funded projects in the field of "Science in Society." It is a 4 year coordinating and support actions project, promoting the adoption of Inquiry-based Science Education (IBSE).

Who is PROFILES?
PROFILES Consortium, consists of 20 (plus one) partner institutions from 19 (plus one) different countries. One institution – the University of Karlstad (Sweden) – has already been co-opted by the PROFILES Steering Committee and will soon become a full-member of the PROFILES Consortium (see 'Members of the PROFILES Consortium' at the end of the Chapter).

What does PROFILES stand for?
PROFILES is the acronym for **P**rofessional **R**eflection-**O**riented **F**ocus on **I**nquiry-based **L**earning and **E**ducation through **S**cience.

What is intended by the PROFILES acronym?
The acronym is a compilation of 4 major components:

1. Professional aspect of PROFILES
The first, 'P' refers to *professional* and recognises that teachers need guidance to change paradigms which could well be a feature in putting PROFILES into operation. A major feature of

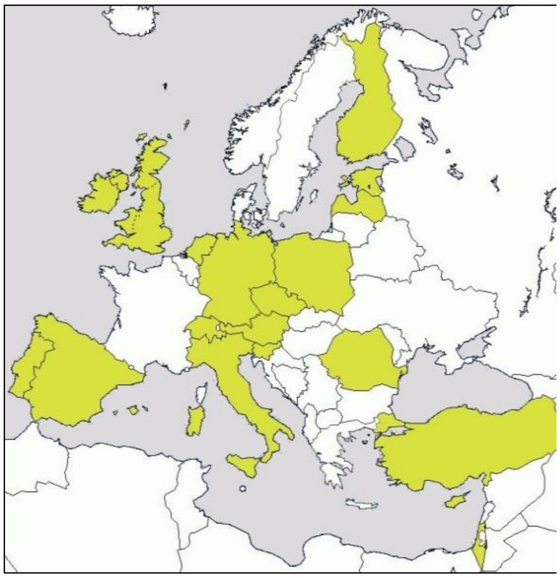

Figure 1. Partner countries involved in the PROFILES Project's Consortium

PROFILES therefore is the additional professionalization of teachers through continuous professional development (CPD). It also recognises that the ultimate goal of PROFILES is teacher ownership of the PROFILES approach and philosophy.

2. Reflection-Oriented Focus within PROFILES
The letters 'ROF', within the acronym of PROFILES, specifically recognises the concept of the teacher as a reflective practitioner. In particular, it sees reporting back on teacher classroom interventions as an integral part of PROFILES. Within the PROFILES project, teachers, in preparing and undertaking classroom teaching, are expected to operationalize the intended outcomes of their teaching and facilitate the pace at which these outcomes are met for an acceptable number of students. This entails being conversant with the ideas behind the PROFILES modules and being prepared to meaningfully modify the modules, should this be considered necessary.

But 'ROF' covers much more than that. Teachers need to evaluate their success in using a module in their teaching, not simply in terms of the science knowledge gained by students, but in terms of the manner in which all intended learning outcomes, including student attitudes and values, are promoted. In short, within PROFILES, teachers are guided to reflect on whether the module is used in line with the expected approach. The importance of this reflection, as an integral part of the CPD and following on from the classroom intervention by teachers, cannot be underestimated. The opportunity for teachers to share their experiences with other teachers is expected to play a major role in enabling teachers to better appreciate the PROFILES intentions. It is also expected to be a major aspect of moral support in helping teachers to minimise or overcome the multitude of constraints, which are likely to arise in embarking on a change of paradigm in their teaching approach and orientation.

While reflections by teachers on their practice within PROFILES CPD meetings is expected, interactions between the CPD providers and teachers, beyond the formal programme, is encouraged as an aspect of networking. This can be expected to lead to additional interactions, perhaps within the school where the teachers are employed, perhaps through classroom observations by the CPD provider (subject to mutual agreement) and possibly (where conditions allow) videotaping of the teaching in action for the purposes of aiding feedback to other PROFILES teachers.

3. Inquiry-based Science Learning (IBSL)

There should be no question that *inquiry-based science learning* (IBSL) is at the centre of PROFILES teaching. It is the 'IL' in the project acronym which points out this aspect. Features associated with IBSE are clearly adopted, as integral to PROFILES, such as –

- student centred teaching;
- posing a scientific question;
- seeking evidence for an acceptable answer to the question, and
- student gains, associated with the learning activities.

However, each of these features needs further clarification and support and this is portrayed both through the CPD offering and also the manner in which teaching modules are compiled.

4. Education through Science – the gateway to enhancing scientific literacy

A further key feature of PROFILES is its interest in student acquisition of all competencies, or capabilities seen as appropriate for science education. This relates to the last two letters in the PROFILES name, 'ES', which stands for *'education through science'*.

Education through science is a term used to suggest education is the major focus, irrespective of whether it is undertaken within science teaching, or teaching within any other discipline. This is based on the premise that science education is much wider than science knowledge and even scientific processes. It also incorporates the learning of a range of educational, largely generic, attributes as identified within the school curriculum.

Simply put, 'education through science' suggests teaching needs to focus on an appreciation of the actual nature of science, the development of personal learning attributes and the development of social abilities, as well as scientific conceptual development (Holbrook & Rannikmae, 2007). And in focussing on these attributes, as they are delineated in the various curricula within partner countries, it is further recognised that student-centred learning is an essential approach.

What is PROFILES wishing to achieve?

The ultimate PROFILES target is to raise teacher's self-efficacy and identify evidence of ownership of PROFILES for the purpose of enhance students' scientific literacy. More specifically, PROFILES aims at the following objectives, in general:

- **Establishing close cooperation and networking of the consortium with stakeholders**
  Through coordination of the CPD offered, modules disseminated for classroom intervention, reflective practices by teachers and the establishment of self-efficacy of teachers in operationalizing PROFILES, the project strives to support consortium members and the teachers involved in a 'community of practice,' recognising the concerns and views of stakeholders and seeking their approval for the PROFILES approach as an interpretation of their expectations.
- **Providing professional development (CPD) and innovative inquiry-based teaching approaches** to introduce methods of, and teaching modules for, inspired IBSE learning and teaching, which feature specifically relevance-identified modules plus enhancement and reflection programmes, linked to classroom intervention support. An extension of the CPD is the introduction of PROFILES ideas into pre-service student teacher programmes, particularly by enhancing science educator awareness and interest.
- **Developing strong(er) teacher professionalization, enhancing teacher self-efficacy and promoting teachers taking evidence-based ownership of PROFILES philosophical ideas and innovative practices** through building on an intervention, guiding teacher reflective processes and aiding teacher initiating use-inspired research accomplishments, especially where these address teacher constraints in operating PROFILES. Additionally, professionalization is enhanced through evidence-based teacher ownership, indicated through such means as the use of reflective portfolios, creating motivational, IBSE-focused PROFILES modules, dissemination of PROFILES ideas to other teachers and illustrating how success can be enhanced through disseminated of outcomes from action research projects geared to the innovative PROFILES ideas.
- **Evaluating the outcomes of the intervention, linked to the CPD,** through student gains and student self-evaluation, both in terms of student attitudes towards the teaching approaches, and their perception of, and interest in, science-related learning and careers in the sciences.
- **Creating interactive local, regional, national and Europe-wide teacher networks** which positively influence teachers' competence and confidence to promote IBSE-related science teaching and hence raise their self-efficacy to teach in an innovative – more student centred, context-led IBSE manner. Such networks also aid PROFILES adoption through interlinking with established teacher networks, including networking with other innovative IBSE, science teaching projects.
- **Disseminating the PROFILES ideas, CPD materials, teaching modules and student outcome** especially the potential to provide - evidence-based outcomes from interacting with stakeholder views; approaches to meeting teacher identified professional support needs; development of successful CPD models interrelated with classroom interventions which lead to strong student motivational gains, and models of effective teacher networking that supports teachers striving for PROFILES self-efficacy plus building on this in identifying evidence-based teacher movements to take ownership of PROFILES and its further developments.

How will the success of PROFILES be determined?

Measures of success within the PROFILES project are through determining:

(a) a high level of self-efficacy established by science teachers in operationalizing the PROFILES approach in the classroom, and

(b) strong attitudinal gains by students towards their learning though science education (such as students' (intrinsic) motivation in learning science).

What are students expected to learn through PROFILES?

The PROFILES teaching modules indicate, a range of student learning outcomes, expressed across competencies which relate to 4 key learning areas:

- conceptual gains in the domains of science;
- skills acquisition at scientific and generic educational levels;
- personal development attributes, and
- social interactions and values.

This is very much in line with the key competencies, as suggested in DeSeCo reports (OECD, 2005), summarised here as:

Acting autonomously (assert/defend one's rights, responsibilities, interests, limits, needs; form/conduct life's plans and personal projects; act within the big picture/the larger context);

Using tools interactively (use language, text, symbols interactively; use information/ knowledge interactively; use (new) technology interactively);

Functioning in socially heterogeneous groups (relate well to others; co-operate; manage and resolve conflicts).

What is unique about PROFILES?

In 'Science Education Now; A Renewed Pedagogy for the Future of Europe' (EC, 2007), a major concern expressed, in relation to science teaching, is that 'science in school' is both "irrelevant" and "difficult" (p.9). To overcome these shortcomings, inquiry-based science education is being promoted in a range of FP7 projects, but little is said as to how this should address issues of relevance, let alone make science learning easier. Thus, the question arises - *why should IBSE be any more successful within FP7 projects, unless steps are also taken to address the underlying issues?* This required innovations and the following are seen as unique to PROFILES.

1. Motivational IBSE

While IBSE has already been introduced as a major feature of PROFILES, this project goes further and sees the need for the IBSE to be 'student-motivationally' driven (*involving the student population as a whole*). Thus, while the IBSE is student-centred (both in terms of the *thinking involved* by the students, as well as the *carrying out of the processes),* major additional components are ensuring that students appreciate why the IBSE is being undertaken and also that they feel they want to be involved.

Stimulating the '*wanting to,*' as opposed to *'doing because it is in the curriculum,'* is a unique feature of PROFILES and is effected by an introductory scenario, illustrating a familiar need for the learning and guiding the students towards wishing to learn the science so as to better understand the situation posed by the scenario. The scenario is further described under the section on the three stage model.

2. Meeting Student Needs; Realism rather than Positivism

PROFILES, in unison with other recognised practices, supports the relevance of building the learning from students' prior experiences in a *constructivist manner* (von Glasersfeld, 1978), with students exposed to meaningful opportunities to construct their own meaning for learning, these being based on appropriate challenges that fit within their *'zone of proximal development'* (Vygotsky, 1978).

But in so doing, PROFILES additionally provides a 'motive' for students to want to satisfy a recognised 'need' (this need may or may not be recognised by students prior to the motive being established). In this, PROFILES strives to move away from positivist teaching (science education portraying science as giving the one, specific answer in the accepted 'ways of scientists' and hence students being trained as 'little scientists,' attempting to behave as scientists do and achieving results that scientists have already achieved). Instead, PROFILES takes on a more 'realist' viewpoint, whereby student findings (under the conditions they find these) are taken as real, have inherent value and are worthy of their effort.

3. Education through Science

Through PROFILES, students are guided to appreciate that the science learning component within science education needs to be part of the 'real world,' as well as an appreciation of the important role science can play within this world, plus the relevance of learning through 'science' for lifelong learning, responsible citizenry and for preparing for meaningful careers. In this way, PROFILES implements the approach 'Education through Science,' which forms the third tier to the PROFILES philosophy and which recognises that science education, to enhance students' scientific literacy, is much wider than science content and skills.

4. The Three Stage Model

Another and major, unique feature of PROFILES is the recognition that IBSE, even if hands-on, is not in itself, motivational for all students, or if it is, the motivation tends to be driven by short term situational interest (Bolte, 2001; Krapp, 2002; Streller & Bolte, 2010). This is especially the case if the IBSE learning is outside students' prior constructs and seen, by students, as being acquired for no specific purpose.

The PROFILES approach is thus to combine the motivational IBSE, a realism approach to science, interrelating the science learning with the real world and the need for an educational thrust as indicated by the education through science conception. This creates the PROFILES three-stage model, which is put forward as a crucial part of IBSE learning. The three-stage model is thus at the very heart of PROFILES and seen as an important approach in dealing with young adolescents, whereby the initial learning of the science concepts is placed in a familiar setting (giving the motive) and, very importantly, ensuring this setting is seen as relevant (stimulating the 'want to') by students.

Stage 1 of the model is arousing students' intrinsic motivation, undertaken in a student familiar, socio-scientific context (the context is the society, not the science curriculum or textbook). An intention is to involve students in undertaking activities that relate to a better understanding of the issue (an issue seen by students as relevant to their lives - not simply relevant to the curriculum) and worthy of greater appreciation. This leads to students' recognition that they 'want to':

(a) know about the science ideas behind the scenario, and
(b) experience scientific ways (by either the teacher or the students putting forward the scientific question) which form the basis for inquiry-based science education.

Such motivation is utilised to encourage students to strive towards identification of the scientific question from which the IBSE evidence gaining experiences follows and hence the science ideas are acquired. Here it is important to note the initial motivation is to assist in the learning of the science – motivation is not an end in itself; *the science ideas are previously not known*).

To PROFILES, motivation is thus a key component for student-centred involvement, both in deriving the scientific questions (undertaken by students assuming this is within their zone of proximal development) and in deriving the outcome from evidence gained.

The motivation is intended to start with a carefully worded title (only terms familiar to the students are used) and a scenario, purposely a surprising phenomena in the nature or of the students everyday life or socio-scientific issues so as to relate to the life of the students are the starting point of PROFILES teaching and learning conception. In this manner the context of the scenario is carefully chosen so that the scientific ideas are embedded and the actual science component of the learning begins when these are decontextualized (Holbrook & Rannikmae,

2010) from the initial context and IBSE is pursued.

In facilitating the move to the 2nd stage, the initial motivation forms a key launching platform for the intended science learning. It seeks to draw the students' attention to thinking about deficiencies in their science knowledge which inhibit them from their desire to undertake a meaningful discussion, related to the scenario. This facilitates the posing of the scientific question or questions intended for investigation.

The intended IBSE stage 2 is expected to sustain the motivational learning from stage 1 and to meet learning outcomes that relate to science cognitive gains, operationalisation of scientific process skills through the intended inquiry-based learning, developing personal attributes (for example in terms of creativity, showing initiative, perseverance, safe-working and identification of risks), and also promote students' social development through collaborative teamwork.

Thus stage 2 is the major science learning stage and can be expected to take up the major teaching time allocated to the module.

These processes are facilitating the move to the 3rd stage. There the outcomes from the IBSE learning and the range of associated scientific concepts, which the teacher feel are important to include, are in need of consolidation. This consolidation stage can be enacted through (for example) interpretation of the IBSE outcomes, presentation of the findings and discussion on the relevance and reliability of the outcomes. But further, the consolidation can be facilitated by encapsulating the science learning into a socio-scientific frame. This strongly promotes attributes associated with acting autonomously, using tools interactively and functioning in socially heterogeneous groups (OECD, 2005).

For stage 3 of the model, the consolidation of the conceptual science is given relevance by including the science ideas back into the socio-scientific scenario which provided the initial student motivation. It enables the students to reflect on the issues, while placing the newly taught science alongside other attributes important for participating in argumentation debates, role playing or discussion, to derive a justified, society-relevant decision shared or considered as reasonable by the grown up.

How does PROFILES function?

PROFILES functions via complying with work packages, for which the main components are:

1. soliciting stakeholder views;
2. meeting teacher needs via continuous teacher professional development programmes (CPD);
3. undertaking classroom interventions using PROFILES modules;
4. soliciting student motivational gains;
5. enhancing teacher networking;
6. striving for teacher ownership of PROFILES ideas and operational methods; and
7. disseminating insights, outcomes and products (e.g. learning and teaching materials) of PROFILES.

1. How are Stakeholder Views Solicited?

A major thrust within PROFILES is the involvement of stakeholders and interactions between them. PROFILES seeks to bridge the gap between different groups of stakeholders (such as science education researchers, teachers, students or scientists) and local actors by supporting a stakeholder network and facilitating cooperation.

A first step so as to reach this aim is fostered, by collecting views of stakeholders, regarding a desirable inquiry-based science education within the partners' countries school systems. For this, consortium partners collected views from more than 2.400 different stakeholders and set out to involve them in discussions regarding IBSE by means of a 'International PROFILES Curricular Delphi Study on Science Education' (Bolte, 2008; Schulte & Bolte, 2012). The PROFILES Delphi Study is designed to poll stakeholder's views through three independent, yet interrelated rounds and to provide the participating stakeholders with feedback regarding outcomes from each round by means of compiled and analysed stakeholder statements (Linstone, & Turoff, 1975; Häußler et al., 1980; Bolte, 2008; Schulte, Bolte 2012).

More and detailed information regarding the involvement of stakeholders in the PROFILES project and about the International PROFILES Delphi Study on Science Education are provided in Chapter 1.4.2.

2. How are teacher's needs supported within PROFILES?

Teachers involved in the project are supported by a carefully devised, one year continuous professional development (CPD) programme (See Chapter 1.4.4; Taitelbaum et al., 2008; Harrison et al., 2008)

The PROFILES CPD courses relate to 4 main features:

1. Teacher as learner

2. Teacher as teacher

These two features are important to support teachers in promoting student interdisciplinarity and student centred teaching processes. The first offers support to teachers by providing opportunities to upgrade their science knowledge, especially in the newer science topics emerging in the 21st century, but also to offer an interdisciplinary science background where appropriate. The second promotes teacher professional content knowledge (PCK) against previously identified teacher needs, in areas considered important for PROFILES teaching.

3. Teacher as reflective practitioner

Based on the classroom experiences in operationalsing PROFILES in the classroom, a reflective teacher is expected to facilitate meaningful PROFILES experiences for themeslves and other teachers by:

- consider their strengths and weaknesses in handling PROFILES modules;
- sharing their good and bad experiences with other teachers and hence seeking for opportunities to raise their self-efficacy;
- suggest ideas for improving performance, time management, PROFILES modules and determination of student gains;
- seek alternatives ways to raise their classroom environment, to increase their teaching reportoire and to enhance students' scientific literacy;
- support other teachers in developing a PROFILES task culture and motivational learning atmosphere, especially with respect to adapting PROFILES type modules, which take into consideration (potential) cultural and gender differences and/or needs.

While the sharing of experiences on a regular basis is intended to be a key feature of CPD programmes, the sharing can take place beyond face-to-face meetings through causal interactions, online exchanges or presentations in other teacher gathering. Hence in the PROFILES project, teacher networking is seen as an important vehicle for sharing reflections.

4. Teacher as leader

The highest level of PROFILES operation (teacher as leader) is the teacher taking ownership of the PROFILES philosophy and approaches. This target, on the one hand, sees teachers being sufficiently appreciative of the PROFILES ideas to be able and willing to guide other teachers concerning the aspects and criteria of the PROFILES CPD programmes, maybe by running seminars, workshops or presentation for others (such as for pre-service or in-service teachers). This is what PROFILES terms "teacher as a leader" (see also the paragraphs regarding "teacher ownership" in this Chapter). From another perspective, 'teacher as a leader' permitted the opportunity to explore PROFILES in operation in more depth via, for example, cases studies, collection and examination of student portfolios (e-portfolios) or undertaken aspects of action research, especially related to overcoming or minimising the inevitable teaching constraints as well as the dissemination of findings, products (e.g. the PROFILES modules) and other PROFILES outcomes (see also: Hofstein et al., 2012; Hofstein et al., 2003).

3. How is PROFILES used in IBSE Teaching?

In initiating PROFILES teaching, teachers are guided by PROFILES teaching modules. The modules are firmly based on the developments in a previous FP6 project, named "PARSEL" (www.parsel.eu). PROFILES type modules have the following characteristics:

A front page, highlighting the title of the module, the age range of students for which it is intended, an abstract of the module, sections included, learning outcomes within competencies covering (within the specific intentions of the module) – conceptual science learning, skills development, personal developments and social issues, plus the intended number of lessons.

A student script, which includes the scenario for the module and student activities or tasks. These activities or tasks relate to all three PROFILES stages without sub-division, as such stages are intended to be invisible to students thus giving the intended impression that a PROFILES module is one continuum. The student script may, or may not, include student worksheets (depending on the type of inquiry-learning intended or whether students are involved in designing the worksheets).

A teacher guide is also included to enable the teacher to be more conversant with the intentions of the author(s) who developed the module. This is important as teachers are expected to modify the way the module is handled in the classroom to best suit their students and classroom environment.

Some modules may also include suggested **assessment strategies** to assist the teacher in handling formative assessment feedback during the teaching, especially in the areas of non-cognitive learning.

An additional section on **teacher notes** may also be included to give teachers more background related to the module, and possibly references and alternatives to assist the teacher.

4. Teacher Ownership of PROFILES

Teacher ownership is the ultimate PROFILES goal, identified not only by a teacher showing strong self-efficacy and being self-reflecting in their teaching, but also through seeking ways to provide evidence that is truly recognised as being in line with the PROFILES approach and is appreciated as a step forward for science teaching (see Chapter 1.4.4).

A teacher exhibiting teacher ownership can be expected to provide tangible evidence of this in a variety of ways, such as:

- Developing, adopting and modifying and/or evaluating PROFILES modules as well as meaningfully promoting the outcome to others;
- undertaking and disseminating cycles of reflective activities - identify, plan a possible solution, enact the plan, reflect on the outcome (which may result in the initiation of further follow-up cycles) for example by means of action research;
- establishing and evaluating student portfolios/ e-portfolios illustrating student learning and – if possible – their motivation;
- case studies of selected students or classes via videotape or podcast documentations, etc.,
- reflective teacher and/or student questionnaires or interviews;
- poster or oral presentations at teacher's conferences;
- running PROFILES seminars for other non-PROFILES teachers;
- being or becoming a PROFILES CPD provider for new and further teachers interested in PROFILES;
- involved in promoting PROFILES to pre-service teachers;
- facilitating teacher networks at the school, local, regional or national levels;

- creating PROFILES related publications in teachers newsletters or science teachers journals at the local, national, or international levels.

Teacher ownership can be enhanced by teachers taking the lead in planning and making available CPD courses for other teachers in a school-based, or informal manner, actively supported by the PROFILES partner to ensure continuity, support, gaining feedback from both the teachers involved and the students and by enhancing interaction with and awareness among other stakeholders regarding the PROFILES project.

The degree of teacher ownership can be determined through:

- the extent of material outputs (portfolios, videotapes, case studies, etc) geared to adopting reflective practices on PROFILES ideas;
- the effectiveness of the training undertaking, monitored through teacher feedback;
- monitoring positive attitudes to PROFILES approaches and outcomes as expressed through reflective practices, networking among teachers at local, national and regional levels;
- the number of disseminated articles.

5. Determining Student Gains

While it is valuable to seek student cognitive gains, it is recognized that within a 4-6 lesson module, enabling limited science learning, the literature shows that identifying meaningful cognitive gains in such a short time period is not really feasible.

With this in mind, the PROFILES steering committee agreed to concentrate on one attitudinal instrument, an instrument for analysing Motivational Learning Enviroments (MoLE) in science classes (see also Chapter 2.3). The MoLE instrument, translated into the local language, is used to collect student data within the frame of a pre-post-intervention design. Reports on the results from the evaluation within a partner country are expected to be shared across consortium partners and act as a stimulus for further developments and in interactions with stakeholders related to the success of PROFILES in meeting stakeholder intentions. Some results will be presented in the frame of the PROFILES 1st International Conference and are to be found in this book (e.g. Albertus, Bertels, Bolte, 2012).

6. Establishing Teacher Networking

The establishment of a PROFILES teachers' network, interrelated to other teachers' networks operating on a local, regional national or Europe-wide scale, is a further feature of PROFILES. The majority of partner countries are building on already existing teacher and school networks as well as networks at international level, which are extended through network meetings. It is expected that PROFILES practices, successes, professional support models and created teaching modules will be disseminated via these networks, both in the national language and through English in a wide range of European countries for use and adaptation by other teachers and teacher educators (Rauch & Scherz, 2009; Altrichter, Rauch & Rieß, 2010; see Chapter 1.4.5).

7. PROFILES Dissemination

The dissemination of PROFILES approaches and products, reactions from a range of stakeholders and insights from associated research and evaluation form a further key project target. The intended outcome of PROFILES is science education become more meaningful to students, more strongly related to 21st century science, more associated with generic education and especially promoting and enhancing IBSE in school science.

Two PROFILES Newsletters have already been prepared and disseminated (see http://www.profiles-project.eu/Newsletters/index.html). A lot of PROFILES partner institutions translated them into their local language and disseminated them among teachers and stakeholders. The next volume of the PROFILES Newsletter will be published in October 2012.

To date, 15 articles have been published in local and international journals (see e.g. Bolte et al. 2012a; 2012b; Bolte & Streller, 2012; Bolte et al. 2011; Keinonen & Hartikainen, 2011; Kyza & Georgiou, 2012) and more are to be encouraged. Already the PROFILES idea has been circulated at various national and international conferences (e.g. Scientix 2011, Brussels (Belgian); ESERA 2011, Lyon (France); GDCP 2011, Oldenburg (Germany), IOSTE.NW 2012, Limerick (Ireland), ICCE 2012, Rome (Italy), or GDCP 2012, Hannover (Germany)), and again more presentations are planned and will be offered in the near future (e.g. IOSTE 2012 in Tunesia, NARST 2013 in the USA, ESERA 2013 in Cyprus etc.).

Who are the members of the PROFILES consortium?

The PROFILES consortium currently consists of 20 (plus one) partners from 19 (plus one) different countries (status quo: August 2012; see Figure 1).

The PROFILES partners are from the following countries and institutions (steering group members are mentioned in brackets):

1. Germany: Freie Universität Berlin (Coordination),(Claus Bolte & Sabine Streller);
2. Austria: Alpen-Adria-Universität Klagenfurt (Franz Rauch);
3. Cyprus: Cyprus University of Technology (Eleni Kyza);
4. Czech Republic: Masaryk University Brno (Josef Trna);
5. Estonia: University of Tartu (Miia Rannikmae);
6. Finland: University of Eastern Finland (Tuula Keinonen);
7. Germany: University of Bremen (Ingo Eilks);
8. Ireland: University College Cork (Declan Kennedy);
9. Israel: Weizmann Institute of Science (Avi Hofstein & Rachel Mamlok-Naaman);
10. Italy: Universita Politecnica delle Marche (Liberato Cardellini);
11. Latvia: University of Latvia (Dace Namsone);
12. Poland: University of Maria Curie-Sklodowska (Ryszard Maciek Janiuk);
13. Portugal: University of Porto (Joao Paiva);
14. Romania: Valahia University Târgovişte (Gabriel Gorghiu);
15. Slovenia: University of Ljubljana (Iztok Devetak);
16. Spain: University of Vallalodid (Angela Gomez Niuo);
17. Switzerland: University of Applied Sciences Northwest Switzerland (Peter Labudde);
18. Turkey: Dokuz Eylul University (Bulent Cavas);
19. ICASE, UK: International Council of Associations for Science Education (Jack Holbrook);
20. Sweden: Karlstad University (Shu-Nu Chang-Rundgren).

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1.4.2 European Stakeholders Views on Inquiry-based Science Education – Method of and Results from the International PROFILES Curricular Delphi Study on Science Education Round 1

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Introduction

The current situation of science education and the importance of a scientifically literate society is in the course of international comparative studies such as PISA and TIMSS increasingly discussed (OECD, 2001, 2004, 2007, 2012). With respect to the discussion about deficiencies, shortcomings and inadequateness in the field of science education and the regarding educational mandate of general school education, science education researchers express wide consensus about scientific literacy being the central aim of science education (Gräber & Bolte, 1997; Gräber, Nentwig, Koballa & Evans, 2002).

PROFILES aims at disseminating a modern understanding of scientific literacy, encouraging new approaches into the practice of science teaching and facilitating an uptake of inquiry-based science education (IBSE) “through raising the self-efficacy of science teachers to take ownership of more student-relevant ways of teaching” (Bolte u. a., 2011, p. 1). A key component is in this respect the development of learning and teaching materials as well as the development and organization of teachers’ CPD programs. An important consideration for realizing these aims is thus the involvement and support of different stakeholders and to take into account their views and opinions. An important aspect is in this regard the need to establish an exchange between the different groups involved with the sciences and science education, such as students and their parents, (school) policy makers, sciences teachers, science teacher trainers, science education researchers and scientists. In this way, PROFILES seeks to “bridge the gap between the science education research community, science teachers and local actors” (PROFILES Consortium, 2012). The particular value of involving different stakeholders is in disseminating their views so that they can reflect on – perhaps different – points of view. Furthermore, this allows for a stronger cooperation between different stakeholder groups. With regard to the aim of the PROFILES project, the particular value of involving stakeholders is moreover in stakeholders being partners in the development, evaluation and dissemination of the projects activities and outcomes (PROFILES Consortium, 2012). Stakeholders are initially involved by taking into account their views and opinions on scientific literacy and meaningful science education. Especially with a perspective beyond the national contexts, this aim is an ambitious task.

A systematic approach to involving a wide range of stakeholders and bringing together their views and opinions is offered by the Delphi method (Linstone & Turoff, 1975), a method that promises specific insights about aspects that are difficult to determine and to predict (Häder, 2009). For this reason, all PROFILES partners carry out a curricular Delphi study (Bolte, 2008; Häußler, Frey, Hoffmann, Rost, & Spada, 1980; Mayer, 1992; Osborne et al., 2003), collecting and analyzing in three consecutive rounds systematically their stakeholders' thoughts and opinions. The purpose of this International PROFILES Curricular Delphi Study on Science Education is to engage in all PROFILES partners' countries different stakeholders from science or science education related areas in reflecting on contents and aims of science education as well as in outlining aspects and approaches of modern science education. In this respect, the PROFILES Curricular Delphi Study on Science Education offers comprehensive insights into the set of opinions of different stakeholders in society that are concerned with the sciences and science education (students and their parents, (school) policy makers, sciences teachers, science teacher trainers, science education researchers and scientists) in all PROFILES partners' countries. The design of this study enables not only individual analyses of each of the PROFILES partners' stakeholder views, but also allows for comparisons on an international level. In the following parts, the method, the procedure and selected results from the first round of the International PROFILES Curricular Delphi Study on Science Education in general and of the study carried out by the working group at the Freie Universität Berlin (FUB) in particular will be described.

Research Questions

In the first round of the International PROFILES Curricular Delphi Study on Science Education, the following questions are addressed:

1. What kind of opinions and expectations regarding meaningful science education exist among the different stakeholder groups?
2. What kind of differences or agreements can be found between different stakeholder groups' opinions?

Method

The overarching aim of a Delphi study is to collect the views and the knowledge of stakeholders (`experts`) from different areas and classify them in a systematic and appropriate way (Häder, 2009). The results of Delphi studies serve to gain insights about aspects that are difficult to predict. In this way, the results provide – derived from these predictions – guidance and support for the accomplishment of tasks and the realization of goals. The Delphi method is characterized by several distinguishing features (Linstone & Turoff, 1975). In general, a Delphi study involves a fixed group of participants (´experts`) who are asked about a certain topic in several consecutive rounds. After every round, statistically confirmed group answers of the respective preceding round are calculated and fed back to the participants. In this way, the participants are, in the light of the "general" opinion, able to reflect on both the general and their own opinion and, if applicable, adjust or reinforce their opinion. Through these aspects, a gradual condensation of the general question in terms of content is reached. Another characteristic feature of the Delphi method is that the participants interact and cooperate anonymously among each other throughout the course of the study. This serves to avoid participants being influenced or affected by particular opinions of well-known or other individual participants. The data collection, the analyses and the reciprocal information flow are administered by a central working group (Häder, 2009; Linstone & Turoff, 1975). As for the curricular elements of this Delphi study, there are two additional aspects: First the working group develops criteria for selecting the participants dealing with curricular matters in the course of the study. Moreover, the general question is specified within a formal question and answer format (Häußler et.al., 1980).

The PROFILES Curricular Delphi Study on Science Education is ***structured into three rounds*** (Figure 1).

The *first round* collects the participants' opinions about aspects of contemporary and pedagogically desired science education according to the formalized three-part question and answer format in three open questions on which the PROFILES Steering Committee agreed. The participants answer in individually formulated statements which are in the course of the qualitative and quantitative analyses organized, labeled, classified into categories (statement bundles) and statistically evaluated.

In the *second round*, these categories are reported back to the participants for further assessment. The participants are asked both to prioritize the given categories and to assess to what extent the aspects expressed by the categories are realized in practice. In order to identify concepts that are considered important regarding science education, the participants are also asked to combine from the given set of categories those categories that seem relevant to them as a combination.

These combinations are processed through hierarchical cluster analyses in order to identify concepts of meaningful science education.

In the *third round*, the identified concepts are fed back to the participants for further assessment from two different perspectives analogously to the second round. In a further step, the participants are also asked to differentiate their assessment among different educational levels. The PROFILES Steering Committee agreed on aiming at a *sample size* of about 100 stakeholders per partner, comprising the following four sample groups: Students (n≈25), science teachers (n≈25), science education researchers (n≈25) and scientists (n≈25).

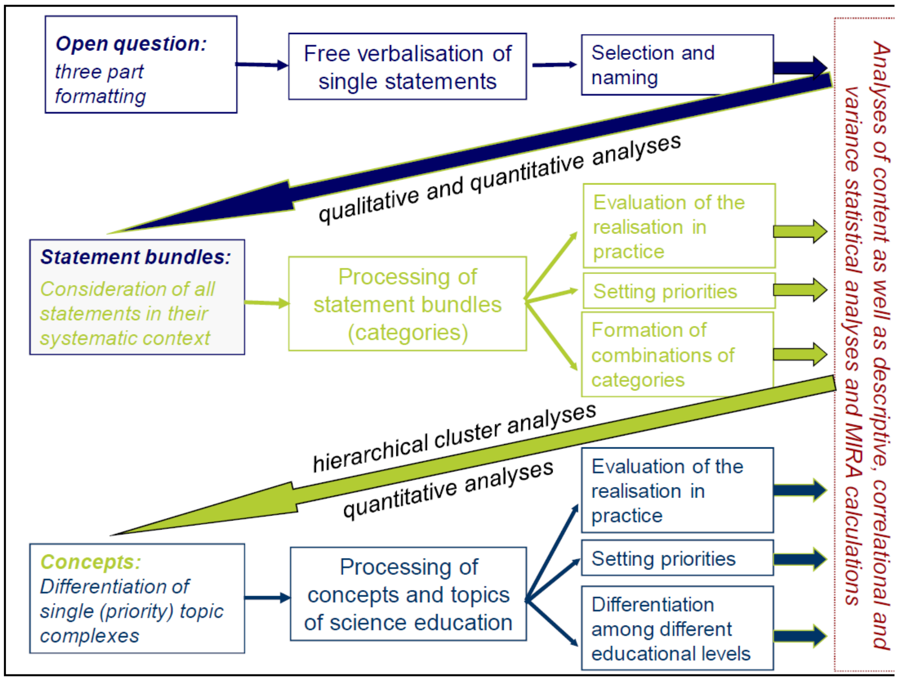

Figure 1. Method of data collection and data analysis in the Curricular Delphi Study on Science Education (Bolte, 2008)

The **central question** of the PROFILES Curricular Delphi Study on Science Education is formulated as follows: "*Which aspects of science education do you consider meaningful and pedagogically desirable for the individual in the society of today and in the near future?*" For the questionnaire in the first round, this question is specified within three open questions following Häußler at al. (1980) and Bolte (2007). The questions refer to motives, situations and contexts for science education, fields and methods students should deal with, and qualifications students should acquire within science education:

1. Which situations and motives can be taken as a basis and in which context should science lessons be put in order to stimulate and facilitate science-related educational processes?
2. Which contents, methods and themes related to science should be taught in science lessons?
3. Which skills, competencies and attitudes should be developed and enhanced to support students in becoming scientifically educated?

Findings from the first round of the International PROFILES Curricular Delphi Study on Science Education

In the following part, first findings and overviews from the international perspective as well as selected results from the PROFILES Curricular Delphi Study on Science Education conducted by the working group at FUB will be shown.

In the first round of the International PROFILES Curricular Delphi Study on Science Education carried out by 18 different partners of the PROFILES project in their respective countries, approximately 100 stakeholders per partner institution and all in all more than 2400 stakeholders were involved (Table 1). In the course of the qualitative analyses, different final classification systems for the analysis of the respective participants' statements were established, ranging from category systems with 26 categories to category systems with 165 categories.

The working group at FUB developed in the course of the qualitative analysis a classification system for the analysis of the stakeholders' statements that contains 88 categories regarding desirable aspects of science education (Bolte & Schulte, 2011), see Table 3a and Table 3b. The inter-rater agreement (Table 2) for this classification system was determined following Bolte (2003), Häußler (1980) and Mayer (1992).

In order to relate the results from the first round of the different PROFILES partners to each other, the compatibility of the different category systems among each other in terms of content was compared. The FUB category system was used as a reference point for this comparison (Figure 2). The diagram in Figure 2 is based on the comparison of the category sys-

	students	teachers	ed.researchers	scientists	ed. admin.	others	total
FUB (Germany)	39	63	30	61	0	0	193
UTARTU (Estonia)	20	30	2	21	12	0	85
WEIZMANN (Israel)	33	35	25	23	0	5	121
UNI-KLU (Austria)	27	48	20	20	15	0	130
CUT (Cyprus)	141	32	15	4	0	25	217
MU (Czech Republic)	138	30	28	25	0	0	221
UEF (Finland)	76	67	23	22	5	0	193
UCC (Ireland)	53	74	21	25	0	0	173
UNIVPM (Italy)	2	82	0	42	0	0	126
LU (Latvia)	30	35	22	20	3	12	122
UMCS (Poland)	30	41	21	25	0	0	117
UPORTO (Portugal)	9	38	2	0	0	19	68
VUT (Romania)	21	43	22	20	4	21	131
UL (Slovenia)	26	39	20	24	8	0	117
UVA (Spain)	61	22	22	21	0	0	126
FHNW (Switzerland)	42	38	23	0	0	0	103
DEU (Turkey)	29	50	26	21	9	0	135
UniHB (Germany)	27	26	25	14	0	0	92
Total	804	793	347	388	56	82	2470

Table 1. Sample of the International PROFILES Curricular Delphi Study on Science Education (data status May 2012)

I. Situations/ contexts/ motives	IIa: Concepts and topics	IIb: Fields and perspectives	III: Qualification	IV: Methodical aspects
$q_I = .78$	$q_{IIa} = .82$	$q_{IIb} = .70$	$q_{III} = .74$	$q_{IV} = .76$
$q_t = .77$				

Table 2. Results of the inter-rater agreement after coding 20 questionnaires – FUB

tems of 18 Delphi studies and shows for each category the number of partners that employ the respective category in their category system. The results show that despite varying degrees of complexity and differentiation in the category systems and different category labeling, all category systems largely correspond to each other with respect to their category content. This verifies their applicability for the quantitative analyses.

In the course of the quantitative analyses of the first round, all PROFILES partners determined the frequencies of how often the categories were mentioned in the respective classification systems of both the total sample and the different sample groups. The different frequencies provide a first impression about the emphases that were made by the specific samples. Comparing the findings of the different PROFILES partners, distinctions as well as similarities can be identified. In all PROFILES partners results, a tendency towards aspects related to current interest, everyday life and Inquiry-based Science Learning can be found. Furthermore, it can be seen that despite common tendencies, the sub-sample groups of the PROFILES partners feature several distinctions among each other within the respective total samples.

Findings from the first round of the FUB PROFILES Curricular Delphi Study on Science Education

Taking a closer look at the FUB results, the following diagram (Figure 3) shows all categories that were mentioned rarely (f_t<5% or particularly often (f_t>20%) by the FUB sample in the first round. As the methodical aspects feature only a low number of cases, they are not included in these considerations.

Figure 3 shows that 24 categories were mentioned particularly often while nine categories were mentioned particularly rarely by the participants in the first round of the FUB PROFILES Delphi Study on Science Education. Considering the total sample (N=193), an especially strong focus is set on the categories "Media/current issues", "Everyday life", "Scientific inquiry", "Acting reflectedly and responsibly", "Content knowledge", "Analyzing / drawing conclusions" and "Judgement / opinion-forming".

A differentiated view on the category frequencies of the four different FUB sample groups is displayed in Table 3a and Table 3b. The tables show that besides common tendencies, the sample groups also deviate in several cases from each other regarding the relative frequency of mentioning the categories.

The analyses also show that the group of *science education researchers* responded in the most differentiated way, followed by the group of *teachers*. The responses of the group of *scientists* and the group of *students* are considerably less differentiated. Regarding the group of *students*, it is noticeable that 29 categories are mentioned by less than 5% of the students or not at all (cf. Table 3a and Table 3b, respective categories put in italics). Especially the latter consideration of these findings raises questions that are to address in the second round; in particular if those aspects that were only rarely mentioned by the students actually reflect what they consider unimportant, or are those aspects only rarely mentioned because they rarely present in regular science education (Bolte, 2008).

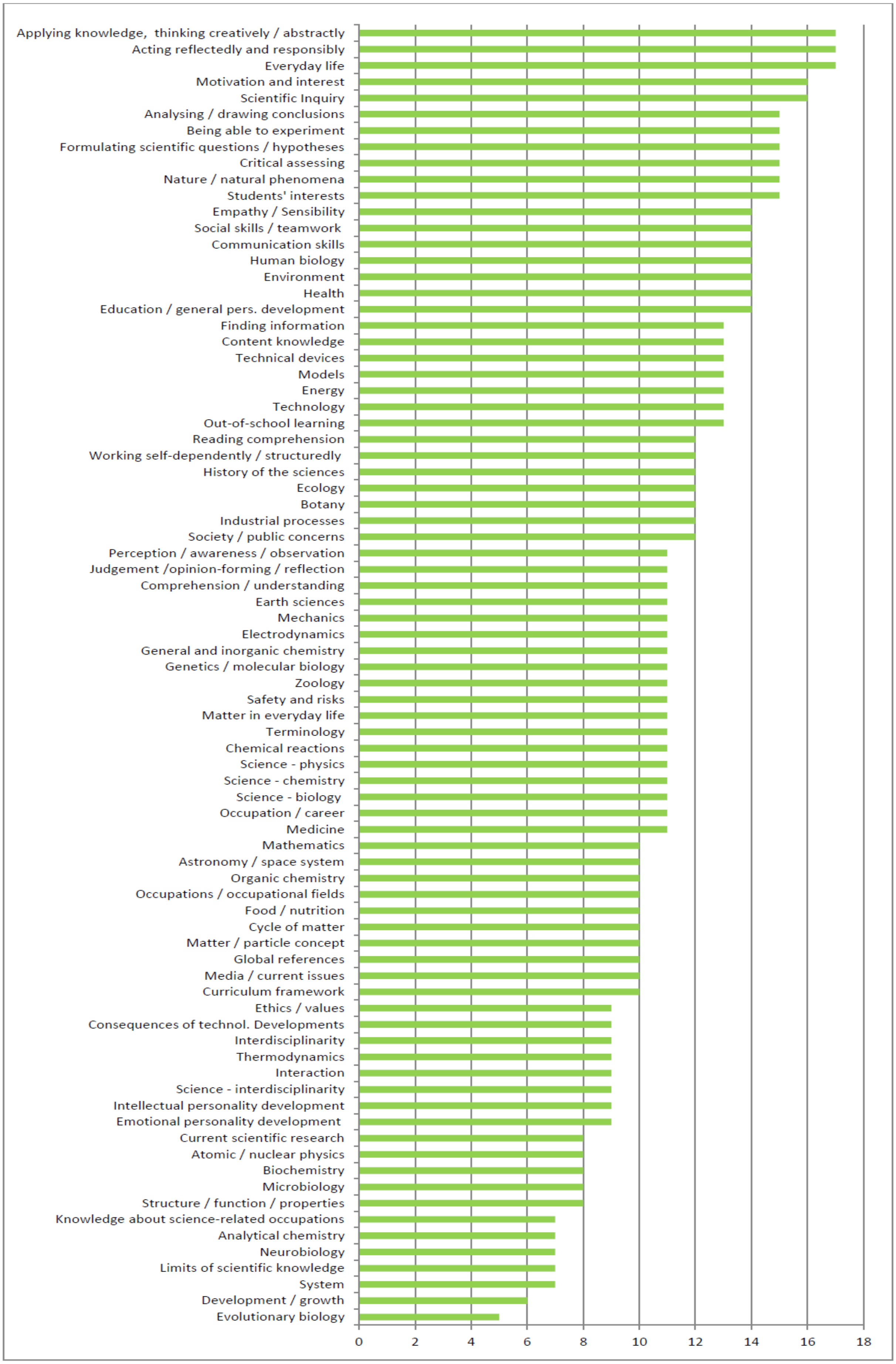

Figure 2. Comparison of the PROFILES partners' different category systems (N=18) on the basis of the FUB category system – Number of PROFILES partners involved (N=18) whose category system contains the respective category

Part		Category	Students	Sc. teachers	Sc. ed. re-searchers	Scientists	Total
I Motives, Situations, Contexts		Education / general pers. Development	13%	19%	40%	20%	21%
		Emotional personality development	5%	8%	20%	7%	9%
		Intellectual personality development	13%	14%	13%	16%	15%
		Students' interests	21%	16%	20%	11%	16%
		Curriculum framework	*0%*	10%	*3%*	*0%*	*4%*
		Nature / natural phenomena	8%	29%	53%	16%	24%
		Everyday life	46%	65%	87%	46%	59%
		Medicine / health	21%	19%	43%	20%	23%
		Technology	8%	29%	30%	28%	24%
		Media / current issues	41%	54%	47%	52%	50%
		Society / public concerns	15%	32%	53%	28%	31%
		Global references	18%	35%	47%	28%	31%
		Occupation	8%	10%	23%	*2%*	9%
		Science – biology	*3%*	*3%*	10%	10%	6%
		Science – chemistry	*0%*	8%	7%	8%	6%
		Science – physics	*0%*	5%	7%	11%	6%
		Science – interdisciplinarity	5%	6%	17%	5%	7%
		Out-of-school learning	*3%*	8%	27%	11%	11%
II FIELDS & TOPICS	IIa Concepts & Topics	Matter / particle concept	5%	17%	20%	8%	12%
		Structure / function / properties	*0%*	10%	13%	*3%*	6%
		Chemical reactions	21%	16%	27%	5%	15%
		Energy	13%	29%	40%	21%	25%
		System	10%	13%	13%	5%	10%
		Interaction	8%	5%	23%	5%	8%
		Development / growth	*3%*	*2%*	7%	7%	*4%*
		Models	5%	13%	10%	8%	9%
		Terminology	*3%*	5%	20%	10%	8%
		Scientific Inquiry	44%	57%	53%	26%	44%
		Limits of scientific knowledge	8%	5%	20%	7%	8%
		Cycle of matter	8%	13%	27%	5%	11%
		Food / nutrition	21%	21%	37%	20%	23%
		Health / medicine	36%	24%	33%	23%	27%
		Matter in everyday life	8%	16%	30%	10%	15%
		Technical devices	*3%*	16%	23%	23%	17%
		Environment	10%	38%	50%	21%	29%
		Industrial processes	*3%*	16%	23%	15%	14%
		Safety and risks	15%	13%	23%	8%	13%
		Occupations / occupational fields	*0%*	*2%*	17%	*2%*	*4%*
	IIb Fields & Per-spectives	Botany	5%	13%	13%	5%	9%
		Zoology	8%	16%	13%	7%	11%
		Human biology	38%	25%	53%	15%	29%
		Genetics / molecular biology	10%	8%	17%	18%	13%
		Microbiology	5%	5%	10%	16%	9%
		Evolutionary biology	5%	*2%*	10%	10%	6%
		Neurobiology	*3%*	*2%*	*3%*	*0%*	*2%*
		Ecology	8%	13%	47%	8%	16%
		General and inorganic chemistry	5%	22%	17%	*0%*	11%
		Organic chemistry	10%	21%	20%	7%	14%
		Analytical chemistry	*3%*	*3%*	7%	0%	3%
		Biochemistry	21%	17%	23%	13%	18%
		Mechanics	13%	8%	7%	21%	13%
		Electrodynamics	10%	16%	20%	26%	19%
		Thermodynamics	*0%*	5%	*3%*	10%	5%
		Atomic / nuclear physics	10%	17%	10%	16%	15%
		Astronomy / space system	0%	*3%*	10%	*3%*	*4%*
		Earth sciences	*3%*	*3%*	*0%*	7%	*4%*
		Mathematics	10%	8%	7%	23%	13%
		Interdisciplinarity	8%	16%	23%	16%	16%
		Current scientific research	*3%*	11%	20%	8%	10%
		Consequences of technol. developm.	10%	29%	33%	10%	20%
		History of the sciences	*3%*	5%	10%	7%	6%
		Ethics / values	8%	6%	30%	5%	10%

Table 3a. Percentages of the categories mentioned in the first round – total sample and sample groups (FUB), part I (data status July 2012)

Part	Category	Students	Sc. teachers	Sc. ed. research-ers	Scientists	Total
III Qualification	Content knowledge	44%	37%	50%	33%	39%
	Comprehension / understanding	18%	29%	50%	41%	34%
	Applying knowledge / thinking abstractly	18%	32%	53%	30%	32%
	Judgement / opinion-Forming / reflec-tion	23%	41%	67%	31%	38%
	Formulating sc. questions / hypotheses	3%	30%	40%	2%	17%
	Being able to experiment	13%	37%	40%	8%	23%
	Analysing / drawing conclusions	21%	33%	40%	52%	38%
	working self-dependently / structuredly	26%	17%	20%	8%	17%
	Researching / finding information	0%	13%	30%	3%	10%
	Reading comprehension	0%	6%	0%	3%	3%
	Communication skills	18%	29%	40%	10%	22%
	Knowledge about scientific occupations	5%	3%	10%	2%	4%
	Perception / awareness	10%	21%	20%	13%	16%
	Sensibility / empathy	3%	16%	17%	13%	12%
	Social skills / teamwork	5%	17%	17%	2%	10%
	Motivation / interest / curiosity	23%	24%	27%	21%	23%
	Critical questioning	8%	44%	43%	20%	29%
	Acting reflectedly and responsibly	26%	38%	63%	36%	39%
IV Methodical Aspects	Cooperative learning	10%	11%	7%	3%	8%
	Learning in mixed-aged classes	0%	0%	0%	2%	1%
	Interdisciplinary learning	3%	0%	3%	3%	2%
	Inquiry-based science learning	3%	8%	0%	0%	3%
	Learning at stations	0%	3%	3%	0%	2%
	Role play	0%	2%	0%	0%	1%
	Discussion / debate	3%	11%	3%	0%	5%
	Using new media	3%	0%	0%	5%	2%

Table 3b. Percentages of the categories mentioned in the first round – total sample and sample groups (FUB), part

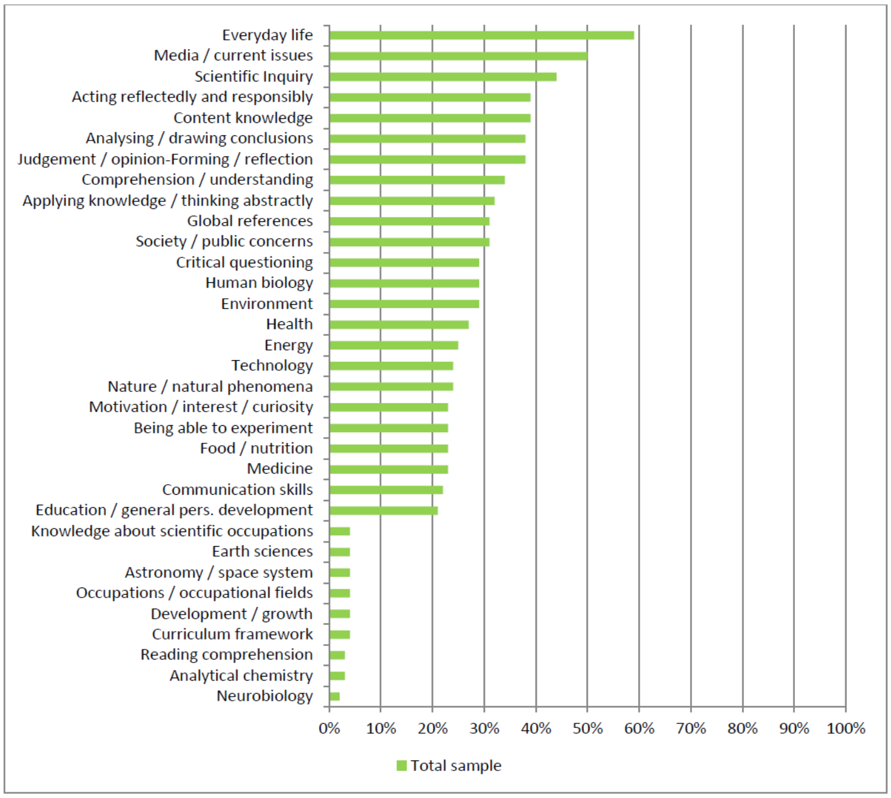

Figure 3. Overview of the categories mentioned rarely (f_t <5%) or often (f_t >20%): Mean percentages of the whole sample – FUB (data status July 2012)

Conclusion and Outlook

Following the procedure of statement analysis of Bolte (2008), a systematization of the participants' statements was reached by all PROFILES partners through developing a classification system. For the FUB category system, the results of the objectivity test show that the chosen procedure of the FUB qualitative data analyses met the demands for objectivity (q = .77) and has thus proven its applicability.

Despite several differences in content and complexity of the PROFILES partners' category systems and in the labeling of the categories, a comparison of the category systems as shown in Figure 2 is possible. In this way, overlaps and differences between the categories of the PROFILES partners can be identified. It appears that all compared classification systems share for the most part a common set of "core" categories, which provides the basis for all further comparisons in this respect. Comparing all PROFILES partners' findings from the first round, a common tendency towards aspects related to current interest, everyday life and Inquiry-based Science Learning can be identified. However, the results of the PROFILES partners' analyses also show several distinctions between the opinions of their respective sub-sample groups.

Regarding the differences in the category frequencies among the sub-sample groups of the PROFILES partners, it can at present not be said to what extent the categories mentioned particularly rarely and particularly often actually reflect what is considered as important or in how far these findings are also influenced by the extent to which these aspects present in educational practice. In what way and to what extent the opinions of the respective sub-sample groups might converge or remain different, and how far the findings of the different PROFILES partners might differ or match in this respect will be investigated within the course of the second and third round of the PROFILES Curricular Delphi Study on Science Education.

The outcomes of this International PROFILES Curricular Delphi Study on Science Education will be used to prepare PROFILES type teaching modules and to develop PROFILES CPD courses, "aiding the implementation and dissemination of PROFILES ideas and objectives to facilitate the uptake of innovative science teaching and the enhancement of scientific literacy" (Bolte et al., 2011).

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1.4.3 Innovative Inquiry-based Science Learning Environments in the Framework of PROFILES

Jack Holbrook and Miia Rannikmae – University of Tartu

Introduction

If PROFILES is to be a success for any partner, then the learning environment created by the teachers and guided by the project, must be the measure. Certainly the continuous professional development programme (CPD) can be expected to play an enormous role in guiding the teachers to enact the PROFILES intentions (the intentions as in the project description of work and which thus form our collective guidelines). But the actual implementation of PROFILES ideas in the classroom is the major target. So what is intended? And what is being achieved?

1. Inquiry-based science education (IBSE)

If science education is to pass a student interest and relevance test, then this project suggests the following CANNOT be seriously considered as the way to construct a learning environment in the classroom:

(a) Teacher centred classroom where the students are expected to sit and listen (a behaviourist approach to education).
(b) Students following recipes, where the carrying out of operations are based on a set of instructions without clear learning targets.
(c) Students are asked to verify, or prove that which is already known (at least to scientists), even if the experimentation has an inherent element of enjoyment.

PROFILES does NOT advocate any of the above, even if textbooks are aligned with these directions. Rather, PROFILES strongly expects teachers to promote student centred learning and this means teachers must expect to involve the students in:

(a) cognitive thinking processes which relate to student-involved learning directions (sometimes referred to as higher order cognitive learning outcomes);
(b) gaining, or improving on, the range of scientific process skills – involving both minds-on (thinking) and hands-on (undertaking the carrying out) attributes;
(c) collaborative teamwork where students are expected to help and guide one another, even to the extent of undertaking peer assessments;
(d) enhancement of communication skills in a variety of ways, including the use of ICT;
(e) development of personal attitudes and aptitudes, especially where laboratory work is involved in risk assessment and taking appropriate actions.

The above list is not intended to be exhaustive but rather serves as a minimum. It is included to show that science education is not simply about the memorisation of facts or gaining of laboratory techniques. Under PROFILES, the learning situation is also to guide students towards democratic values, enhancement of long term memory acquisition and above all, to enhance scientific literacy.

As an aside, it is worthy to point out that PROFILES is aligned with the curriculum in each partner country (modules with non-curriculum content won't be used!). Thus, of extreme important, is the realisation that teachers are not expected to teach the curriculum (in their usual manner) and simply add on PROFILES modules. PROFILES is intended to REPLACE practices that lead to poor classroom environments, limit student learning or interpret the curriculum in a narrow sense (the latter often being the major complaint against textbooks).

By endorsing IBSE, within PROFILES, the intention is to promote a student-centred learning situation. This can be undertaken at various levels and it is the self-efficacy and ownership of the teacher, taking into consideration the maturity of the students, the students' prior experiences and the learning outcomes put forward for the learning, which determines the level of IBSE included in the particular learning environment for the set learning. But whatever the level (while the DoW only refers to open inquiry targets, intended levels are – structured, guided and open), the PROFILES learning environment advocates two conditions:

1. there is a scientific question (or questions) which drives the specific learning, either put forward by the teacher, or where feasible by the students themselves;
2. efforts by the teacher are directed towards ensuring the students are motivated to address the scientific question(s) by seeking the appropriate evidence.

Having said this, it is important to stress that PROFLES is striving towards a learning environment under the **ownership of the teacher** involved and thus the teacher can approach the two factors as the teacher determines. For example, the scientific question can arise from a discussion on a socio-scientific issue, where student involvement in initiating social or socio-scientific questions eventually leads to scientific questions. Alternatively, a stimulating teacher indicated activity, within which students are guided to observe, can also be a starting point, which then leads to the putting forward of scientific questions (usually by the students in this case) for investigation.

2. Motivational learning environment

Clearly from the foregoing comments, the major key for successful PROFILES teaching and learning is establishing a motivational learning environment. Nevertheless, for the most part, this is surely nothing more that good teaching practice and an expected component of every teacher's repertoire.

The difference, in the PROFILES approach, is to suggest motivation stemming solely from the teacher, or from a specific situation created by the teacher, **is not enough**. The literature tends to agree with this point of view, in painting a picture of science learning environments as boring, irrelevant and abstract (Osborne et al., 2003; EC, 2007). The PROFILES expectation is that teachers will enable learning environments which are intrinsically motivation to students i.e. the motivation is coming from the students while the teacher's role is more towards reinforcement of this motivation and seeking to extend this into the IBSE science conceptual learning phase. The PROFILES task is thus to guide teachers to create intrinsically motivational environments for students and to enable the teacher to take ownership of this approach.

The PROFILES approach to stimulating students' intrinsic motivation for learning in science lessons is based on the following (all of which are seen as crucial):

(a) Recognising science and science education are not the same; producing 'little scientists' is not a 21st century intention for science teaching.
(b) Teaching in science lessons is 'education through science.' While it has content and conceptual learning, it is also personal, value-laden and encompassing the goals of education put forward within a country at the given teaching level.
(c) The title of the teaching being introduced is student-friendly; it is sufficiently familiar, appreciated by students as personally relevant to them and does not include scientific terms that create an image of abstractness or being difficult.
(d) The teaching is initiated by means of a scenario with which students' can and also 'wish to' be involved. The scenario is not stereotyped (always of the same style or using the same teaching approach) and can be modified by the teacher to further enhance students' intrinsic motivation.

The target in establishing a meaningful PROFILES learning environment is thus two-fold:

(a) The teaching is motivational from a student's point of view. They 'want to' be part of the lesson.
(b) The motivation can be extended into the science conceptual learning, thereby enabling the IBSE learning to be a continuum from the scenario and the students (in general all students) 'want to' be involved in this further learning.

3. Consolidation of the learning

A consideration often missing in the learning environments within science classrooms is the need to consolidate the learning. While analysing and interpreting findings from IBSE investigations (involving the laboratory, the internet, or other sources), presentations of solutions and discussions on the learning, are all components of a PROFLES learning environment, there is still the need to go further so that all students are given the opportunity to consolidate their learning.

Motivational approaches, for consolidation of the science ideas, need to go beyond (test) assessment situations, whether by means of creating concept-maps or classroom tests. And this is the intention of the third stage in the PROFILES 3-stage model. Here, students are guided to transform their science ideas, derived from the de-contextualised (science conceptual learning in a non-context environment) IBSE learning from stage 2, to relate to the initial context depicted by the scenario and thereby enable students to be involved in a decision-making, learning experience. Not only are the students gaining argumentative skills and seeing science in a socio-scientific framework, as it impacts on society, but they are learning to use the science in a conceptual appropriate manner and to use scientific terminology in a meaningful context. Motivational learning environments, in promoting the learning in stage 3, can stem from role playing, debates, or lively class discussions.

The three learning environment components, indicated above, come together in PROFILES within the 3 stage PROFILES model. This is unique to PROFILES thinking, but makes sense from an educational point of view.

PROFILES teaching modules

To facilitate PROFILES teaching and to guide teachers in gaining self-efficacy in enacting PROFILES during the teacher invention component of the CPD, PROFILES advocates carefully designed teaching modules, compatible with, but not directly indicating, the 3 stage model.
Such modules specifically intend that the teacher:
(a) Sees the importance of stressing student motivation as the key to success in science teaching.
(b) Recognises that science education includes cognitive learning, the gaining of scientific skills, personal development in terms of attitudes and aptitudes toward science learning and the development of social attributes, most noticeable teamwork skills and developing societal socio-scientific values.
(c) Ensures the time spent on the teaching/learning is in keeping with the meaningful learning to be developed. The learning acquired by students must be meaningful and sufficiently comprehensive to enable students to meet the full curriculum intentions*.

*If a teacher does not recognise all the learning outcomes indicated in a module (and wishes to omit some even though students have yet to acquire these), then the teacher must seriously question whether PROFILES modules are useful aids for establishing their classroom learning environment. Definitely PROFILES must be viewed from the need to focus on guiding teachers to educate all students (through science) and not just an elite sub-section, only seeking cognitive advancement.
Each PROFILES module encompasses a front page (actually 2 pages in most cases), a student

section, plus a section for teachers as described in the introductory chapter of this book. The modules are web-based, or in printed formats. The front page gives the scientific conceptual area of student learning, as well as the intended grade (age) level and number of lessons. Of major importance for the learning environment is that each module carefully indicates the learning outcomes intended, in a manner which is measureable, and can thus be considered the students' learning and assessment target, against which the success of the learning environment, created by the implementation of the module, can be determined.

The student section can be modified by the teacher to match the level of IBSE seen as appropriate for the students. The student learning is usually indicated by tasks covering all 3 stages of the model and may also encompass homework, or other out-of-school learning.

The teacher section is given as a suggestion to enable the teacher to appreciate the thinking by the module's authors. As such, the teacher can, and must, modify the approach to maximise the learning environment for the intended learning by their specific students. Teachers, however, need to be careful in shortening the module by ensuring that the student learning is meaningful against the learning outcomes expected. It is important the teacher does not skip learning areas where the students have not acquired prior learning, even where these should have been the intended practice in previous grades). This can be the case with learning in grades 10 and above, when students have been given the opportunity to master basic science processes and practical skills in earlier grades.

A footnote

Many of the articles in this book relate to the creation and utilisation of teaching modules to create the PROFILES environment. It is worthy to examine the associated posters during the conference to see how the developed modules enhance the classroom environment in a meaningful and motivational manner. The poster session is intended to be interactive and hence the successes and failures can be discussed by participants to further consolidate ownership of PROFILES, as well as evaluate the PROFILES project as a meaningful way to raise the science (or separate science subjects) classroom learning environment for the 21st century.

A summary of the 43 poster article submissions is given below:

Poster Articles related to Supporting PROFILES			**Poster Articles related to Monitoring PROFILES action**		**Poster Articles related to Evaluating PROFILES impact**	
No. articles = 16 (40%)			No. articles = 24 (54%)		No. articles = 3 (6%)	
Sub-division			*Sub-division*		*Sub-division*	
CPD (pre & in-service)	**Delphi study**	**Others**	**Developing/ using modules**	**Teaching reflections**	**Student gains**	**General Impression**
8 (50%)	4 (25%)	4 (25%)	15 (67%)	9 (33%)	2 (67%)	1 (33%)

Table 1. Summary of the PROFILES poster articles in this book, by category (N=44)

Others = Philosophy, Teacher Needs, Networking and Web-based Environment

1.4.4 Teachers' Ownership: What Is it and How Is it Developed?

Avi Hofstein, Dvora Katchevich and Rachel Mamlok-Naaman – Weizmann Institute of Science, Israel
Franz Rauch – Alpen-Adria-Universität Klagenfurt, Austria;
Dace Namsone – University of Latvia, Latvia

Introduction

In recent years, science curriculum developers realized that one of the key factors regarding the effective implementation of science curricula is the involvement of the teachers in the process of designing and active development of the various learning materials (Bennet et al., 2006; Rannikmae, 2005; Ogborn, 2002). Ogborn in the UK for example in his essay regarding involvement of teachers in an innovation, concluded that:

"One of the strongest conclusions to come out of decades of studies of the success and failure of a wide variety of curriculum innovations is that innovations succeeded when teachers feel a sense of ownership of the innovation: that it belongs to them and is not simply imposed on them. This lesson is hardest to learn in countries with a centralized curriculum" (pp. 144).

This curricular approach is fondly called the Bottom-up approach as opposed to the traditional Top-down approach (Blonder, Mamlok-Naaman & Hofstein, 2008) that prevailed for many years in the western countries, e.g. the 1960s' and early 1970s' in the USA (The Golden age of curriculum development) and the UK (Nuffield projects).

Based on a long-term study conducted in Estonia, Rannikmae (2005) investigated the development of ownership among chemistry teachers. She wrote:

"The potential for developing social issue based-students participatory, supplementary teaching materials by teachers and seeking teachers' feedback that involves both conceptual and values education has been considered as an essential component of teacher ownership. Teacher ownership of STL teaching was defined as the phenomenon of adaptation of everyday teaching by the teacher, accordingly to the STL philosophy.
Irrespective of the type of ownership most teachers, during the intervention, developed a more advanced perception regarding their role as facilitators of learning. The teachers increased their confidence to teach science (chemistry) in a student centered manner. They appreciated the students' motivational feedback, collected through the essay type answers after lessons where the materials developed by the teacher, were used."

Similar findings were found regarding development of ownership in the process of adaptation of several PARSEL modules in Israel. Blonder et al., (2008) wrote that:

"The "bottom-up" approach helped the teachers to align their teaching with the philosophy and the teaching style of the PARSEL project. At the same time, the teachers adopted the modules to their own needs, their schools, and their students, and maintained their own professional identity. Each phase in the adaptation process increased the teacher's ownership towards the PARSEL project and its unique value aided in forming the modules before the teachers met the Israeli students."

To sum-up this section, it is fair to claim that the involvement of teachers in the curricular process is a promising way to ensure effective implementation of new teaching and learning innovations (Mamlok-Naaman, Hofstein & Penick, 2007).

Developing teachers' ownership in a CPD program

It is suggested that in order to develop a sense of ownership among teachers, it is vital to develop the teachers as learners and as practitioners in their classroom. In other words, the goal should be to equip the teachers with the relevant content knowledge (in PROFILES context the scientific content and its related social applications) and the aligned PCK (pedagogical content knowledge).

These two developments, namely the teacher as learner and the teacher as teacher, are the two initial and basic components in the Four Stage CPD Model (See Figure 1) that is used in the PROFILES project.

It is suggested that the 3rd stage, namely the teacher as a reflective practitioner, is the initial stage in which sense of ownership starts to be developed in the teacher's mind.

In addition, this stage is the foundation stage for further development leadership oriented characteristics and behaviors (Hofstein, Carmi, & Ben-Zvi, 2003).

The development of ownership among science teachers during the PROFILES workshops

In the PROFILES project teachers are involved in a CPD oriented workshop. This includes face to face meetings on line discussions. The various PROFILES partners adopt varied-types of professional development models that differ in the degree of teachers' active involvement.

However, the CPD approach provides the teachers with ample opportunities for reflection on their experiences regarding the adaptation, development, and implementation of the PARSEL oriented (now PROFILES) modules.

Ideally the workshop provides (or should provide) a platform for reflection (and feedback) for the teachers. The feedback is provided by the other teachers as well as by the professional development providers (leading teachers).

In addition to the ability to reflect on their practice, we have observed (and identified) other variables that indicate development of a sense of ownership namely (these are only examples):

- The willingness to involve other teachers in school in the project
- The willingness to identify socio-scientific issues (to be developed) that has a local characteristics (e.g. an environmental-type issue) looking for a relevant issue.
- Identifying themselves with the project (development and implementation).
- Identifying one self with the newsletter (published on the web)
- Involving the principle in the project (stakeholders).
- Telling your students that you were involved in the development or adaptation of the module.
- The dissemination of modules among peers.
- Teachers make an attempt to bring items (artifacts) that eventually will provide evidence for their classroom behavior and practice.
- When teachers perceive that the topic or

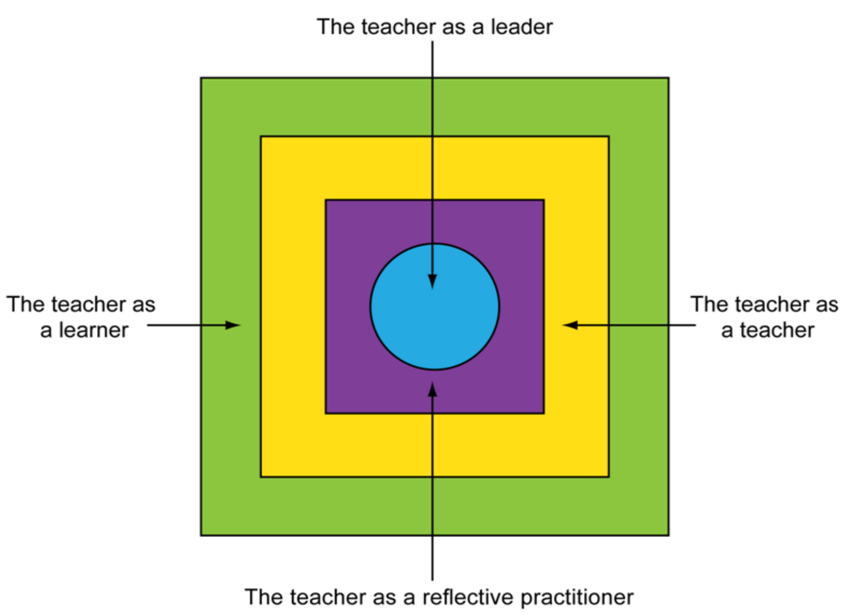

Figure 1. The Four Stage CPD Model

issue taught is relevant to his/her classroom (the nature of the students).

- When teachers decide to make changes, alternations, and amendment to the original module (based on their reflection).
- Willingness to serve as leaders in the 2nd year CPD program (2012 - 2013 academic year).

In the beginning of this working paper we wrote that there are professional development models that are more effective in regarding the development of ownership and those that are less effective. Based on several years of experience with CPD we came to conclude that the most effective models are:

1. *The teacher as a curriculum developer*: In which the teacher is intensively involved in the various curriculum development stages.
2. *Action research*: In which the teacher in collaboration with science educators researches his/her own class.
3. *Focus groups*: In which the teacher collaborates with other teachers as a community of practice.

These are teacher-centered approaches in which he/she is in control regarding content, pedagogy and implementation.

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1.4.5 How to Involve Stakeholders in IBSE Networks

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PROFILES envisages the setting up of networks, based upon already existing structures, to both support the dissemination and mutual learning, as well as to make teachers more aware of the PROFILES project and the goals it has set out to achieve. This article deals with conceptive and theoretical considerations, an example from Austria, as well as with first developments within PROFILES.

Introduction

PROFILES is a project devised to give teacher ownership of the PROFILES approach to the teaching of science subjects so as to enhance the scientific and technological literacy of students. As such PROFILES recognises the importance of dissemination of developments for the benefit of science teachers across Europe and even worldwide by webpages, newsletter, conferences and publications. In addition mutual learning is needed through a networking system at the school, local, national and European/worldwide levels (see also the Introduction in this book). Networking is seen as the creation of intermediate structures which address, among other things, the fields of autonomy and interconnectedness of structures and processes, parameters and freedoms, as well as voluntariness and obligations. Practice and science teaching try to forge new paths in the formation of learning and the cooperation between people and institutions (Rauch et al., 2009). For the development of the PROFILES networks, theoretical aspects of approaches to social networking concepts need to be addressed.

What are Networks?

Networks are support systems based on reciprocity. Those involved can exchange views and information and cooperate within the scope of mutual concerns. The networks are aided by a platform for ongoing process management, seminars to make other teachers aware, important to facilitate further levels of networking. As the concept of the networking is related to theories of social development, key components are recognised as:

- *Mutual intention and goals* – PROFILES networks focus and orient themselves on PROFILES framework topics and targets which have been mutually agreed by teachers and the partner (Liebermann & Wood, 2003).
- *Trust orientation* – mutual trust among teachers is seen as a prerequisite in order to encourage the exchange and sharing of knowledge and experiences. Under such conditions, networks have been shown to bolster new innovation paths (risk taking) and support conflict resolution (Mc Donald & Klein, 2003).
- *Voluntary participation* – this key aspect means attitudes and values of the teachers are of paramount importance in enabling the networking to function. Clearly sanctions and penalties are absent and interventions suggested by PROFILES partners, lead teachers and other stakeholders can be vetoed.
- *Principle of Exchange* (win-win relationship) – maximising the exchange of information, without comprising the PROFILES goals of promoting self-efficacy of teachers towards IBSE-related science teaching. The phenomena of power and competition are not excluded (a check is clearly needed on exchanges deemed unsuitable in a PROFILES environment and the concept of building towards best practice is not more related to collaboration than competition), but rather are approached and dealt with on the same level between the partner and the teacher users (OECD, 2003).
- *Steering platform* – networks do not operate by occasional interactions and relationships, but rather in a continuous phase with an in-

stitutionalised configuration. Clearly PROFILES networks require coordination and maintenance in order to support and facilitate the exchange processes, cooperation and learning (Dobischat et al., 2006).

- *Synergy* – networks make synergy effects possible through structural organisation, offering an alternative to classic rationalising strategies which are characterised by the dismantling of structures (Schaffter, 2006).

Functions of networks

Following Dalin (1999), networks take over the *function of information.* This becomes visible in the act of direct exchange of practical knowledge for instruction and school and as a bridge between practice and science/research. Communication within networks takes place on electronic platforms (webpages) and printed materials like newsletters. But also face-to-face meetings like regular seminars guarantee the flow of information and exchange of knowledge. Through networking, extended learn-possibilities and development of competences (process of professionalization) are fostered and justify networking as a *function of learning.*

Trust is seen as a prerequisite in terms of networking, the basis for the *psychological function* of networks and which bolsters and improves the individuals.

The fourth, so called *political function* of networking, raises the self-assertiveness in terms of education concerns, according to the concept: “United we achieve more” or together we are powerful. To have an effect on the educational system, steering structures for communication and the knowledge exchange between teachers, science educators, scientists and experts from all social subsystems (for example the economy) are essential.

Educational dimensions of networks

In the last ten years, there has been noticeable reflection on networks in the educational system. Structure changes in the administration and policy of decentralization are seen as two reasons for that. Single schools take more responsibility and develop or foster “intermediate” structures (Czerwanski, Hameyer & Rolff, 2002; OECD, 2003; Berkemeyer at al., 2008, 2009). Networks can be seen “governance-theoretically” (Kussau & Brüsemeister, 2007), as structures in which we can break fresh ground. In the tension between administration (top-down) and grass-root movement (bottom-up), autonomy and community, instruction/guideline and freedom, voluntary nature and obligation, difference and participation, practice and science, new ways of education and teamwork of persons and institutions on a regional and local level can be created.

Educational-scientific dimensions of networks

Currently networks are seen as promising structures to support the instructional and school development (Veugelers & O´Hair, 2005; Berkemayer at al., 2009). Nevertheless, there are only a few papers on the effect of networks. The requirement for accompanying research needs to increase, and a new field of research to be established, with new fields of development and challenges taking shape (Dedernig, 2007; Hollstein & Straus, 2006; Jansen, 2006; McLaughlin at al., 2008).

Types of networks

Networks might be distinguished with regard to their complexity, from networks at schools to inter-school networks and networks on local, regional, national and even international levels. Networks on the level of teacher-groups, schools and local structures are likely to be closely linked to instruction and may contribute to improve the regional structures best (Altrichter, Rauch & Rieß, 2010). Examples of different levels of networks are:

- **Networks at school (teacher network)**
  A group of science teachers within one school co-operate towards the common aim of enhancing instructional and school development through science/IBSE. They

are supported by the head teacher and set themselves up as a steering group in the school to guarantee the coordination and maintenance of the network.

- **Networks between schools (school network)**
  A school network consists of two or three schools; within this group of schools one leading school is established. Setting up further partnerships (i.e. with the community, partners from science or economy, personnel within the society, etc.) opens the school to the outside.
- **Local and regional networks**
  At the next level, schools within one school district/region work together, not only on the basis of joint projects among science teachers, but also by exchanging knowledge and experiences in network seminars. A local/regional co-ordination group facilitates the maintenance of the network and includes/supports teacher- and school networks. One important aspect is the involvement of local stakeholders i.e. education, administration, politics, business and NGOs.
- **National networks**
  Networks on a nation-wide level are structured in the same way as local and regional networks (co-ordination group; annual network conferences) but are more complex structure-wise.

The networking described so far is seen as an institutionalised system promoting and supporting science teaching (in an interdisciplinary or single subject context). The example below shows that such networks can extend across subject domains, yet have subject domain sub-programmes, all illustrating the same teacher and teaching support which is key to the concept of networking.

Regional Networks in Austria – Networking in the Project IMST (Innovations Make Schools Top)

The project IMST

The nation-wide project IMST (Innovations Make Schools Top) aims at improving instruction in mathematics, science, IT, German language (the latter targeted at literacy) and related subjects. The focus is on students' and teachers' learning (www.imst.ac.at).

Since 1998, the project has been repeatedly commissioned by the Austrian Federal Ministry of Education, Science and Culture to the Institute of Instructional and School Development (IUS) at the Alpen-Adria-Universität Klagenfurt. It developed in three phases: (1) Analysis of the disappointing Austrian results at the Third International Mathematics and Science Study (TIMSS, 1995); (2) development- and research project IMST (2000 – 2004); (3) build-up of a support system for schools (2004 – ongoing). In the first and second phase, the project targeted only secondary upper-schools but since then it was opened to the entire educational system (K – 12 and teacher education). The project currently involves about 21.000 teachers who participate in projects, attend conferences, or co-operate in regional and thematic networks.

The IMST programme ‘Regional and Thematic Networks’ supports regional networks in all nine Austrian provinces, and three thematic networks which operate on the national level. Within the IMST thematic programmes, teachers put into practice innovative instructional projects and receive support in terms of content, organisation and finance. Furthermore, 18 Regional Educational Competence Centres (RECC) in science subjects were implemented all over Austria to act as a cooperative structure between universities and teacher education colleges. They partly fill the gap of a lack of subject didactic centres in higher education throughout Austria which can provide research-based didactical professional development for teachers. Gender sensitivity and gender mainstreaming are important principles of the project, and their implementation is supported by the Gender Network. In order to investigate the impact of IMST, evaluation and research are integrated at all levels.

IMST and the strategies to implement IBSE

During its quite long duration, IMST strengthens all important strategies to improving the educational system: Professional Development and Support (CPD), Giving Teachers access to Resources, Community involvement (Mobilising Decision-Makers, Coordinating a Local Support Network), Assessment/Evaluation, and Creating Teachers Networks.

With respect to Professional Development, courses for teachers in mathematics and science are organized. These four-semester courses called "PFL- Pedagogy and Subject specific Instruction for Teachers" are based on the hypothesis that:

- learning and teaching innovations are supported best when developed in close connection with teaching practice, and
- when teachers are investigating their own work and networking with each other and with the academic community (action research).

The teachers further develop their teaching knowledge and competences as well as their theoretical understanding.

Teachers participating in the IMST programme are engaged in different sub-programmes (currently by thematic programmes on competency, experimental learning, IT, assessment for learning). Within these thematic programmes the teachers are coached and receive learning materials for their classroom projects. Participants of IMST - individual teachers, teacher groups, whole schools or local school networks – have to report on their activities/innovations. Over the years, IMST, therefore, has accumulated a rich database consisting of project reports stored in the IMST-Wiki. These reports contain reflections on teaching and learning processes.

The intervention model of IMST, namely to support teachers in their practical work, has indirectly influenced the curriculum. Members of IMST-teams served on state commissions responsible for new curricula in schools some years ago.

Evaluation is a central element of IMST. IMST can be described as co-operative structure between schools, school administration, universities/teacher training colleges, businesses etc. co-ordinated by the Alpen-Adria-Universität Klagenfurt. Every sub-programme within IMST is assessed by internal and external evaluation measures. The sub-programme networks are described in more detail below, as these will develop dynamically in the upcoming next phase (2012 – 2015).

Networks within IMST

The Regional Networks are, in addition to the Thematic Programmes and the "Gender Network", an important part of the project. "Regional" refers to each of the nine Austrian federal states. As of July 2012, regional networks supported by IMST exist in all states. In some provinces more finely woven district networks have been set up. The formation of regional networks is based on two principles:

(a) Use of existing personnel, institutional and material resources.
(b) The networks act autonomously

The goals of the networks are threefold:

(a) Raising the attractiveness and quality of lessons in mathematics, biology and ecology, chemistry, physics, information technology, geography, descriptive geometry and related subjects, as well as promoting cross-curriculum initiatives and school development in grammar, vocational and secondary modern schools, primary schools and kindergarten
(b) Professional development of teachers
(c) Involving as many stakeholders as possible

IMST supports the setting up of steering committees in each regional network to coordinate the generation of content and to create cooperative structures for schools, the educational authority as well as teacher training colleges and universities. In order to facilitate a sustainable grounding of regional networks in their respective federal states, the financial support of IMST is conditioned on raising additional financial or personnel support in each of the federal states (i.e. teaching hours, funds for further education) as well as local industries (i.e. support of projects and network conferences).
The exact task profile of a regional network is geared towards the needs of the respective schools in the region and the existing resources. The profile depends on the vision of the people comprising the local steering committee, but enhances

- the establishment of a platform for schools, teachers and other stakeholders,
- the organization of opportunities for exchange of experiences and professional development,
- the support of creating concentrations and their development in schools,
- the development of a pool of experts to advise on instructional and school matters,
- drafting an annual report and interim reports on the activities of the regional networks
- and the implementation of an evaluation (Rauch & Scherz, 2009).

The networks and the RECC are supported by the network-team at the IUS at the Alpen-Adria-Universität Klagenfurt via a platform for ongoing process management, two seminars per year for members of the network's steering committee and leaders of the RECC, public relations (folder, IMST newsletter), accompanying research and studies on the development of networks through the team of networks. Thus the local needs and developments are balanced by a national exchange of experiences and endeavours. The IMST regional networks are assessed by self and external evaluation. The individual regional and thematic networks each submit an annual written documentation, including an evaluation in accordance with the cooperation's agreement. As of now, about 70 reports have been submitted from regional networks.

The results might be summarized as follows: Social contacts prove to be indispensable to the creation of structures, the exchange of experiences and mutual learning. Therefore the approach of using and further developing existing regional structures is, so far, successful. Such development, however, needs small steps. The support from state education authorities is essential for the development of regional identities in networks. The duties of the steering committee and its coordinator(s) are diverse and can only be accomplished by teamwork.
With reference to the four functions of networking according to Dalin (1999), namely informative function, learning function, political function and psychological function, the evaluation data collected up to now give rise to some indicators and examples. Innovative projects are carried out within the regional networks and increase the attractiveness of science lessons with cross-curricular teaching as well as in collaborations between schools.
The dynamic development of RECC is remarkable; they developed out of the networks. In the next few years, the focus will be on constructing collaborative structures between networks and RECCs as well as quality development and assurance through process management, process guidance, evaluation and research. Experiences in the network process in science education within IMST, gathered over six years, are a good basis for the PROFILES project in Austria to build on already existing networks. Since 2011 PROFILES was infused into IMST through presentations at network meetings, teacher training seminars (CPD) and conventional information material (PROFILES newsletter).

Lessons Learned

Good practice cannot be cloned, but exchange of experiences on a personal level supports learning and innovations. Networks offer goal oriented exchange processes among teachers *(information function)* which support professional development of teachers (i.e. fresh ideas for classroom teaching, inter-disciplinary co-operations at schools) *(learning function).*

Networks have the potential to create a culture of trust with the effect of raising self-esteem and risk-taking of teachers (*psychological function)* and upgrading of sciences at school *(political function).*

It is necessary to maintain a balance of *Action & Reflection* (goal-directed planning and evaluation) and *Autonomy & Networking* (analysis of own situation, but also support by „critical friends“ i.e. colleagues at school, IMST-facilitator) in order to set up a sustainable support system for schools.

Evaluation and Research needs to be oriented towards an iterative connection between an interest to gain new knowledge and a developmental interest. A culture of self-critical and collective reflection might flourish, but reflection should not hamper the carrying forward to the project (see previous aspect).

The overall challenge might be described as keeping the momentum going between structures and processes or in other words between stability and fluidity in order to enable sustainable development of learning in the long run.

As the experience in Austria showed, networking in practice is not without fault. Some risks that have been identified can be summarized as:

- gap between electronic information/ networking and concrete practice;
- the networks move away from the interests of teachers and from the teaching and learning of students;
- common visions and goals disappear;
- weak co-ordination;
- lack of resources;
- only active teachers participate.

Development of a PROFILES Network-system

PROFILES envisages the setting up of networks on different levels to both maximise the dissemination and to make teachers more aware of the PROFILES project and the goals it has set out to achieve.

At the Start-up meeting in Berlin, Germany (9th – 11th December 2010) the philosophy and concept of networking were presented and discussed. In a workshop following the presentation participants reflected their network concepts and conditions for networking in their countries or regions. Possibilities of electronic platforms were discussed as well. After the meeting a list of contact persons responsible for networking and disseminating PROFILES was compiled.

At the consortium meeting in Tartu, Estonia (25th – 27th May 2011) networking and dissemination was part of the programme. The objectives and deliverables for the project partners were presented and discussed. At the meeting all participants completed a questionnaire to provide information about the status-quo regarding a network system in their countries. This so called “state of the art questionnaire” was constructed to describe the network-process within the different countries and to illustrate their development (Figure 1).

At the consortium meeting in Ein Gedi, Israel (13th – 17th February 2012), the findings of the state of the art questionnaire were presented and discussed.

For networking and dissemination, the minimum target goals were put forward as:

- By September 2012, cooperation among science teachers in one school (teacher network); dissemination of PROFILES modules to stakeholders in one local structure (district, town).
- By September 2013, cooperation among science teachers in two/three schools (school network); dissemination of PROFILES modules to stakeholders in one region.

- By September 2014, cooperation among science teachers in a local/regional structure (local/regional network); dissemination of PROFILES information to stakeholders nationwide.

Findings of the "State-of-the-Art-Questionnaire"

Based upon the questionnaire the charts below shows, that all of the partners were able to build on existing networking structures at an early stage (May 2011). The majority are teacher and school networks. Mainly teachers and Formal Educational Institutions are involved. In Austria and Turkey (and in some other countries) also non-educational organizations (like NGOs, businesses) are already part of networks. The number of teachers involved vary. Two partners are not depicted in this map: ICASE (works internationally) and Sweden (joined PROFILES later).[1]

In order to extend the existing channels, all partners were asked to organize networking-meetings to promote the PROFILES project. All partners should draw on already existing networks. As a further consequence the partners should bridge the different networks within their countries.

In May 2012, the project partners updated the network questionnaire (state of the art questionnaire) to give insight into the development

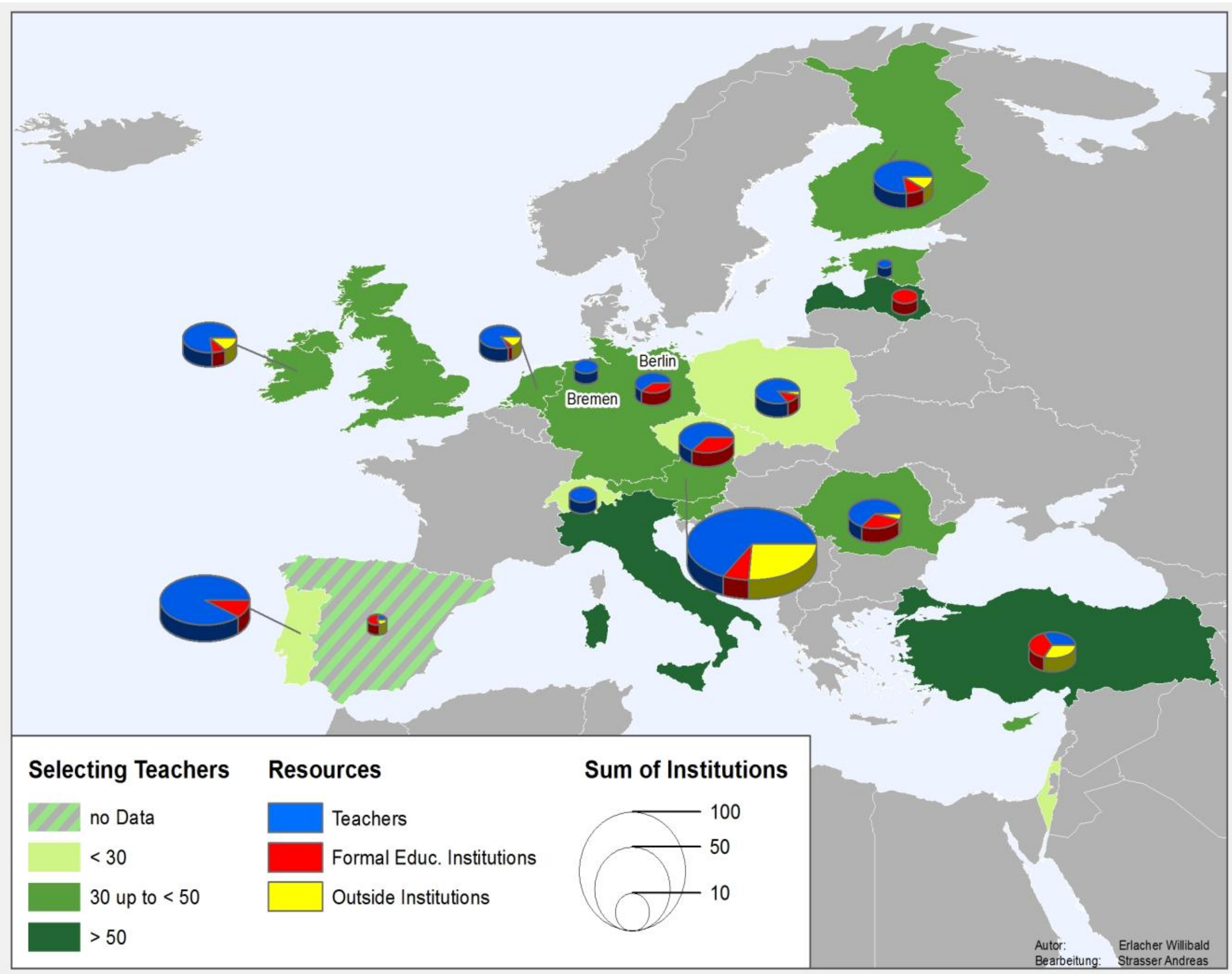

Figure 1. Findings of the state of the art questionnaire (May 2011)

[1] Italy and Slovenia provided data about their resources only at the second round of the state of the art questionnaire in May 2012; One partner in the United Kingdom left the project.

of their network activities. The findings show that within one year (from May 2011 to May 2012) six partners could increase the number of teachers and formal educational institutions involved in the networking process.

Summary and outlook

Networking could be considered as a constant process. It would be a success if PROFILES could support the start of a networking process which would go on after the end of PROFILES in 2014. The goal should be the maintenance and sustainability of PROFILES networks. To keep networks going, it would be necessary to constantly provide new impulses from inside, but also from outside the network. External perspectives and constant (self-) evaluation would be the fuel that keeps the network going. These would be the factors which maintain the dynamic, flexibility and democracy within networks. The development/training of so called “lead teachers” within continuous professional development (CPD) programmes could be seen as one important factor.

At the moment a number of partners are in a networking process. In terms of operationalisation, there is always a tension between clear guidelines and space for necessary local, regional and national development. Networking cannot be undertaken based on a recipe, but it needs some ingredients like joint goals and interests, feedback loops and evaluation in order to reflect upon processes and structures. Looking at the different approaches of the partner countries towards the establishment of networks, we are optimistic to achieve the targeted goals within PROFILES.

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CHAPTER 2: EXPERIENCES WITH AND REFLECTIONS ON THE PROFILES PROJECT – POSTERS

2.1 Science Teachers Cooperate: PROFILES Teachers Continuous Professional Development and the FU Berlin "ProNawi"-Project

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Abstract

"Pro Nawi" (Pro Science) is a project group brought to life in 2009 by motivated primary school teachers teaching science in grade 5 and 6 in Berlin. The reason behind the formation of the group was and is to continuously develop and improve science education – working together with colleagues in schools as well as in education. Our poster will highlight the concept as well as core themes of this long-term teacher training programme. We will also report on experiences during the project work and discuss first results of our accompanying research.

Introduction

The scientific professionalization of pre-service and in-service teachers is one – in our eyes even the – key objective of the educational disciplines (Jaumann-Graumann & Köhnlein, 2000). Professionalization is characterized both as a task continuing over the course of the professional career and as the process of personal professional education (Terhart, 2009).

Professional requirements for teachers are constantly changing. Among numerous examples are the reforms in the university education of teachers as well as the reforms in school practice (e.g. the introduction of all-day schools, comprehensive schools and secondary schools in some German states as well as science as a school subject). Professionalization programmes must address these changes that teachers face. In many cases, however, the states' support programmes which precede or – as it often happens – accompany such reforms do not meet the teachers' demands. To remedy what teachers obviously consider a deficit (Bolte & Streller, 2007), an initiative – also supported in context of the PROFILES project – arose in Berlin, in which teachers and educational researchers founded together a long-term, cooperation-based training programme. "Pro Nawi" (Pro Science) is a project group of interested teachers who teach sciences outside their subject areas in grades 5 and 6 in Berlin elementary schools (for a discussion of problems in Berlin schools see Bolte & Streller, 2007). They intend to develop and improve their teaching in cooperation with colleagues from school practice and education research. The teachers themselves gave the impulse for the formation of this teacher working group after a one-day training course. They wanted a continuous training which would give them the opportunity to work cooperatively on questions and problems regarding their own teaching.

Conception and Context of the "ProNawi" Project

After the successful foundation of the "ProNawi" CPD initiative, expectations, wishes and interests of the ten participating teachers were collected in a written survey, following PROFILES CDP models. As the time frame was initially set on monthly meetings over the course of one year, the teachers needed to discuss their objectives as well as negotiate and commonly agree upon viable aims within the group. Apart from the primary aim of "improving science teaching", a focus on "methods of scientific work" emerged. The teachers wanted to "get to know and develop a variety of ideas and suggestions for learning methods of scientific work", "work on research questions as well as practical implementation and testing of experiments that appear useful for education", "plan lessons together and support each other in lesson planning" and "discuss possibilities of differentiation in science education". The results of this survey were sorted, summed up and main aspects were presented on a poster. At subsequent meetings, this poster was used for orientation and to check the progress of achieving own and common goals. The scientific topics that were developed during the meetings corresponded to the curriculum for sciences and touched upon fields such as "Weather and Seasons" or "Food and Digestion".

In addition to the teachers' voiced demands concerning scientific and pedagogical basics, another key factor in the conception of this project was to systematically examine the learning conditions and competence development of the participants by means of a specifically developed questionnaire on Methods of Scientific Inquiry (Erb & Bolte, 2011). In this way it was possible to identify knowledge deficits or problems in this area of which the participants may not have been aware and to discuss them as "learning condition diagnosis" (here the learning conditions of the participating teachers). The pre-test analyses showed that teachers are very well capable of identifying technically correct statements concerning scientific methods of "observing and describing" and "formulating scientifically appropriate hypotheses". However, it also showed the teachers' "insecurities" in identifying scientifically incorrect or inappropriate statements in this context.

Implementation of the Pro Nawi project

The meetings, lasting three hours each time, were always a mixture of "classic (conventional)" training (with phases of lectures, explanations, demonstrations and practical exercises which were initiated and prepared by AG PROFILES of FUB) and "constructive" phases when the teachers decide autonomously on their main focus. In many cases, they researched, consolidated and differentiated contents and methods they considered specifically important before sharing their work in their learning group and adapt it for their own teaching. The training programme was structured as follows in Table 1:

	Main contents – primary topic: Scientific methods
Oct.	Clarification of general conditions, wishes, expectations and goals
Nov.	Development of research questions in groups (e.g. Can cola actually dissolve meat?), supporting the teachers with learning aids of different degrees
Dec.	Adaptation of last month's work for own teaching, assisting with teaching-specific questions
Jan.	Working in laboratories – practical exercises (equipment, measuring, weighing, different sources of heat and burner), safety regulations
Feb.	Focus: observations (exercises, evaluation of children utterances)
March	Focus: hypotheses (clarification of the concept, tasks for the subject area air), planning experiments for verification
April	Presentation of a lesson sequence "Magnetism" by a participant, conducting the experiments, discussion of the experiments and materials
May	Presentation of an exam with practical parts on magnetism by a participant, discussion of the students' answers; formation of models
June	Systematization of scientific inquiry, topic: Can wind blow around the corner? (developing the question up to the explanation and the formation of models)

Table 1. Overview of *Pro Nawi* meetings in the school year 2009/10

We want to illustrate the realization of Pro Nawi meetings in more detail by describing the session on the topic "(scientific) observation" as an example (Box 1).

At the beginning of this meeting, a short evaluation of the questionnaire (Erb & Bolte, 2011) on "(scientifically sound) observation" was presented to the participants. According to the analyses, *Pro Nawi* teachers as well as their students had difficulties in identifying statements which could be described as "scientifically incorrect observation" (item example: *The fizzy tablet sinks down because it is heavier than water.* – This statement is *scientifically incorrect* as the subordinate clause already includes an explanation). The results of our accompanying research that were available at this point initiated a joint discussion about the exact meaning of the term "scientific observation". The result was an agreement to understand it as "perceiving with all senses" without referring to explanations and reasons for the alleged observation. The participating teachers were given the task to closely observe – in a scientific way – a phenomenon. For this purpose, oil was poured into a champagne glass filled with colored water, and salt was added. The participants observed their perceptions, described them and discussed their scientific correctness of the wording. Afterwards, the *Pro Nawi* teachers were handed a group interview transcript of children in fourth grade who had the same observation task. After listening to an audio recording of the class discussion as well, teachers analyzed the children's statements and interpreted them according to their scientific correctness (*Example: **Child I**: … [if you] look from below, you see that the salt is white **Child II**: Bubbles are rising … rising up in the middle **Child III**: Yeah and if you look down there, down there in the glass there is a … small heap and there are bubbles coming from it…).* Finally, teachers worked on additional tasks about observable phenomena and transferred the suggestions to their own teaching.

Box 1. Description of the meeting on „scientifically sound observations"

Summary and Outlook

The long-term training for science teachers was designed and implemented to suit the participants' needs, promote teachers' learning progress and to provide space for reflection and cooperation. In the following school year, Pro Nawi will continue as requested by the participants. The focus will be on "internal differentiation in science education" according to the teachers' wishes and interests for their professional development. Apart from that we will collect the data for the post-test analyses before the next PROFILES Conferences 2012. Surely we will report on the results of our accompanying research – on the survey of teachers as well as students (reg. WP5/6: Teacher CPD and Ownership) as well as reg. WP7: Students Gains) on the PROFILES Conference 2014.

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2.2 Professional Development regarding Stages of Concern towards Inquiry-based Science Education

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Research Framework

According to the ROSE study (Schreiner & Sjøberg, 2004), students in many countries have only little interest in science and in learning science. To change this, different associations (Minstrell, Van Zee, & AAAS, 2000; National Research Council, 2000; Rocard et al., 2007) state that Inquiry-based Science Education (IBSE) seems to be an appropriate approach to enhance learning outcomes in a positive way. Therefore one of the aims of the PROFILES project[2] is the dissemination of IBSE in Europe.

For implementing IBSE in schools, teachers play an important role (Bolte et al., 2012; Bolte et al., 2012). One goal of the FUB PROFILES working group is the development and realization of Continuous Professional Development (CPD) programmes for pre-service chemistry teacher students. In the context of a chemistry education intervention, pre-service teacher students plan and perform IBSE-oriented lessons about environmental pollution. During the intervention course the pre-service students are supervised by a chemistry educator, who introduces theoretical and practical based the PROFILES IBSE model. Overall, the intervention course focuses, among other aspects, on the following topics:

- introducing the IBSE model theoretical and practical based
- talking about advantages and disadvantages of IBSE in school practice
- designing inquiry-based science learning environments
- using inquiry in the classroom for topics of environmental pollution
- reflecting IBSE-oriented lessons

To evaluate the impact of this CPD courses, we analyzed the participants' attitudes and concerns regarding the implementation of IBSE with a pre-post-test design. According to the theory of planned behavior (Ajzen, 1991) the benefit of analyzing attitudes and concerns is that those science teachers with positive attitudes and concerns towards IBSE are highly probable to implement IBSE (Teacher Ownership).

To gain insights into pre-service teacher students' attitudes and concerns towards IBSE we refer to the Concern-Based Adoption Model (CBAM) by Hall and Hord (2011), and especially to their Stages of Concern (SoC) theory and questionnaire (Hall & Hord, 2011). The SoC model is based on seven stages: A – Unconcerned, B – Informational, C – Personal, D – Management, E – Consequence, F – Collaboration and G – Refocusing (Hall & Hord 2011).

Applying the SoC questionnaire provides information about the testees' attitudes and concerns towards IBSE by creating SoC profiles (Hall & Hord, 2011). In order to apply a SoC questionnaire to pre-service chemistry teachers, we first have to enhance our adapted SoC questionnaire (Schneider & Bolte; according to Pant, Vock, Pöhlmann, & Köller, 2008; Hall & Hord, 2011) and investigate the scientific quality of the adapted and modified questionnaire version.

Therefore we ask:

1. Does our adapted SoC questionnaire (Schneider & Bolte; according to Pant et al., 2008; Hall & Hord, 2011) meet the criteria of scientific quality?

If our SoC adaption provide similar psychometric features compared to other studies (e.g. Pant et al. 2008, Schneider & Bolte, in press), we also want to investigate the following questions of research:

2. What 'profiles of concerns' do pre-service chemistry teacher students show regard-

[2] http://www.profiles-project.eu/

ing the SoC model in the frame of the FUB PROFILES CPD?

3. In what way do pre-service chemistry teacher students' attitudes and concerns regarding IBSE develop during a course of our specific PROFILES CPD intervention?

Methods

For our analysis we have adapted a German questionnaire version of SoC (Pant et al., 2008; according to Hall & Hord 2011). The adaption is necessary as SoC questionnaire (Pant et al., 2008) focus on in-service teachers only. To ensure our adaption, we have developed further items for some SoC stages. In the questionnaire version of Schneider and Bolte (2011) stages A, D, E, F are represented by five items, stage C is represented by 6 items and stages B and G by 7 items. Each item has a rating scale from 1 "Not true of me now" to 7 "Very true of me now" (Hall & Hord 2011, p. 283-284). Furthermore, if the content of an item is currently not relevant to a person at all, there also is the possibility to choose "0".

Before we gain insights into the pre-service teacher students´ attitudes and concerns regarding IBSE in particular, we have to analyze reliability (Cronbach´s alpha) for each SoC subscale. For this purpose we want to collect data of approximately 100 pre-service teacher students. These students also function as a control group sample. Furthermore we want to collect data of approximately 20 pre-service teacher students, who will participate in our PROFILES pre-service CPD intervention programme. With these collected data we plan to analyze mean scores for the seven SoC-subscales and to create SoC profiles differentiate by our control group and our CPD intervention group. The data of control group and those of the intervention group will be compared in the frame of t_0 data collection. Hence, we collect data from the CPD intervention group at different times (t_0, t_{n-1}, t_n) to analyze possible developments in the participants' attitudes and concerns during the intervention. In order to describe the different samples in more detail, we test the statistical significance of (potential) differences within the SoC-subscales by means of unpaired and paired t-tests, multivariate analysis of variance (MANOVA) and effect sizes (Cohen´s d).

Results

Our control group (CG) sample was collected in 2011 and 2012 and includes 122 pre-service teacher students. The sample size of our CPD intervention group (CPD_IG) was collected in summer term 2012 and consists of 16 pre-service teacher students at t_0 and t_{n-1}. At the moment the data collection for t_n is in progress. Table 1 shows the data analysis regarding reliability: Cronbach's α ($N_{CG\&CPD\_IG\_t0}$ = 138) of the SoC subscales ranging from α = .70 to α = .88.

SoC	A	B	C	D	E	F	G
Vers. 1	**.70**	**.78**	**.77**	**.82**	**.78**	**.78**	**.88**
Vers. 2	.81	.77	.75	.66	.73	.82	.74
Vers. 3	.76	.68	.75	.70	.71	.71	.63

Table 1. Cronbach's α of SoC-subscales:
Vers. 1: Schneider & Bolte, 2011 (N = 138);
Vers. 2: Schneider & Bolte, in press (N = 91);
Vers. 3: Pant et. al., 2008 (N = 1123)

The pre-post-SoC profiles of the pre-service teacher students are shown in Figure 1. For the t_0-t_0-comparison of CPD intervention group and control group across unpaired t-tests, we could not find any statistical significances. However, the data analysis shows statistically significant differences regarding the SoC profiles of controll group (t_0) and CPD intervention group (t_{n-1}). The analysis resulted in statistically significant multivariate differences (Wilks-Lambda = .638, df1 = 7, df2 = 131, $p < .01$) and statistically significant univariate differences in the SoC stages "Unconcerned" (t = 8.05, df = 137, $p < .001$, d = 2.14), "Management" (t = 2.367, df = 137, $p < .05$, d = 0.63), "Consequence" (t = 3.317, df = 137, $p < .01$, d = .88), "Collaboration" (t = 2.131, df = 137, $p < .05$, d = .57) and "Refocusing" (t = 2,961, df = 137, $p < .01$, d = .79).

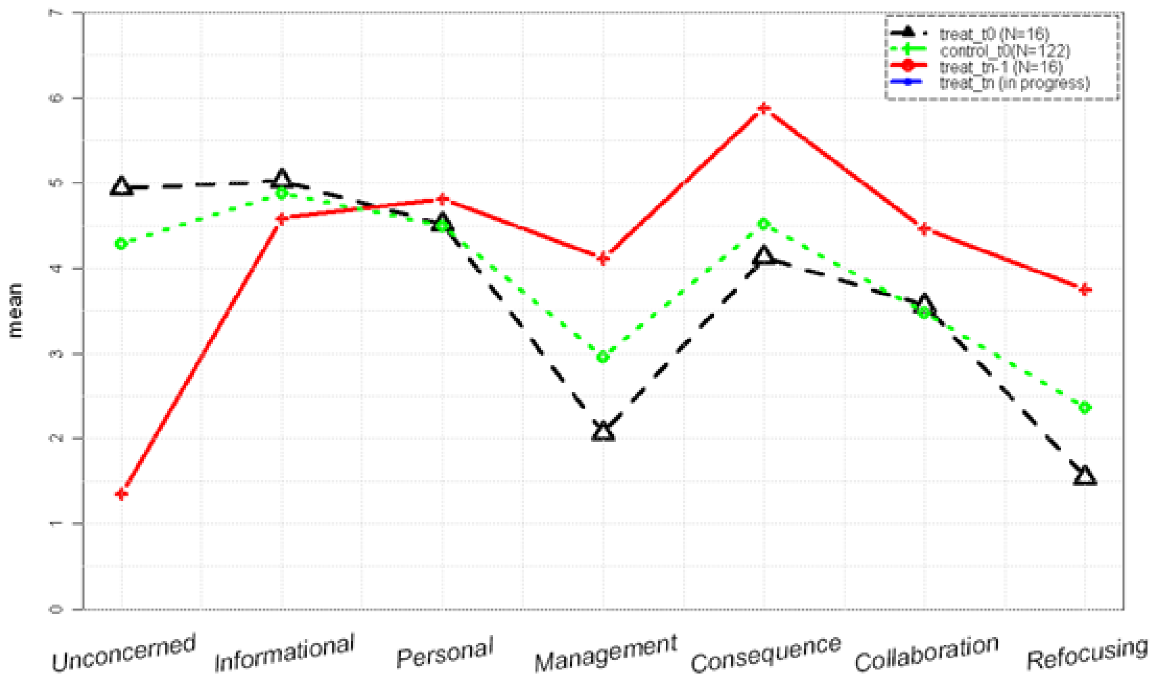

Figure 1. SoC profiles of control group (N = 122) and CPD intervention group (N = 16)

Regarding the intervention group at t_0 and t_{n-1} we observed different SoC profiles. For the SoC-stages “Unconcerned” (t = 15.05, 8.937, df = 15, p < .001, d = 3.76), “Management” (t = -3.568, df = 15, p < .01, d = .89), “Consequence” (t = -3.864, df = 15, p < .01, d = 0.97) and “Refocusing” (t = -6.672, df = 15, p < .01, d = 1. 67) the results of paired t-test analyses show statistically significant differences and according to Cohen (1962) high effect sizes (Cohen´s d).

Discussion

First of all, we have shown that the adapted SoC questionnaire provides similar psychometric features compared to other studies (Pant et al. 2008; see Table 1). Hence the adapted SoC questionnaire is suitable for further studies.

Regarding the CPD pre-service teacher students attitudes and concerns assessments towards IBSE at t_{n-1} we observe a “positive” development in comparison with our control group and the CPD group at t_0 as we could identify the typical profile of a cooperator (according to Bitan-Friedlander et al., 2004) at the end of our theory-based seminar (t_{n-1}).

Furthermore, the CPD pre-service teacher students are at t_{n-1} more concerned (SoC A) about IBSE and have also higher concerns on mangement tasks: Hall and Hord (2011) state that a first using of the innovation - in our case an IBSE approach - is given when management (SoC D) concerns are higher at t_{n-1} than at t_0. For SoC subscales “Consequence”, “Colla-boration” and “Refocusing” the pre-service teacher students are more concerned at t_{n-1}. Hall and Hord (2011) pointed out that such results are positive regarding the imple-mentation of educa-tional programs, such as the imple-mentation of IBSE in school practice.

Nevertheless Hall and Hord (2011) explain that the development of concerns regarding educational programmes or innovations can take years and depends on the educational programme. Our results show that by means of the FUB PROFILES CPD programme for pre-service teachers it has become possible to affect participants attitudes and concerns in a positive manner.

Therefore we will provide further IBSE-oriented courses for pre-service teacher students to build up a teacher ownership among the participants in a positive way.

Outlook

The data collection for t_n is currently in progress. We will present the questionnaire and the results at the PROFILES conference in Berlin 2012. Furthermore, we plan to continue our research regarding concerns and attitudes towards IBSE over the next terms.

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2.3 Analyzing the Relevance of Science Education from Students' Perspectives regarding Developmental Tasks, Self and Prototype Attitudes and Motivation

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Introduction

The Inquiry-based Science Education (IBSE)-centred PROFILES continuous professional development programme (CPD) for science teachers aims at influencing the way of science teaching of the CPD courses' participants. How the teachers are adapting the PROFILES approach and to what extent they take ownership of the PROFILES science teaching and learning approaches should be detectable by characterizing individual changes and outcomes that the students experience throughout the duration of the PROFILES intervention. PROFILES refers to this as *student gains*.

Theoretical Framework: Constructs to analyze the impact of the PROFILES intervention on students

Based on the complexity of IBSE learning, different constructs and methods can be adapted to investigate the PROFILES influences on students who are taught by the teachers involved in the PROFILES CPD programme.

According to Havighurst's ***Developmental Tasks Theory*** (1981, VI), developmental tasks (DTasks) are a "midway between an individual need and a societal demand". Six developmental tasks can and should be supported by science education (Schenk, 2005). They are labeled *(1) value*, *(2) concepts*, *(3) vocation*, *(4) self*, *(5) gender* and *(6) body*. The theoretical construct of developmental tasks may offer valuable insights into the personal relevance of science education that students perceive against the background of how well they feel supported in coping with the DTasks in their actual science/chemistry lessons.

Another approach to determine changes caused by teaching the PROFILES way is the analysis of the students' ***Self-to-Prototype Matching*** (StoP). Following Kessels and Hannover (2002), a prototype is the stereotypical image a person has about the typical representatives of a specific group. People are constantly comparing their self-image with prototypes. This influences their decisions (e.g. choice of science courses and career) more or less consciously. Kessels and Hannover recommend analyzing the following aspects: *(1) attractiveness, (2) social competence, (3) self-centeredness, (4) intelligence, (5) creativity, (6) maleness* and *(7) femaleness.*

A third model which describes science classes by means of the students' (intrinsic) motivation is the ***Motivational Learning Environment*** (MoLE) (Bolte, 1995). Students' learning and development progress is mainly affected by their experiences with school and with a subject in the corresponding field of interest. Hence, students' experiences regarding the *Motivational Learning Environment* in their science classes affect their attitudes towards science in general (e.g. concerning a science-related career choice or self and prototype attitudes) as well as their engagement in science classes and therefore science learning (Bolte, 2006). The MoLE model of Bolte originally consisted of seven dimensions: *(1) satisfaction, (2) comprehensibility, (3) subject orientation, (4) relevance of the topics, (5) students' opportunities to participate, (6) class cooperation and (7) students' willingness to participate*. An additional dimension named *(8) vocation* has been added to the MoLE model in more recent publications (e.g. Bertels & Bolte, 2010).

The theoretical concepts described above have been arranged to illustrate the personal relevance and perceived reality of science classes. With this model, the students' assessments of selected variables are evaluated, especially stressing their effect on the students' career choice (Figure 1) (Bertels & Bolte, 2010; Albertus et al., 2011).

Questions of Interest

For an evaluation of the students' benefits from the PROFILES intervention, the Berlin PROFILES group focuses on the following research questions.

1. Developmental Tasks*:* How do chemistry lessons support students in dealing with their school science related developmental tasks? Which potentials and shortcomings can be deduced from the students' and trainees' (students from vocational schools) developmental task assessments?

2. Self-to-Prototype Matching*:* What kind of self-image and prototypes do students from middle high schools and trainees from the field of the sciences express with respect to employees working in the field of the sciences (e.g. in the chemical industry)?

3. Motivational Learning Environment*:* How do students from middle high school and from vocational schools (trainees) perceive the motivational learning environment of their science/chemistry classes?

Method and Scales

To answer the research questions we adapted scales from the studies described above and developed a questionnaire instrument which tests - amongst others - the following variables:

- The ***Science-related Developmental Tasks Scales*** (potentially) relevant from the students' perspectives should be assessed a) on the basis of individual weighting (priority), and b) on how the students assess their presence in science/chemistry classes (practice); (6 subscales with a total of 18 items in both cases).

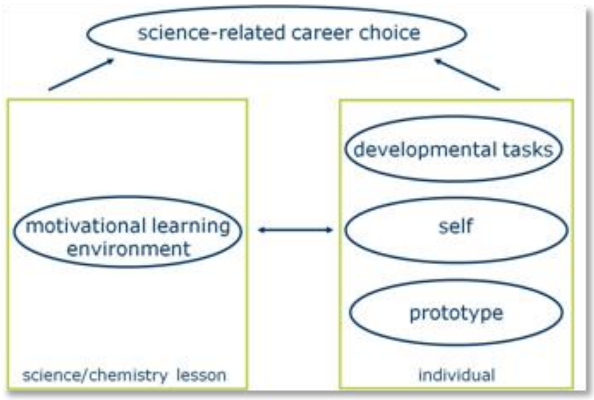

Figure 1. Research model for students' career choice (in the sciences) (according to Bertels & Bolte, 2010)

- The ***Self-to-Prototype Matching Scales*** consist of *Prototype Attributions Scales* concerning people working in the field of science/chemistry and the students' *Self-Image Attributions Scales* (7 subscales with a total of 21 items in both scales; following Kessels & Hannover, 2002).
- The ***Motivational Learning Environment in Science/Chemistry Classes Scales*** in the MoLE-REAL-version (focusing on how the students perceive their actual science/chemistry lessons) and the MoLE-IDEAL version (focusing on how the students wish their science/chemistry lessons to be) (8 subscales with a total of 16 items in both versions; according to Bolte, 2006)

To investigate these research questions we focus on a sample consisting of middle high school students and trainees from the field of the sciences. The sample should ideally consist of approximately 500 participants in each of the two groups (N ≥ 500).

First, we analyzed the reliability coefficients of the scales we adapted to determine their statistical quality.

Findings

We will limit our presentation to those findings that represent best the relevance and reality of science education from students' perspectives. As Table 1 shows, all scales we adapted proved to be scientifically credible according to the

Scale	N			Dimension/Subscale (for the number of the Dimensions/Subscales see Theoretical Framework)							
	students	trainees	total	1	2	3	4	5	6	7	8
DTasks relevance	969	502	1471	.73	.83	.87	.75	.81	.80		
DTasks reality	996	508	1504	.85	.88	.92	.86	.92	.84		
self image	368	514	882	.88	.75	.73	.87	.67	.77	.74	
prototype	343	498	841	.90	.83	.85	.90	.81	.80	.80	
MoLE REAL	1045	517	1562	.88	.70	.68	.64	.73	.76	.62	.77
MoLE IDEAL	1045	517	1562	.87	.77	.75	.75	.76	.60	.76	.55

Table 1. Reliability coefficients (Cronbach's alpha) of the adapted scales

criteria of scientific quality. The scales are objective, reliable and – considering other studies – valid.

Furthermore the questionnaires proved to be helpful and economically applicable.

From the descriptive statistical analyses of our data we can conclude that from students' perspective science classes lack support in coping with the **developmental tasks** *(1) value, (3) vocation, (4) self, (5) gender* and *(6) body*. However, the support of *(2) concepts* in students' science lessons is exceeding their personal needs.

When looking at the **self and prototype** descriptions of our sample it becomes apparent that trainees show a much closer match of self and prototype in contrast to the group of middle high school students.

Additionally, the trainees perceive their science lessons to be more positive in terms of **Motivational Learning Environments** compared with middle high school students.

Conclusion and Outlook

Based on our previous experiences, it can be stated that the implementation of PROFILES modules into science classes can be successfully evaluated with the questionnaires we presented above. Especially with MoLE pre-post-test- analyses we are able to show that "PROFILES intervention students" are more motivated to learn science compared with the control group students who were taught in a conventional manner (Bolte and Streller, 2012, Keinonen et al., in press).

From our investigations and analyses we assume that PROFILES lessons seem to fit better with the students' perceived personal relevance of their developmental tasks. A better accordance of relevance and reality assessments should enhance students' (intrinsic) motivation more than regular science courses. Considering the model shown in Figure 1, this should cause changes in the students' attitudes towards science in general and their science learning in particular. In accordance with the PROFILES approach, science lessons should focus more on issues and topics that are relevant to students for a greater student gain.

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2.4 My Beliefs and Experiences in Teaching a PROFILES Module

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Background

As a biology and chemistry school teacher working in a country school and teaching lower secondary level students (aged 14-16) lacking labs and with poor financial resources, I am challenged to move away from traditional ways of teaching sciences seen as rather theoretical. Lower-ability students tend to lose interest and even talented boys are often under-achieving which I have found really worrying.

My Concern

In the modern world, developing scientific literacy is crucial because the world is changing so fast. Young people who are studying at school now need to make decisions in the future and their decisions will affect the society. To prepare students to live and work in tomorrow's world, I feel I need to look for more effective ways of teaching science. I think that teaching is not effective when learning is not happening at the same time; outcome is more important than input.

I wish my students to learn how to undertake scientific inquiry, because it is a useful model for organising thoughts and actions. I see this as essential, not only at school and in science lessons, but also as a model to follow in everyday life. Students need to learn how to notice and formulate their problems, collect other peoples' experiences and knowledge, think of possible solutions, solve problems and assess in their minds whether the solution is good enough, or whether they need to find a new one. I am sure that if we expect life-long learning in the changing world, then the role of school is to provide young people, not only with knowledge, but also with good learning strategies. Learning to undertake scientific inquiry is not only an aim in itself, but it is also a good way to develop necessary competences for life.

My Interest in PROFILES

From the beginning I did not expect to teach simply biology or chemistry content within PROFILES, because this was only one part of the 4-5-lesson-long module. In these modules I noted the opportunity to deal with different content and competences at the same time and I believe it is a good way of organising lessons. I hoped students would not only learn the scientific content, but they would be more active in taking their learning process into their own hands. I hoped they would be more motivated to learn from everyday situations, learn to notice problems and find solutions on a scientific basis. The PROFILES modules seemed to be good for developing many competences in school, such as: communication skills, mathematical competence and basic competences in science and technology, digital competence, learning to learn, social competence, plus, importantly, a sense of initiative. I think that we, teachers, sometimes forget that there is much more in the curriculum than only the content of our subjects. My experience is that very often teachers care more about what is written in the text book than what the full range of expected outcomes should be.

My Teaching Approach

I have used several PROFILES modules in my teaching. Here I describe how I used one of them in my class. When teaching acids in chemistry, I decided to include an Estonian PROFILES module entitled "Coca Cola – myths and reality". In the first lesson, I tried to explain the way we (the students and I collaboratively) were going to study and we discussed the difference between scientific and social problems.

We tried to find out different features of Coke – both scientific and social. Students divided themselves into groups of 4 persons. This time they could choose who to work together with. Every group was asked to choose one feature and to prepare a presentation for the next lesson. Through reflecting on the aspect chosen and in trying to create a meaningful presentation, students practised identifying problems and asking questions. They also practised making decisions and dividing tasks within the group. I also told them that at the end of the whole module there will be an evaluation of their work within the group, related to each stage, so nobody should stay passive and they should divide tasks between their members.

In the second lesson, we listened to the presentations (in total there were 5) and discussed the content and form of each presentation. Students pointed out the good and bad sides of each presentation and put forward suggestions on how to improve them. Though appreciating the necessity to give comments, at the end of each presentation, activated them to listen more carefully and make notes. By being guided to be creative, to evaluate information critically, express their ideas clearly and give or receive both positive and negative feedback, they commented on the content, logical construction, colours and size of the text, illustrations, presenting process, etc. All these were seen as important skills for scientific literacy in everyday life and thus an integral part of science lessons

As Coke is a very aggressively advertised product, at least in Estonia, we developed an interesting discussion about advertising and how people are very often manipulated by advertisements (ads). Ads are something that we see all the time and young people feel they are a part of their lives. In biology, we had just studied aspects of human anatomy and physiology, so this led to the question on how the brain works and how the brain can be confused – perhaps an intention of advertisers! Years ago, the students might well of said that this was not appropriate for a chemistry, only for a biology lesson, but my intention has always been to help students understand that there are no strict boundaries between different school subjects. That is why I welcomed the discussion and was happy that students had noticed the connection. We watched some Coke ads on 'You Tube' (which I had previously selected) and tried to find details that could influence people to buy this product. We discussed about the importance of critical thinking in life as a whole and in science as well. I am sure that this is an important part of scientific literacy (even if not expressed mentioned in the curriculum) and I hope that our activities helped students to understand better. At the end of this lesson as an introduction to the next and with the main message that we should not believe everything that is told to us blindly, we recognised the need to find additional information to check the facts. For this, the groups had the task of bringing different soft drinks including Coke which they could then analyse.

The purpose of the third lesson was to finding out more about acids. We had studied the topic of acids earlier, so now we tried to consolidate previous knowledge and build on this in the new situation. I think it is very important for the students to realize that everyday life is linked to their learning at school and in dealing with everyday situations they can benefit from their science knowledge. In this way we can combat an often made student comment that they do not need the things they are taught at school. As the school did not have enough titration equipment to follow exactly the investigatory work indicated in the PROFILES module, we decided to change the approach and find our own way to measure the acidity (pH) of different drinks. This was stimulated by students who had heard, from the media, that high acidity is considered one of the health risks of Coke. They knew already that pH can be measured with indicators and so they were able plan their work. They discussed in groups what and how to measure and set up their own hypotheses. We also decided to pay attention to the nutrition and ingredients information on the packaging. Later students added the pH values determined and ingredients found on the packaging into a big grid, drawn on the board, so that everybody could see the results and also record these in their notebook. Based on the grid, the students, as a whole class, were able to compare drinks and discuss why one or another drink would be good or bad for their health. They decided there was not an ideal drink (or maybe this was water, but this depended on the circumstances!) and they decided that, in reasonable amounts, they could drink any of the studied liquids. During this simple yet scientific learning activity, which did not require much by way of resources or equipment, students learned how to plan an experiment, carry it out, set up hypotheses, collect and interpret data, present outcomes and draw conclusions. And above all, the students enjoyed doing it.

In the fourth lesson, we turned back to the beginning and held a discussion to try to draw social – scientific conclusions. The students wrote their conclusions into their notebooks, as well as giving oral feedback to both me and to each other about what they liked and had learned during the four lessons. I gave feedback to the students about how they had worked in my opinion and what I had noticed.

All students said to have enjoyed the lessons a lot due to the investigatory work and the opportunity to be actively involved. They seemed to enjoy working with the context-based course materials and participating on a context-based teaching approach. Most students said they had enjoyed the discussion on social problems because there were not many lessons where they could do that. Sometimes it seems that science can be better communicated and certainly it seems more motivational, when we use the everyday interests of students as starting points.

Conclusion

As a result of this simple example of context-based learning within a Science-Technology-Society (STS) approach, my students said they have started to notice both scientific and social problems, learned to divide tasks and take responsibility, make better presentations, plan their own scientific inquiry, draw conclusions and evaluate the work of their work. I noticed the students' developed in investigative and manipulative skills, as well as communication, problem-solving and decision-making skills.

I think using the module was worthwhile, because students were active and the learning opportunities seemed to make sense for them. It was interesting to get to know about their attitudes and see how they were learning and doing things better next time. This so-called STS approach seemed to attract students and I am planning to use more PROFILES materials in my lessons during the new school year.

2.5 Identifying Teacher's CPD Needs for Self-Efficacy in PROFILES

Ana Valdmann – University of Tartu and Tartu Kommerts Gymnasium, Estonia

Continuous professional development (CPD) is shown to have a positive impact on curriculum implementation and use of pedagogy by teachers, as well as teachers' sense of efficacy and their relationship with students (Craft, 2000). Although CPD can have many orientations, at its core are (a) teacher reflections, and (b) teacher enhancement of pedagogical content knowledge (PCK) (Day, 1999).

Driving the provision of a meaningful CPD within PROFILES is the identification of teachers needs, indicating gaps in the understanding or beliefs of teachers towards a new paradigm (for example, education through science – Holbrook, 2010) and ways to relate this to various pedagogical practices components, such as motivation, constructivism, NOS and inquiry-based learning. The intention is that through the PROFILES CPD, teachers build up the competence to appreciate and operationalise the new direction.

But this is not enough. Teachers also need the confidence to implement the ideas in their teaching. This competence and confidence is referred to, in PROFILES, as self-efficacy. Bandura (1977) introduced the concept of self-efficacy beliefs in which he proposed that belief in one's abilities was a powerful driving force, influencing "motivation to act".

Teachers with higher levels of self-efficacy tend to be open to new ideas, demonstrate greater levels of planning and enthusiasm, and are committed to their profession (Tschannen-Moren et al., 1998; 2001), promote positive classroom behaviour management (Emmer & Hickman, 1991), are less critical of students when they make errors and are willing to work longer with struggling students (Gibson & Dembo, 1984). Furthermore, teacher efficacy is also linked to students' affective growth, student motivation, student self-esteem, and student achievement (Midgley et al., 1989).

Teacher Needs Questionnaire

To determine teacher 'needs' in the case of PROFILES, a carefully constructed and validated questionnaire was developed, made up of 52 items that formed the following 10 subscales:

1. nature of science (items 1-6),
2. STL (items 7-11),
3. objectives of education (items 12-15),
4. inquiry-based learning (items 16-19),
5. learning environment (items 20-29),
6. motivation (items 30-35),
7. assessment (items 36-40),
8. theories of education (items 41-46),
9. self-analysis (items 47-50),
10. integration (items 51-52).

The questionnaire, exhibiting a high internal consistency for teacher's self-confidence (Cronbach α=0,95) and training needs (competence) (Cronbach α=0,98), was administered to volunteer teachers wishing to participate in the CPD programme. In the questionnaire, teachers were asked to rate their competence and their training needs on a four-point scale (1 – not at all … 4 – definitely). Thirty two teachers: 11 biology, 11, multi-subject, 9 chemistry, 1 physics teacher participated.

Findings

Of the 52 items include six were shown to be of particular importance for the CPD programme ($m \geq 3,5$) (Table 1).

Two of these items relate to inquiry learning seen as a crucial PROFILES component and an important part of the 3 stage model (Holbrook & Rannikmae, 2010) while two items relate to scientific and technological literacy (STL), significant for a new Estonian curriculum (Estonian Curriculum, 2011) as well as Europe wide (EC, 2007). The items, with their corresponding means and SD, are illustrated in Table 1:

Emphasis for Course	Mean	SD
Q17 Guide students to put forward scientific questions and hypothesis for investigation *(Inquiry-based Science Education*)	3,6	,56
Q34. Encourage self-motivation by students in science lessons *(Student motivation*)	3,5	,67
Q16. Distinguish between „structured“, „guided“ and „open inquiry“*(Inquiry-based Science Education)*	3,5	,67
Q10. Guide students to deal creatively and justify the socio-scientific problems (issues) *(STL)*	3,5	,57
Q9. Guide students to use the acquired knowledge and skills to new situations (contexts*)* *(STL)*	3,5	,51
Q3. Explain to students the difference between science and pseudo-science. *(Nature of Science)*	3,5	,51

Table 1. High emphasis items (m≥3,5)

Low self-confidence (m≤2,5) were indicated by eight items, although these did not overlap with the high level emphasis for CPD content (Table 2). Two items related to assessment and another two to self-reflection. Within the assessment field, formative assessment is a rather new approach in Estonian schools but highlighted in the new Estonian curriculum (2011). In the light of the new curriculum, a lack of teacher self confidence is not surprising and the need for CPD in this area. Table 2 illustrates items given low self confidence by teachers.

Self-confidence items	Mean	SD
Give meaning to ZPD (zone of proximal development) *(Education theories)*	1,9	,84
Aware of SDT (self determination theory) to motivate the students. *(Education theories)*	1,9	,70
Make self-reflective teaching videotapes *(Self reflection)*	2,0	,77
Carry out action research to raise effectiveness for my teaching *(Self reflection)*	2,1	,70
Undertake a range of formative assessment strategies with one`s own students (*Assesment)*	2,3	,72
Assess students knowledge and skills by their portfolios *(Assesment)*	2,3	,74
Distinguish between intrinsic and extrinsic motivation of students *(Education theories)*	2,4	,66
Teach in a constructivist manner so that students are guided to construct the meaning of knowledge *(Education theories*)	2,5	,79

Table 2. Items exhibiting the lowest self-confidence (m≤2,5)

In developing the CPD programme, it was also considered useful to be aware of the biggest, significant mean differences between self- confidence and competence (emphases for courses). For this, Z is an indicator of the difference in value between the two items (on a different set of scales) and P shows there is a statistically significant difference in each case.

Items	Self-confidence	Emphases for courses	Difference
Q10: Refer students to a creative and reasonably to resolve the social dimension of natural scientific problems	M= 2,7 SD=0.60	M=3.5 SD=0.57	Z =-3.9 P=0.00
Q16: Distinguish between structured, guided and open inquiry	M= 2,5 SD=0.62	M=3.5 SD= 0.67	Z=-4.0 P=0.00
Q17: Guide students to put forward scientific questions and hypotheses for investigations	M=2.9 SD=0.55	M=3.6 SD=0.56	Z=-3.5 P=0.00
Q37: Undertake a range of formative assessment strategies with one`s own students	M=2.3 SD= 0.72	M=3.4 SD=0.71	Z=-3.9 P=0.00
Q42: Give meaning to ZPD (Zone of proximal development)	M=1.9 SD=0.84	M= 3.4 SD=0.74	Z= -4.2 P=0.00
Q43: Aware of SDT and self-actualisation to motivate students	M=1.9 SD= 0.7	M=3.4 SD=0.74	Z=-4.3 P=0.00
Q44: Distinguish between intrinsic and extrinsic motivation of students	M=2.4 SD= 0.66	M= 3.4 SD=0.74	Z=-3.7 P=0.00
Q47: Make self-reflective teaching videotapes	M= 2.0 SD=0.77	M= 3.1 SD=0.88	Z=-3.8 P=0.00
Q48: Use of action research to make teaching more effective	M=2.1; SD=0.70	M=3.4 SD=0.75	Z=-4.4 P=0.00

Table 3. Significant differences between confidence and competence items (Wilcoxon Signed Rank for the scores Z≥3.5)

Two items related to assessment and another two to self-reflection. Within the assessment field, formative assessment is a rather new approach in Estonian schools but highlighted in the new Estonian curriculum (2011). In the light of the new curriculum, a lack of teacher self confidence is not surprising and the need for CPD in this area. Table 2 illustrates items given low self confidence by teachers.

In developing the CPD programme, it was also considered useful to be aware of the biggest, significant mean differences between self- confidence and competence (emphases for courses). For this, Z is an indicator of the difference in value between the two items (on a different set of scales) and P shows there is a statistically significant difference in each case. This is illustrated in Table 3.

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2.6 Hazard from Above – Which Sunscreen Should We Choose? Development & Implementation of a Module on Sunscreen in an Israeli Teachers' PROFILES Course

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The Sunscreen module – rationale & concepts

A PROFILES module, *"Hazard from above – Which sunscreen should we choose?"* was developed by a group of Israeli chemistry teachers participating in the PROFILES teachers' professional development programme, initiated by the Science Teaching Department at the Weizmann Institute of Science. The module was developed according to the principles and rationale of the PROFILES project. According to the philosophy and rationale of the project, the approach is expected to be student-centred. It includes inquiry-based activities, which contribute to decision making in relevant topics related to everyday life. The module emphasizes the use of inquiry skills, by using instructional activities such as: acquiring information on the web or through research experiments conducted in the chemistry lab and other activities that direct the students towards social research by performing a market poll about the product and its consumption.

Sunscreen is a product aimed at protecting its consumers' health, but in contradiction to other cosmetic products or drugs, it is perceived by youths as a "sexy" product, because it is related to sports and leisure activities, on the beach or in swimming pools, in such Mediterranean countries as Israel, and perhaps at ski resorts in European mountainous countries.

From a scientific perspective within chemical education, the subject allows one to teach aspects, such as the interaction between radiation and matter, emulsions, and how they are produced. From a social and educational perspective, this module is aimed at creating an awareness of the hazards originating from a long exposure to solar radiation (a habit very popular among youths in Israel), as well as understanding the meaning of the SPF number (Sun Protection Factor) that appears on the product, how these numbers are determined, and what they depend on.

Overview of the module – contents

The Sunscreen PROFILES module includes student activities, an evaluation sheet, directions for the hand-in assignments, as well as a teacher's tutorial including a description of the different parts and the scientific background. The students' activities are as follows:

1. ***Introductory Scenario*** – exposing the subject to the students by use of short video clips on the web and short blogs, followed by a written assignment that guides the students through the brainstorming process, by asking questions, and making inquiries into some of the subjects using the web. The goal of the first activity is to present the subject in a way in which the students' curiosity focuses on the subjects in question, and it also enables the students to obtain a general understanding of a sunscreen.

2. ***Market research*** – This involves designing a survey aimed at comparing the products available on the market, or conducting a consumer survey. Students, by themselves, define the objectives of the survey, but receive specific guidelines concerning the requirements of the assignment; this includes methods, results, and conclusions. The goal of the second activity is to allow the students to reveal the social aspects of the subject and to motivate them to inquire further.

3. ***Investigation in the Laboratory*** – As a preliminary experiment, the students prepare hand moisturizing lotion. Ultraviolet sensitive, colour-changing beads were found to be a simple means of detecting UV radiation. At the next stage of the research activity in the laboratory, the students plan and execute their own original experimental inquiry, related to a sunscreen product. The goal of this component of the learning is for students to acquire research skills, and to learn the subject in an experiential way.

4. ***DecisionMaking*** – Students write a summary of the module, which relates to various aspects learned on the subject throughout the task, and refers directly to the process of making a decision about a suitable sunscreen.

The module's Teacher's Guide presents the sequence of teaching activities; it includes student activity sheets, a review of the relevant scientific background, and also allows teachers to assess students' activities. The role of the teacher as an activity coordinator is altered. Rather than the teacher's classic role in frontal teaching, the students play a central role in this educational programme. Nevertheless, the importance of the teacher's involvement in directing and initiating discussions throughout the module, as well as broadening and adding relevant knowledge to the subject, is emphasized.

Implementation of the Sunscreen module and Reflection on its Value

The sunscreen module was implemented, by those teachers involved in its development, in three different high-schools. Adaptations of the module were made in accordance with the charecteristics of the students chosen, specifically, their age, skills and prior knowledge. All students in the different groups demonstrated excitement and enthusiasm related to the versatile and alternative way of learning, which was evaluated in a different manner. The students' interest and their high involvement in the process indicated that the stucture and content of this activity fittedsthe targets and goals that had been set, namely establlishing relevance.

One of the groups that experienced the activity was unique, because all the students were new immigrants in Israel, coming from the former Soviet Union, with a climate and radiation exposure that differed entirely from that of Israel. In this group the module had an even bigger impact. The parents were also involved in home assignments and thus experienced the involvement and awareness as well. "*Now we* *understand the importance of using sunscreen in Israel"*. Educating through science helped in integrating the new immigrant students and their families into the Israeli lifestyle. Boaz the teacher says:

“The teaching of the sunscreen module at my school was divided into 10-12 lessons, and it was the highlight of the educational activity in the chemistry class all year long. From the curricular point of view – the module had little connection to this years’ syllabus, but the importance of the subject and the interest shown by the students made me realize that I had made the right decision. I felt that allowing my students to study in a different way, to be creative, involved and inquisitive – raised the level and quality of the educational activity in class and made the adivity fun to my students. I think that integrating this kind of activity into the regular and mandatory corriculum was essential for creating relevance to everyday life, and for strengthening students' pride in choosing a subject to major in during their high-school years.”

Some students' reflected on their experiences:

“First of all – I loved the subject of this activity. It is relevant and close to my everyday life, especially because it is now the beginning of summer. After participating in the different activities and tasks, you realize for the first time how a sunscreen really works. Next time that I will be exposed to the sun, I will put on sunscreen, because I understand the importance of doing so. In addition, learning through planning and performing my own experiments has been more interesting and challenging than the traditional way we usually study in class.”

“Everything I've learned during the course on the sunscreen module changed my attitude towards it. All the hazards related to sun radiation that I've encountered caused me to think twice before I decide not to put on sunscreen!”

Boaz says:

“I would like to introduce more teachers to the option of integrating PROFILES modules into their science education curriculum. I think it is important that teachers who teach other subjects know what is happening in their classroom, and recognize the possibility of upgrading the educational work and classroom teaching by various means. I intend to share this experience with all the teachers in my high school, and to share the sunscreen module with the rest of the community of chemistry teachers.”

2.7 Development of the PROFILES Community of Practice in Austria – CPD Provision, Teaching Modules and Teacher Reflections

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The PROFILES project aims at ensuring the improvement of science education in the classroom with respect to promoting the meaning of the nature of science and encompassing education through science. For this, the project promotes inquiry learning and the engagement of students in creative, scientific problem-solving and socio-scientific decision-making procedures (Kremer, 2010). These goals are expected to be approached through inquiry-based science education (IBSE) embedded in the PROFILES 3 stage model.
Teachers are supported in 3 key ways:

(a) Guided by continuous professional development courses (CPD courses) using the didactical expertise of the Austrian PROFILES team at the Austrian Educational Competence Center (AECC Biology) of the University of Vienna, the CPD programme enhances the professionalization of IBSE.
(b) Teachers are oriented to develop materials (modules) for classroom teaching, seen as a bottom-up approach based on a vital exchange between colleagues (Blonder, Kipnis et al., 2008).
(c) After implementation of the modules in science lessons, teachers are encouraged to jointly reflect on the gathered experiences by each of the teachers.

First steps of the Austrian PROFILES team at the AECC Biology – Module development

The Austrian PROFILES team received their initial impression of the PROFILES philosophy during a workshop on Inquiry-based learning in Tallinn, Estonia, May 2011. After acquiring appropriate knowledge and information through this workshop, the team started to develop its first modules.
Modules developed within the PARSEL project (www.parsel.eu), a forerunner to PROFILES promoting inquiry learning through a 3 stage model, were helpful for this work.

The team at AECC chose as the focus of its first module "A flourish of green: the meaning of photosynthesis". The initial development of the module was followed by reflection phases during which the module was further revised and piloted in BRG 18 gymnasium, with one class of fifth grade students.

Figure 1. Pupils working on the module on photosynthesis

Two other modules were developed, reflected and revised in the same way: "Orientation of wild bees" and "Stumbling over biodiversity – plant diversity in paving cracks".
All three modules were translated into English and put on the Austrian PROFILES website: http://ius.uni-klu.ac.at/misc/profiles/pages/materials.

Setting up a community of practice

The process of module development was supported by implementation of the theoretical concept of a so called "community of practice". Teachers were invited to work with the AECC team on suggested or self-chosen topics aiming

at mutual module development, classroom implementation and teacher reflection. It was recognized that teachers need to develop a sense of ownership for such innovative teaching materials so as to implement these successfully in their daily practice (Blonder et al., 2008).
Another positive effect was the feeling of accomplishment by good teamwork and successful products.

The CPD course

The CPD course was ran by the AECC Biology in cooperation with the Applied University for Teacher Education and the Science Network of Vienna, consisting of two professional seminars in September and November, 2011.

First CPD Meeting

The first CPD took place under the title: "Project ideas for the EU project PROFILES – inquiry learning in Biology, Chemistry and Physics Education" at the AECC Biology (University of Vienna). During this meeting, the PROFILES project and its philosophy was introduced to give teachers an initial impression of the project. A lecture on "Using inquiry learning methods" was given.
One central aspect was how to create modules which incorporate inquiry learning assignments. Selected materials from the project PARSEL were presented and the participants were encouraged to implement one of these modules in their teaching before the next meeting.

Second CPD Meeting

During the second meeting the teachers reflected on their implementation of the Biology oriented modules introduced in the first meeting. At the end of the meeting, to facilitate further module development, the participants agree on additional modules in five different areas:

- Photosynthesis, Investigation with chromatography
- Microbiology and Bacterial growth
- Germination experiments
- Bones and bone stability
- Comparing alternative energy sources to those from conventional energy sources.

According to their interest, participants work on these topic areas in teams and developed PROFILES teaching modules.

Further meetings – dynamic arises

The PROFILES teachers met two more times (February and May 2012) at the AECC Biology, where they discussed and reflected on the process of module development in teams. These interesting and very successful phases of reflection push work forward, because teachers have an opportunity to:

- talk about their experiences including insecurities
- reflect the module from different point of views (content, professional and practical dimension)
- report on the implementation of the modules and the reaction of pupils

All participants were aware of the positive aspects of these meetings. Some reported about time constrains.
Similar to the CPD meetings in Autumn 2011, another PROFILES introduction seminar was held in March 2012 with new teachers. The community is expanding.

Reflection and outlook

Within the field of Biology Education in the Austrian school system, the tradition of teachers working as a community of practice, in the sense of promoting inquiry learning is largely unknown. That is why it is all the more gratifying that a group of interested teachers interacted together within the PROFILES project to mutually work on various ideas and modules. First visible successes are three developed modules so far and the planning of further ones. Teachers were found to be very interested in the PROFILES project, but the temporal expenditure for teachers turned out to be a challenge. However, the reformation of the school leaving examination in Austria which has emphasised student

Figure 2. CPD meeting with PROFILES teachers

acquisition of competencies was seen as one framework condition conducive to the introduction of the PROFLES approach in schools. The PROFILES modules in promoting a variety of students' competencies and skills and at the same time intending a motivational approach were seen as able to strengthen the development of such competencies. In addition, this approach increased teachers' acceptance and willingness to invest their effort and work.

The further development of the PROFILES project is supported by a planned collaboration with the sparkling science project KiP³ (Kids Participation in Research) at AECC Biology. This collaboration offers an additional opportunity to develop and implement the PROFILES modules. Moreover, another collaboration is being established: as from Autumn 2012, the team of AECC Chemistry at the University of Vienna will participate in the PROFILES project.
The aim of implementing the PROFILES modules at different school locations seems to be realistic. At the same time the established community of practice is expected to be maintained and further developed.

The possibility to receive valuable feedback from the international PROFILES community is supporting the development of modules as well as the development of the community of practice. Thus, within the first phase of the CPD course it was suggested to put more emphasis on the socio-scientific approach in science education in order to strengthen the focus on the intrinsic motivation of students. The PROFILES modules should also enable students to gain a conceptualization of the nature of science and apply it in reflecting on socio-scientific daily decision making. The Austrian PROFILES modules will be revised further to guarantee this important aspect as well.

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2.8 What Have We Learned? The Impact of the PROFILES Instructional Approach on Cypriot Students

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Introduction

"Europe needs more scientists" was the title chosen for the high level group report published by the European Commission (2004). Indeed, this urgent call reflected the current situation since upper level students often lacked interest towards learning in science (Eurydice Network, 2011). Expository didactic approaches, as well as the detachment of science teaching from authentic contexts related to daily lives and society, have been blamed for this failure. Aiming to gain students' interest once again, a growing movement supports that students' interest could be increased when the learning content is embedded within authentic contexts related with important societal issues (Chinn & Malhotra, 2002) and when fostering active and collaborative participation. These perspectives are aligned with several recommendations promoting the inquiry approach for teaching and learning science.

The PROFILES Project

PROFILES is a four-year European project aiming to contribute to the mitigation of this situation by promoting inquiry learning and teaching. More specifically, in Cyprus the in-service science teachers participating in the local PROFILES network were asked to collaboratively design and subsequently enact inquiry-based teaching modules. Following a three-stage approach, the participating teachers engage in designing inquiry-based modules that:

- are based on an authentic scenario related to students' lives,
- actively involve students with technology-enhanced inquiry-based investigations,
- engage students in a decision-making process asking them to take an evidenced-based stance.

This article seeks to address the question of what we have learned from the experience of the first PROFILES teacher network in Cyprus, particularly as this relates to student gains.

Methodology

Research goals

Science education – as promoted by the PROFILES project – can be considered successful if the inquiry-based modules increase students' motivation to engage in meaningful learning about science. Thus, our research goals focus on examining the PROFILES modules enacted in Cyprus; in this context, we investigate whether these modules motivate the students.

Teaching interventions

The PROFILES science teachers in Cyprus developed seven inquiry-based modules, based on the PROFILES 'education through science' approach. Two of these modules are:

1. "Natural gas: A curse or a blessing" (developed by secondary school chemistry teachers)
2. "Should Artemis and Costas proceed into assisted reproduction?" (developed by the biology education middle school group).

Both modules were designed around a socio-scientific scenario; the chemistry module was designed for five 40-minute sessions whereas the biology module was designed for five 80-minute sessions. Both employed a narrative of local interest (the discovery of natural gas in Cyprus, a young couple facing difficulties in conceiving a baby) to motivate students' interest to learn about natural gas and human reproduction.

STATEMENTS	Biology module Mean Values REAL	IDEAL	p	Mean Values REAL	TODAY	p	Chemistry module Mean Values REAL	IDEAL	p	Mean Values REAL	TODAY	p
I enjoy the lesson	4.85	6.14	.000*	4.88	5.22	.000*	4.03	5.37	.000*	4.01	5.35	.000*
I understand the lesson	5.59	6.37	.000*	5.64	5.80	.017*	4.76	5.57	.000*	4.76	5.47	.000*
I have time to think before I answer	5.29	5.96	.000*	5.29	5.96	.000*	4.37	5.40	.000*	4.45	5.25	.000*
I make suggestions to my teacher	4.94	5.65	.000*	5.02	4.78	.201	3.11	4.86	.000*	3.14	4.32	.000*
I make questions to my teacher	5.53	5.96	.000*	5.58	5.66	.300	4.47	5.34	.000*	4.50	4.99	.000*
I make an effort to understand	5.71	6.32	.000*	5.75	6.02	.000*	4.84	5.47	.000*	4.86	5.45	.000*
I participate in the lesson	6.00	6.43	.000*	6.02	6.14	.072	4.45	5.39	.000*	4.49	4.94	.000*
Students co-operate	4.50	6.03	.000*	4.47	4.68	.021*	4.27	5.50	.000*	4.26	5.70	.000*
My class makes an effort	5.05	6.08	.000*	5.04	5.30	.000*	4.54	5.44	.000*	4.53	5.58	.000*
Issues important for everyday life	5.60	5.85	.002*	5.64	5.96	.000*	4.68	5.66	.000*	4.64	5.62	.000*
Issues important for the society	5.52	5.62	.193	5.52	5.76	.003*	4.43	5.29	.000*	4.43	5.29	.001*

**Statically significant difference (p<.05)* *Scale 1-7 (1 =Strongly disagree and 7=Strongly agree)*

Table 1. MoLE results for biology and chemistry module

Sample

The chemistry module was implemented to a total of 171 10th graders (82 boys and 89 girls) at five different public schools. The biology module was implemented in all of the public schools of the island. However; the results presented in this article were derived from 413 7th graders (199 boys and 214 girls) from four different high schools.

Data collection

Data were collected through the MoLE (Bolte, 2000) survey that was universally employed by all PROFILES partners. The survey consisted of three different versions. The REAL version, administered before the teaching intervention, aimed to collect students' views of traditional science lessons. The IDEAL version, again administered before the teaching intervention, aimed to collect students' views about an ideal science lesson. Finally, the TODAY version, administered after the teaching intervention, aimed to collect students' views about the inquiry-based module implemented. Thus, the aim of the questionnaire was to examine students' motivation gains, if any, after their participation in the PROFILES inquiry-based modules, by comparing the three versions.

Data analysis

During the data analysis process, REAL-IDEAL versions as well as REAL-TODAY versions were compared by employing the t-test paired-sample statistical test.

Results

REAL Vs IDEAL version

Table 1 compares students' answers regarding a real and an ideal science lesson. As Table 1 indicates, biology as well as chemistry students seem to consider that current lessons are less motivating when compared with the ideal lessons which they envision. More specifically, this comparison reveals that students desire to enjoy and to understand the lessons more, to have more time to think before providing answers to questions, to have more opportunities to make suggestions as well as questions, to make more effort to understand, to participate more, to collaborate to a greater extent with other students as well as to be taught about issues that are both relevant to their daily lives and the society in general. Such differentiations are statistically significant for both the chemistry and biology students.

REAL Vs TODAY version

As presented in Table 1 the comparison of students' aspects regarding the real and the today versions indicate that both the biology as well as the chemistry students express that the inquiry-based lesson significantly improve their experience of learning in science. More specifically, this comparison reveals that students understand and enjoy the inquiry-based lesson more than they had, previously, enjoyed traditional ones, they have more time to think before answering a question, they have more opportunities to make suggestions and questions, they invest more effort, they participate more, they collaborate to a greater extent with the other students and they are taught about issues that are more relevant to them. In the case of chemistry all of these differentiations are statistically significant, whereas in the case of biology these differentiations are statistically significant in all but three aspects.

Discussion

"Europe needs more scientists"; however according to Bolte & Streller (2011) this will not happen if science education is not meaningful for students, if students cannot relate what they are taught with their lives and if instruction does not motivate them. Following this reasoning, the findings of the present study create a sense of optimism since students who were taught with the PROFILES-based modules revealed a great desire of involvement with the learning process and found the instructional context more meaningful.

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2.9 Conceptualizing Science Education in Cyprus Using a Delphi Method

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Introduction

Scientific literacy is an issue of paramount importance in every modern society. However, when it comes to public understanding, it seems that there is no consensus regarding what aspects should be addressed within the regular science education curriculum or how scientific literacy should be promoted (Bolte, 2008). According to Osborne (2003), in most societies, aspects that are both important and salient within a given domain are usually defined by the academic community. In such a case though, the voices of educators, scientists, students and other stakeholders are suppressed. Taking into account as many of the stakeholders' views as possible could result in a more inclusive and acceptable construct since it would reflect public opinion and not merely the ideas of a specific stakeholder sub-group.

Methodology

The PROFILES Delphi Study

Within this framework, the PROFILES project aims to gather the views of different experts regarding aspects of science education that are considered to be pedagogically desirable for the individual in today's society (Schulte & Bolte, 2012). The method selected for eliciting the stakeholders' views is a three-stage Delphi study. The work described in this article focuses on the results derived from the first two rounds of a Delphi study conducted in Cyprus within the context of the PROFILES project.

Sample

A total of 96 participants completed the first and second round of the Cyprus Delphi study. More specifically, these two rounds were answered by 48 high school students, 18 in-service science teachers, 12 science education researchers as well as by 18 individuals that were not directly involved with science education (e.g. parents).

Research goals

The PROFILES Delphi study sought to address the following research questions:

1. Which aspects of a desirable science education do the participants consider as being important in Cyprus?
2. Which conceptual framework is considered important for science education?

Data Analysis and Findings

Delphi Study Round 1

The first round of the Delphi study consisted of 3 open-ended questions in which participants were asked to express their ideas about content, contexts as well as the development of qualifications within the frame of science education. More than one thousand statements were gathered and were qualitatively categorized in 87 categories – 21 of these categories referred to contexts, 22 referred to contents, 22 of the categories were referred to scientific fields, 11 referred to qualifications and 11 of these categories concerned methods.

Delphi Study Round 2

Within the second round of the study, the participants were asked to assess the 87 categories in terms of their priority and extent of current practice (Table 1). In addition, they were asked to group these categories into combinations that they considered important in order to form a conceptual framework regarding desirable science education.

Priority Assessment

Employing descriptive statistics, and based on the mean value of each category, it seems that the Cypriot participants considered the "understanding of scientific issues" as the most important aspect. At the same time, the participants gave priority to several other qualifications such as the development of skills (e.g. inquiry skills, social skills) and they emphasized the importance of teaching concepts that are directly related to society (e.g. environmental actions, Health Education). In contrast, the ten bottom categories referred mainly to scientific fields such as meteorology, geology, etc.

Practice Assessment

The study participants considered several traditional scientific fields, such as physics and mathematics as being practiced to a high degree. In contrast, they considered scientific fields such as medicine and geology as being practiced to a low degree.

Priority-Practice Difference

As presented in Table 1, according to priority-practice differences of the 87 categories that were assessed, it seems that the participants believe that there is a great gap among the categories regarding the development of qualifications (e.g. inquiry skills, personality competences), the instruction of current topics (e.g. biotechnology, modern physics modules) and teaching through less traditional contexts such as outdoor activities or digital games. In contrast, the lowest gap among priority and practice was recorded for more traditional topics of instruction.

Across Groups Comparisons

Focusing on the differentiations observed among the four sub-groups regarding their priority and practice assessments as well as the priority-practice difference, the groups of *students* and *teachers* presented the most statistically significant differences, whereas the groups of *students* and *others* had the lowest number of statistically significant differences. However, the assessments of the sample groups do not contradict each other but instead represent different emphases.

Conceptual Framework

The analysis of the participants' responses identified two main clusters reflecting distinct conceptual frameworks regarding desirable science education. "The Development of a scientific background" (Conception A) attributed

Priority assessment		Practice assessment		Priority-Practice difference	
Top 10 categories	***Mean***	***Top 10 categories***	***Mean***	***Top 10 categories***	***Mean***
Understanding of scientific issues	5.44	Physics	4.17	Out-of-school-activities	2.74
Well-equipped classrooms	5.39	Mathematics	4.14	Personality competences	2.74
Health problems	5.39	Physics modules	3.97	Well-equipped classrooms	2.67
Environmental actions	5.38	Human physiology	3.95	Modern physics modules (Current issues)	2.59
Inquiry skills	5.38	Biology	3.77	Model development	2.56
Personality competences	5.33	Physics theories	3.74	Democratic attitudes	2.45
Social skills	5.32	Environmental actions	3.73	Integration of games within classroom	2.44
Experiments	5.28	Environmental phenomena	3.72	Biotechnology	2.43
Problem-Solving	5.27	Natural phenomena	3.69	Inquiry Skills	2.38
Basic scientific skills	5.24	Use of scientific terminology	3.68	Computer-based games	2.37
Bottom 10 categories	***Mean***	***Bottom 10 categories***	***Mean***	***Bottom 10 categories***	***Mean***
Meteorology	4.16	Integration of games within classroom	2.24	Structure of matter	1.15
History of scientific theories	4.15	Medicine	2.24	Chemical phenomena	1.09
Economics	4.13	Interaction with experts	2.21	Inorganic chemistry	1.02
Computer-based games	4.12	Computer-based games	2.21	Physics modules	0.98
Nuclear Physics	4.11	Nuclear Physics	2.16	Physics theories	0.88
Demographics	4.03	Pharmaceutics	2.15	Lectures	0.87
Lectures	3.98	Geology	2.14	Scientific terminology	0.85
Geology	3.95	Astrophysics	2.04	Mathematics	0.82
Architecture	3.74	Meteorology	1.95	Physics	0.76
Paleontology	3.68	Paleontology	1.94	Use of scientific terminology	0.66

**Scale 1-6 (1=lowest value and 6=the highest value)*

Table 1. Top and bottom 10 categories derived from priority assessment, practice assessment, priority practice difference

a more holistic view to the learning of science, since it included learning gains but also referred to the development of skills and positive attitudes in order to enhance the development of scientific literacy. "Science in society" (Conception B) gave much emphasis to the connection of science with the radical technological development as well as with several socio-scientific issues, highlighting the connection of science and society.

Discussion

To sum up, it seems that, according to the Cypriot participants' assessments, science education in Cyprus should shift from more traditional concepts and contexts towards a more general perspective including more contemporary themes and motivating approaches. In addition, science education should focus not only on the development of understanding, but on the development of skills and attitudes and should be focused on current societal issues. Interestingly enough, these findings are aligned with the Delphi study carried out by the Freie Universität Berlin which concluded that science education at present is determined by elements from the "classic" scientific disciplines, whereas many of the aims of general science-related education, such as the relation of science with everyday life and the development of inquiry skills, are only rarely taken up in science classes (Schulte & Bolte, 2012). Therefore, it seems that in both cases the Delphi Studies provide clear directions regarding science education based on the consensus of the different stakeholders who participated in these studies.

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2.10 Participatory Design of Web-based Learning Environments to Motivate Cypriot Students' Science Learning

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Introduction

At a time of continued dissatisfaction with the state of science education in many parts of the world, researchers, educators, and policy makers are investigating ways to develop students' appreciation of the nature of science, enhance the quality of learning and establish science learning as a meaningful and motivating activity. In this context, inquiry is widely considered as the primary approach to learning science (Abd-El-Khalick et al., 2004; NRC, 2012) while the teachers' role is being recognized as crucial in any inquiry implementation (Bolte et al., 2011). In fact, the success of any reform effort is based upon the extent to which teachers understand, appreciate, and commit to the innovation (Brown & Campione, 1996; Fullan, 2007). Along with many other researchers, we believe that developing teacher ownership of educational innovations, such as inquiry-based learning, is extremely important to the sustainability of the innovation (Kyza & Georgiou, 2012; Mamlok-Naaman, Blonder & Hofstein, 2010). Furthermore, we argue about the merits of participatory design as a potent way of developing motivating learning environments that capture students' interest and support teachers' continuous professional development (Kyza & Nicolaidou, Under Review). We will next detail the process of engaging local PROFILES teachers in participatory design and describe the learning environments they designed.

Participatory Design in PROFILES

All teachers participating in the PROFILES local network in Cyprus were asked to join one of five groups, organized according to disciplines (Biology, Chemistry, Physics (2 groups), Elementary School Science Education) to facilitate a design approach to professional development. As a result, during the 2011 – 2012 academic year, the five disciplinary groups developed seven inquiry-based modules based on the PROFILES "Education through Science" approach (Holbrook & Rannikmae, 2007). The development of all of the modules follow the three-stage PROFILES methodology, according to which students are presented with a motivating, socio-scientific problem and engage in discipline-specific but also general skill-developing inquiry activities in order to solve a problem.

The participating teachers collaborated in their groups for an extended period of time to iteratively develop web-based, data-rich investigations with the goal to motivate students, increase their self-regulated involvement in inquiry and, at the same time, support conceptual understanding of the socio-scientific concepts addressed by each module.

Technology in support of design

From the outset of the professional development process the Cyprus University of Technology (CUT) PROFILES team adopted a variety of technological tools to support the teachers' continuous professional development effort. A combination of synchronous and asynchronous communication tools (Moodle, the WEBEX web conferencing system and the STOCHASMOS web-based learning and teaching platform) were used to support constant access to information and increase teachers' capacity to participate in the design effort of each disciplinary group. Participants used Moodle asynchronously as a depository of ideas as well as for sharing resources, while the WEBEX system allowed design-related decision making during synchronous video meetings. The development of the web-based units actually took place on the STOCHASMOS web-based platform (Kyza &

Constantinou, 2007; Kyza, Constantinou & Spanoudis, 2011), which is explained next. This combination of technologies supported the facile communication of ideas and seeded teachers' reflective engagement with participatory design and the enactment of inquiry.

The web-based learning environments

The web-based learning environments were developed on the authoring tool of the STOCHASMOS platform. STOCHASMOS, a scaffolded environment, enabled teachers to assume a more active designer role and provided computer-based scaffolding to support students' data-rich and reflective inquiry of previously collected data. As teachers were using the STOCHASMOS platform for the first time, the collaborative design discussions focused on conceptual issues about the planning of the activity sequence and the scaffolding of students to promote a more active participation. The CUT PROFILES team supported the process by implementing the teacher designs on the platform and then initiated a process of reflective discussions about the extent to which the designed outcome met the goals of the teachers and of the design team. The teachers iteratively engaged in the design process, with ample opportunities to provide feedback to each other, received feedback from the CUT PROFILES team, and also presented to and received feedback from other disciplinary PROFILES groups. Our belief was that these cycles of design, along with the implementations of the design in actual classrooms, greatly enhanced the capacity of any learning environment to reach the target audience and meet its instructional goals.

Examples

The Chemistry group developed two web-based modules. The first one focused on fossil fuel, whereas the second focused on ethanol. Both modules were developed around a locally important decision making scenario; in the first case, the module was motivated by the recent discovery of natural gas reserves off the coast of Cyprus, whereas the second scenario was relevant to students' lives as it dealt with alcohol consumption and drunk driving.

The Biology group developed one learning module, which was implemented both on the web and using hybrid, paper-based and multimedia, methods. The driving scenario of this module concerned human reproduction, one other topic that was seen to be of great interest to early secondary school students.

The Elementary School Science group collaborated on the issues of heating and insulation, using the context of insulating the students' class as the motivating scenario.

The analysis of the MoLE motivation survey given to all students before and after the PROFILES intervention yielded statistically significant results for all three classroom enactments (Georgiou & Kyza, 2012), suggesting that the approach taken by the Cyprus University of Technology PROFILES team was successful in reaching at least some of its major goals: creating and sustaining students' motivation through powerful scenarios relevant to their lives, and engaging them actively in learning science. In addition, the participatory design approach allowed teachers to think deeply about their goals and instructional approaches and allowed them to not only design learning environments that met their students' needs, but also met the educational framework set by the school context and curriculum.

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2.11 Development of Teachers' Creativity during the Implementation of PROFILES Modules

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Introduction

Teachers, who participated in the first year of implementation of inquiry-based science education (IBSE) modules in the project PROFILES, improved their various professional skills. We have recognised the development of their creativity as a very important part of professional growth in several areas, such as:

- Creation of scenarios
- Undertaking experimentation
- Interacting with worksheets

Examples of teachers' creativity are presented in the module entitled "*Brushing up on chemistry*".

Creation of Scenarios

A scenario is a new element in Czech teaching materials and PROFILES teachers learned how to implement this as part of teaching. As the scenario of module "*Brushing up on chemistry"* is not suitable for all ages of students, Czech teachers create new scenarios to stimulate motivation to study problems of dental caries and learn analytic chemistry skills - evidence of the fluoride ions. Two very different examples are given below.

Scenario 1: Dental caries (age 12-13) *Peter receives money for a snack, for which, however, he buys sweets. His friend John advises him against this eating because of problems with dental decay. However, Peter ensures that every morning and evening he cleans his teeth using quality toothpastes. His teeth have only white stains, so nothing to worry about. On the contrary, Peter thinks that John will have problems of dental decay, because a lot of drinking Coca-Cola and orange juice. Who's right?*

Figure 1. Scenario in action

Scenario 2: Analysis of toothpaste (age 16-17)
Toothpastes often appear in television commercials. Their importance for the prevention of tooth decay is emphasized. Especially fluoride is considered as very important and active ingredient in toothpastes. Tooth brushing with fluoridated toothpastes results in increased salivary concentrations of fluoride, which has an anticariogenic effect. Fluoride infuses into tooth enamel making teeth more resistant to acids produced by plaque bacteria, as well as acids found in fruit juices and certain foods. Fluorides are retained for longer periods in the oral cavity and hence the duration of their anti-cariogenic effects is longer. Is the advertising for toothpaste really true? After cleaning using fluoridated toothpaste do we have declared concentrations of fluoride in the mouth? Are you sure you do not unnecessarily spend the money when you buy expensive toothpaste, but you use them in the wrong way? Is it recommended after use of fluoridated toothpastes rinsing the mouth with water? Can rinsing with water decrease the salivary concentration of fluoride and thus reduce the anticariogenic effect?

Experimentations

To strengthen IBSE in the module, teachers, together with students, have looked for alternative experiments. Such investigations help to explain the issue of the effect of toothpastes. Here is an example of a very structured investigation into home-made toothpaste.

Homemade toothpaste
Ingredients:
6 parts baking soda
1 part vegetable based glycerine
1 part hydrogen peroxide solution 3%
flavour to taste: a *few drops of peppermint oil or tea tree oil, cinnamon oil, food-grade grape or bubble gum flavour oil*
Procedure:
(1) Measure six parts of baking soda, one part of ***vegetable based glycerine*** *and one part of* ***hydrogen peroxide solution****. Stir until well mixed. The mixture will be thick. Add the glycerine with a dropper while stirring until the mixture has about the same consistency as commercial toothpaste. To make a smoother mix, reduce the soda. To omit the glycerine, increase the peroxide. It is possible to use some measuring tools from the kitchen - all of these products are food safe, so clean them as normal when done.*
(2) Add ***a*** *few drops of flavour according to what taste you prefer and what toothpaste you want to prepare. Stir as thoroughly as possible.*
It is recommended to use a flavouring. It's totally optional, but adding a drop of peppermint oil will leave your mouth feeling super fresh. Tea tree oil boosts the anti-bacterial properties and tastes good. A few drops of cinnamon oil will definitely spice things up. Food-grade grape or bubble gum flavour oil may entice children to brush more regularly - just be sure to supervise them and make sure they're not ingesting it!
Safety note:
The basis of homemade toothpaste is baking soda and hydrogen peroxide. Either one in huge doses can be dangerous, so DO NOT INGEST! Hydrogen peroxide is UV sensitive, so be sure to store your toothpaste out of sunlight, or in an opaque container.
The effect of ingredients:
Sodium bicarbonate (baking soda) is a mild abrasive and has anti-bacterial properties. Hydrogen peroxide helps by break down bacterial films with its foaming action.
Vegetable-base glycerine liquid lends a nice consistency and sweetness, but is completely optional. Good options for storing homemade toothpaste are plastic tubes, squeeze bottles, or jars.

Worksheets

All teachers made their own worksheets. Worksheets have been created to reflect the different levels of student skills. A key aim of the very structured worksheets was to help, in particular, the younger and academically weaker students. Skilled students did not need this way of leadership and were able to undertake more open inquiry learning and record their observations individually.

Worksheet A

Analysis of packaging toothpastes:
Check the packaging of toothpastes and determine the content of fluorine compounds. Toothpaste is divided according to the content of fluorine compounds on:

Brand of toothpaste	***Content of fluorine compouns***
Toothpaste for children aged 2-3 years	*containing 250 ppm F*
Toothpaste for children aged 3-6 years	*containing 250-500 ppm F*
Toothpaste for school children	*containing 500-1000 ppm F*
Normal toothpaste for adults	*containing 1000-1500 ppm F*
Therapeutic toothpaste	*containing 1800-2500 ppm F*

Worksheet B

Toothpaste Brand	*Ingredients (Latin form)*	*Ingredients (Czech form)*	*Effect of Ingredients*

THE REFERENCE PROPERTY	***HOMEMADE TOOTHPASTE***	***COMMERCIAL TOOTHPASTE***
The appearance and consistency.		
Colour		
Scent		
Taste (In the case of domestic pastes we only guess!)		
pH		
Roughness of toothpaste (determined by touch)		
The ability to clean a surface (observe on the coloured egg)		

Worksheet C

Purpose of toothpaste	***The ingredients Identify from the product packages***
whitening toothpaste	
toothpaste with baking soda	
toothpaste for gingivitis	
children's toothpaste	
toothpaste for smokers	
toothpaste for adults	
toothpaste against the smell from the mouth	

The basic ingredients of toothpastes	***Compound***	***Purpose***
Fluoride	*Sodium fluoride, Stannous fluoride, Sodium monofluoro-phosphate*	*Perhaps the most important toothpaste ingredient is fluoride. Fluoride incorporates itself into tooth enamel making your teeth more resistant to acids produced by plaque Bacteria, as well as acids found in fruit juices, soda (both regular and diet) and certain foods.*
Abrasives	*Calcium phosphate (chalk) Aluminium oxide (alumina) Calcium carbonate Silicon dioxide (silica) Hydrated silica Titanium dioxide*	*Abrasives give toothpaste its cleaning power. They remove stains and plaque, as well as polish teeth. Toothpaste should be abrasive enough to remove plaque and stains, but not abrasive enough to damage tooth enamel.*
Detergents	*Sodium lauryl sulfate (SLS) Ammonium lauryl sulfate (ALS)*	*Detergents create the foaming action we associate with toothpastes. Foam keeps the toothpaste in our mouths, preventing it from dribbling out as we brush. Unfortunately, SLS and other detergents have been linked to the promotion of canker sores (mouth ulcers) in susceptible individuals. The presence of bad tasting detergents requires the use of strong flavourings to mask the bad taste.*
De-sensitising agents	*Strontium chloride Potassium nitrate Potassium citrate*	*These ingredients relieve tooth sensitivity. Strontium chloride works by blocking the tiny crevices (microtubules) that enable cold and heat sensations to reach the tooth's nerve. Potassium citrate and Potassium nitrate work in a different way by blocking the mechanism of pain transmission between nerve cells.*
Humectants	*Glycerine, sorbitol, water,xylitol*	*Humectants give toothpaste its texture as well as retain moisture so that tooth paste does not dry out.*
Thickeners	*Carrageenan, cellulose gum, xanthan gum*	*Thickeners also help to create the texture of toothpaste and determine how 'thick' your toothpaste is.*
Preservatives	*Sodium benzoate, methyl paraben, ethyl paraben.*	*Preservatives prevent the growth of micro-organisms in toothpaste. This eliminates the need to refrigerate toothpaste.*
Flavouring Agents:	*Mint, herbs*	*These are added to improve the taste of toothpaste. Nowadays, a number of flavours are used, to impart a yummy taste to the toothpaste. People experience fresh breath due to these enhanced flavouring agents. These are necessary to cover up the horrid taste of most detergents, especially SLS.*
Sweeteners	*Sodium Saccharine*	*They also improve the taste of toothpaste. Toothpaste without a sweetening agent does not taste good. Most toothpaste sweeteners are artificial and contribute very little to cavity formation.*
Colouring Agents	*Titanium dioxide*	*Some toothpaste would look down right disgusting if it were not for colouring agents. Colouring agents provide toothpaste with pleasing colours. Artificial dyes are used to make red, green, and blue toothpastes. Titanium dioxide is used to make some toothpaste white.*
Teeth Whitening agents	*Hydrogen peroxide Sodium carbonate peroxide Various enzymes (from papaya, pineapple)*	*The whitening toothpastes, except of the mechanical whitening action of toothpaste abrasives, use extra chemical whitening ingredients.*
Additional ingredients	*Enzymes, vitamins, herbs*	*These ingredients are added in special toothpastes and perform different functions.*

Conclusions

We have observed the changes in the teaching style of teachers after the implementation of the PROFILES teacher training. Teachers have shown much greater creativity in developing teaching materials. The creation of scenarios has reflected the attempt to increase student motivation by linking education with issues in everyday life. When creating worksheets the teachers have had in mind the different levels of IBSE. Teachers have turned away from frontal teaching, have focused on inquiry and have looked for appropriate experiments in seeking evidence in answer to the scientific question raised, which help students in understanding the discussed issues.

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Figure 2. Alternative Experiments


Figure 3. Worksheet A

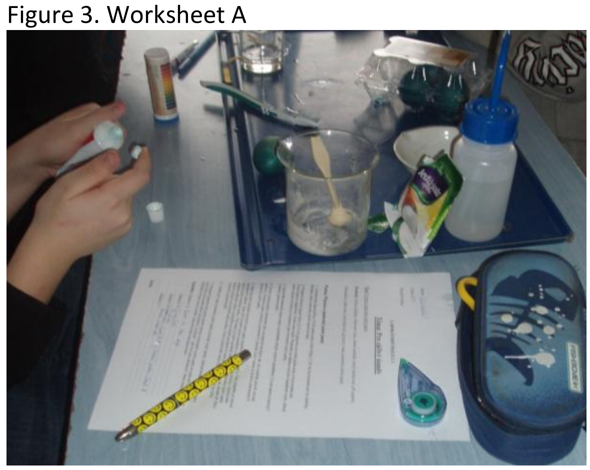
Figure 4. Worksheet B


Figure 5. Worksheet C

2.12 Chemistry in the 7th and 8th Grades: Learning Environments concerning Water

Jaana Vartiainen and Esko Väyrynen – Kontiolahti School, Finland

Two different scenarios

Two scenarios were created for teaching concerning water, one for the 7th grade and the other for the 8th grade.

The 7th graders were presented with a fictional internet article (shown in Figure 1) which reported a situation of pollution in their home municipality: Drinking water of Kontiolahti polluted?

The scenario continued: Newspaper Karjalainen reports that water in the municipality of Kontiolahti is unsuitable for drinking and maybe even dangerous. At the moment, the authorities do not know the source of the pollution. The municipality has set up a working group which strives to clarify the situation as soon as possible. Help has been asked from all possible organizations in the region.

Thoughts such as: "How is it possible for the water to get polluted? What could be done to prevent it happening once again? How can it be purified?" kept running through the minds of the inhabitants in the municipality.

The Kontiolahti school has decided to participate in solving the problem. Your task is to construct a piece of equipment which will extract the extra substances from the water, producing once again clean drinkable water for the inhabitants of the municipality.

The scenario for the 8th graders introduced the issue of water in the following way. 'You just drank a glass of fresh water – THE SAME water may have been on the lips of a dinosaur millions of years ago'. The scenario continued: The Science- and Nature magazine '**H_2O**' is advertising for young journalists to work as summer trainees. Imagine, based on written applications, you are a group of young people who have got into the final stage of the selection. The editor gives the applicants a task to write an article for the magazine with the title: 'You just drank a glass of fresh water – THE SAME water may have been on the lips of a dinosaur millions of years ago'. To activate your ideas, you will be shown a video made by the 4H-club in Kontiolahti 'The planet said to me' (http://kontiolahden.4h.fi/kuvagalleria/planeetta-sanoi-minulle-leader-h/).

The editor has named groups in which you will undertake inquiry-based experimentation, as well as construct an idea map about water; this will then be presented to other groups. After discussion, everyone will write his/her own article on the given subject, which can then be published in the magazine. The editor will evaluate the idea maps, the presentations and the personally written magazine articles.

Seventh graders' inquiries and decision making relating to the purification of water

After introducing the scenario of the polluted water, students planned different solutions to separate the soluble and insoluble parts of water. They worked at first in pairs, then in groups of four students. They discussed the alternatives, made compromises and pondered the difficulties of choice and combination.

Figure 2 shows an example of students' solutions to clean water.

Finally, students decided to test the equipment shown in Figure 3. They were not aware of the

Figure 1. A fictional net article used in a scenario

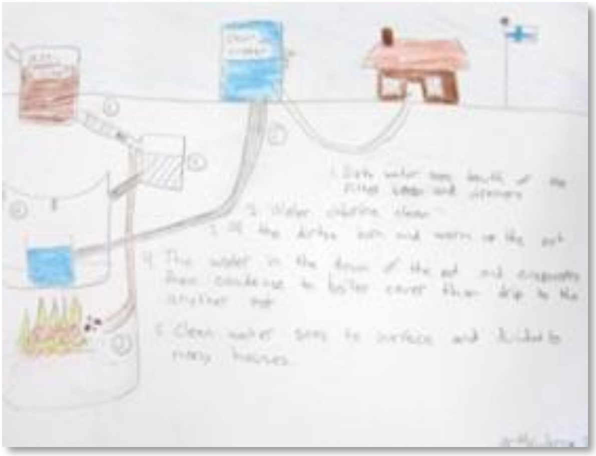

Figure 2. The students' plan for cleaning the water

method needed, they only discussed the separation. Using this plan, the students purified water and learned to use the chemical concepts.

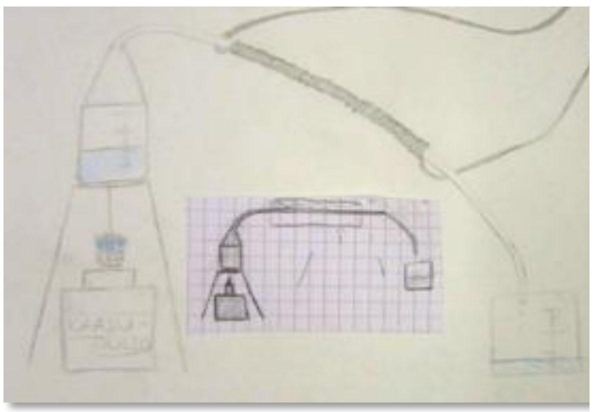

Figure 3. The equipment which students decided to use to separate different substances from water

Eight graders' inquiries and decision making

The students studied in working stations experimenting with the following issues: capillary, surface tension, evaporation, condensation/water cycle, water as a solvent, tasting water, a sewage treatment plant – internet inquiry, habits of clean water use – internet inquiry, water as a product of combustion, the modeling of a water molecule with the use of balls, water as a part of nature.

In the decision making stage, groups of students prepared an idea map in an attempt to answer the question: "Could it be possible that a glass of fresh water which they drank, be the same water as that which has been on the lips of a dinosaur millions of years ago?"

Finally, each student wrote an article on the issue deciding whether the argument about THE SAME water was correct.

An example of students' articles is shown in Figure 4.

Students' experiences

The seventh grade students enjoyed working independently, taking responsibility and planning by themselves the equipment with which they could solve the water purification problem. They also perceived that their learning was improved because they had the possibility to think more for themselves. Students were very proud of their efforts and outputs.

The eight grade students considered the scenario to be interesting. Working in the role of applicant for a summer job was experienced as being something new and gave the feeling that the studying was not happening at school at all. The students' work was more diversified than normally and they took more responsibility for it. In addition, different kinds of strengths and fields of the students' know-how became apparent and were appreciated during the project.

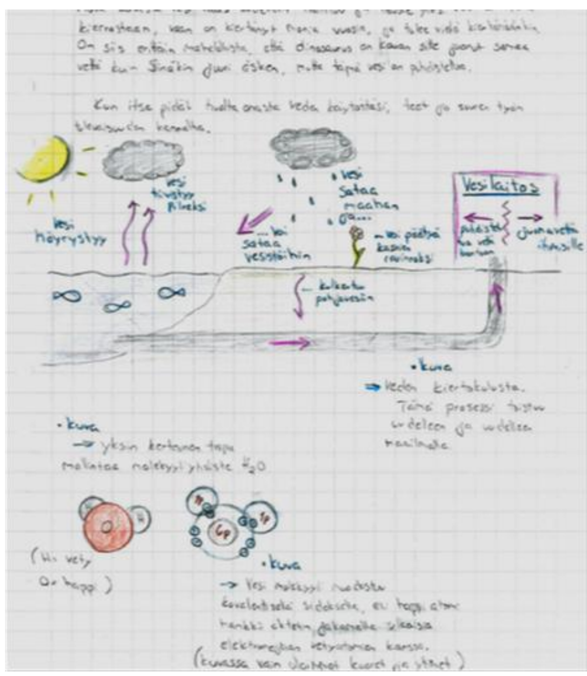

Figure 4. An example of students' magazine articles

Teachers' experiences

We experienced that during the process we had good opportunities to follow students' work, assess students' learning and other different skills. The learning environment was challenging for us. Before instruction, we had to make extra preparation relating to the inquiry environment and equipment. Also, work with the idea map demanded questions for each group which were to be answered. However, we felt that the students' enthusiasm was rewarding and compensated for the extra work. This enthusiasm was also apparent to the parents as the water project raised a lot of discussion at home.

2.13 Teachers' Continuous Professional Development Programme in Finland

Kari Sormunen, Anu Hartikainen-Ahia, Seija Juntunen, Tuula Keinonen and Sirpa Kärkkäinen – University of Eastern Finland, Finland

Introduction

The Finnish programme for teachers' continuous professional development (CPD) comprises ten lessons in each face to face meeting, with three meetings in all, and with distance education between the meetings. During the process of distance education, in which teachers modify the modules and carry out interventions, online guidance has a significant role which is realized through the electronic learning environment of Moodle. The use of this model in the CPD programme has been decided, due to the long distances between participating teachers and the programme provider, the University of Eastern Finland.

The content of the CPD programme is based on the common PROFILES CPD principles and is tailored to the specific needs of the participating teachers. Before starting the CPD programme, teachers estimated their own competence regarding how confident they are in undertaking certain tasks in their science teaching. Teachers were familiar with inquiry-based learning, because it was included in teacher education in Finland. They also had good knowledge of subject content. This being so, the CPD programme could concentrate more on the PROFILES approach and the three stage teaching model, emphasizing the building up of scenarios and stressing the importance of the decision making stage.

Participating teachers

The PROFILES CPD programme was presented in the Teacher Associations' magazines: DIMENSIO for physics and chemistry teachers, NATURA for biology and geography teachers and OPETTAJA for grade 5-6 teachers. There was a form on the PROFILES project's Finnish website which participants filled out for participation. Facts about the teachers participating in the programme are shown in Figure 1.

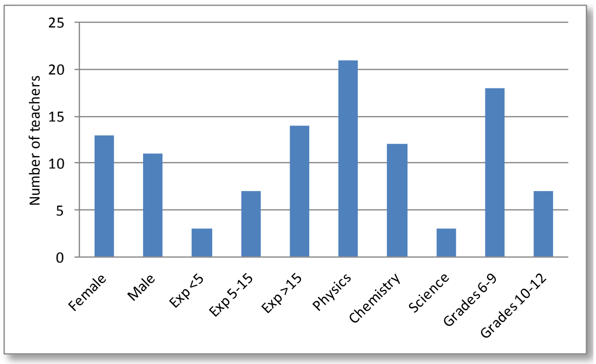

Figure 1. Teachers, their gender, experience, subject which they teach and the level of education

Teachers' competence as a basis for the CPD programme

Teachers were asked to indicate their confidence in undertaking tasks, carrying out the teaching intended, as well as their wishes with respect to emphasis and aspects of professional development which should be included in the programme.

The majority of the teachers considered themselves to be 'somewhat confident' concerning almost all of the indicators. As an exception, the majority of teachers considered themselves to be 'not very confident' concerning the following indicators: identifying a context-based teaching approach; putting forward investigatory questions that provide a stimulating challenge for students; building portfolios; illustrating the teacher as a reflective practitioner; making self-reflective teaching videotapes; explaining what is meant by action research; carrying out action research in a meaningful manner; giving meaning to the zone of proximal development; understanding the activity theory; undertaking and presenting ongoing action research; creating feedback instruments related to knowledge, skills, attitudes and values of the students. Furthermore, the teachers were asked what areas they thought should be emphasized on the course.

Table 1 summarises topics teachers though should be emphasised in the CPD.

Content of the CPD Programme

Based on the topics and content emphasized by the teachers for the PROFILES programme, the programme was planned and is shown with the schedule in Table 2. The model used in the programme can be seen as blended learning.

Students' attitudes and motivation	• positive attitudes towards science learning • self-motivation by students in science lessons • making science teaching and teaching materials interesting for students • motivational challenges for students within their capabilities
Relevance of science learning for students	• developing teaching modules to enhance students' STL in a relevant and meaningful way • determining topics, relevant in the eyes of students • creating student-relevant teaching scenarios to enhance students' STL
Nature of Science	• the meaning of the Nature of Science • distinguishing between a law and a theory • distinguishing between everyday knowledge and scientific knowledge • interpretations of the 'scientific and technological literacy'
Students' learning	• knowledge, skills, attitudes and values • valuing science learning as being useful for life and lifelong learning • promoting creative thinking • promoting the ability to reason and also to make decisions • 'minds-on' (thinking), 'hands-on' (doing), 'hearts-on' (giving value) science teaching • promoting intellectual development, especially higher order learning • putting forward scientific questions for investigation • communication skills in a variety of ways, both orally and in written formats • effective peer-peer learning through student group work • undertaking scientific problem solving activities • focusing on preserving knowledge in students' long term memory rather than the short term
Assessment	• a range of formative assessment strategies • a variety of assessment strategies that are designed to measure competencies
PROFILES approach	• the purpose of PARSEL-and similar material • determining a suitable module for classroom use within PROFILES • conducting a lesson based on a socio-scientific scenario • consensus forming, group decision-making among students
Professional devel-opment	• guiding other teachers as a professional support exercise in seminars • familiarity with teacher networking • a teacher's professional network to enhance the teaching of others • discussing the teaching of science with science educators

Table 1. The topics and content that, in the teachers' opinion, should be emphasized on the course

Date	Title of the activities	General description of the activity
August 2011	Orientation	Orientation tasks in an on-line learning environment
26.8.2011 8 hours, 10 lessons face-to-face	Introduction to PROFILES	Lecture, getting to know each other, teaming
	PARSEL/PROFILES study modules	Workshop in groups
	PROFILES approach; Education through Science	Lecture
	Modification of PARSEL study modules	Workshop in groups
	Decision making stage in the study modules	Workshop in groups
	Student gains, Mole questionnaire	Lecture
	Reflection	Focus group discussions
	Documentation, learning diaries, action research	Lecture, instructions for the first distance learning period
	Delphi study: results of the first round	Lecture
	Evaluation of the first meeting: teacher satisfaction	Evaluation
September-November 2011 20 hours, on-line	The first distance learning period: Modification of the study modules, Interventions, Documentation, Student gains questionnaires, Reflection	Planning of instruction and interventions, group discussions and reflection via on-line learning environment, support by providers personally and via an on-line learning environment
2.12.2011 8 hours, 10 lessons, face-to-face	Sharing experiences of the first interventions, collective reflections	Focus group discussions
	Student gains – results	Lecture, discussions
	Values in science education	Lecture
	Formulating inquiry questions: from the scenario to inquiry (questions)???	Lecture, group work
	Nature of science in science education	Lecture, group work
	Formative assessment in PROFILES study modules, assessment tools	Lecture
	Delphi study: results of the first round and taking part into the second round	Lecture, taking part into the survey
	Instructions for the second distance learning period	
	Evaluation of the second meeting: teacher satisfaction	Evaluation
December-April 40 hours On-line	The second distance learning period: Modification of the study modules, Interventions, Assessment, Documentation, Student gains questionnaires, Reflection	Planning of instruction and interventions, group discussions, reflection via an on-line learning environment, support by providers personally and via an on-line learning environment
27.4.2012 8 hours, face-to-face	Sharing experiences of the interventions, collective reflections	Workshop / Focus group discussions
	Student gains – results	Discussion
	Teachers' role in scaffolding students' learning	Discussion, focus group discussions
	Teachers' networking Idea of 'Teacher as a leader'	Lecture
	Reflection - professional development	Reflection

Table 2. Content and schedule of the CPD Programme in Finland

Teachers' Experiences

According to feedback, the participating teachers felt that the CPD process gave them a lot of new ideas and perspectives. The teachers thought that linking science learning to real life contexts was a proper way of promoting pupils' learning and the participating teachers felt that the CPD programme also offered them inspiration. Here are some teacher experiences:

"I strongly feel that the inspiring meetings and interventions on the CPD programme have made me rethink and revise my teaching."

"It has been challenging but rewarding to plan the PROFILES-type study modules. Planning the modules has forced me to develop my teaching and thinking about what essential information should be included in it. By planning these modules, I have had an opportunity to link science content to real life situations."

The best thing that the PROFILES project has given me is a feeling of enthusiasm. I'm eager to consider my teaching and my profession from a new perspective.

2.14 Three-stage Study Modules in Finnish Physics Education at the Secondary School Level

Antti Lehtonen – Kirkkoharju school, Finland

Introduction

As part of the PROFILES project, I piloted three different study modules in physics: a traffic accident, sound and hearing and electromagnetism. The study module about a traffic accident was strongly modified from the PARSEL module by the UEF team (available in Finnish: www.uef.fi/profiles) to suit the Finnish context. The other modules I created myself.

The traffic accident module was piloted in the 8th grade in a typical heterogeneous class of 19 students. Students learned the concept of velocity and acceleration so as to decide who had been the guilty party in the accident.

The module on sound and hearing was piloted in a 7th grade physics class of 24 students. The scenario of the module was based on a real article telling about the influence of noise from iPods and MP3s on young peoples' hearing. After carrying out inquiry-based experiments and learning about how sound is produced and how it propagates, students decided how they could protect themselves from noise. They also planned their own earphones.

The third module, concerning electromagnetism and electric energy production was piloted in the 9th grade with 20 students. The scenario presented a case of a grey, stormy autumn evening during which students had arranged a party using LED light bulbs. They had to decide how to ensure an electricity supply through the use of a generator, in the event of an electricity blackout. By undertaking experiments, students acquired the concept of electromagnetic induction and how it is used in generators. At the end of the study, students decided what would be the best way to produce electricity, giving reasons for their choice. They also constructed models of LED simulated lightning systems, including a 'party room' made of board LED light bulbs and a generator. Students had to decide whether the room could be lit if the mains electricity failed, or they should abandon the party.

Study module – Sound and Hearing

The study module on 'How to get the MP3-instrument to be more hearing-friendly,' concerned sound and hearing. The following scenario was used to set up the problem, motivating students towards making inquiries and decisions.

Scenario: The burden on young peoples' hearing

Many factors are related to young people's hearing. Music in discos, bars and restaurants is far too loud and every day, people jog or hang around in the city to the rhythm of an MP3 device. Researchers are also of the opinion that young people have difficulties in perceiving the music listened to through iPods and MP3 devices, noise which can damage hearing when the exposure is long-lasting. Furthermore, the poorest part of the population in the USA often lives in the noisiest regions of big cities, spending much of their time on the streets listening to their music devices. It is not worth making young people in Finland or the USA feel guilty about listening to music which is too loud, but who intentionally wants to damage his/her hearing? The MP3 device itself costs several hundreds of euros while the headphones cost only two to three euros. It is not surprising that the user turns the knobs to southeast to be able to listen to all the frequencies of music. If possible, it would often be wiser to buy personally adapted headphones. Studies published this year are worrying, in the sense that even slight damage may hinder the hearing of children and young people. This then may affect their schooling, their social life and, even worse, their displacement. This being so, the volume in music devices should be turned down and people should be made aware of the danger of this way of comforting music. If you can hear what your neighbour is listening to, then he/she has it on too loud. (Penttinen, Kuuloviesti 6/10)

Inquiry-based learning

Students explored ways to produce sound through two experiments, one with a ruler and one with a table tennis ball and a tuning fork. The purpose of both these experiments was to show that sound is produced by mechanical vibration. Then sound propagation was studied with a thread of wool, metal rods and scratching a table. Thus, students listened to the surface of the table while the partner scratched it at the other end. The thread of wool was used to conduct the sound from jingling metal rods, first with the threads being tied to the index fingers with the hands held out in front and then, with the rods still being tied to the fingers, by placing the index fingers in the ear. Going further, the influence of the medium was observed with a mobile phone and a freezer bag. A sound level meter and a tape measure were used to show the influence of distance on the sound intensity level. The equipment which was used in the experiments is shown in Figure 1.

Figure 1. Equipment used in the module for studying sound

Decision making stage

Based on the knowledge gained from the science inquiries, students answered the two following questions: Why can hearing be easily damaged with earphones, and should earphones be made more hearing-friendly? Finally, in groups, students planned their own earphones.

Experiences

This study module is planned to be carried out during 3 to 4 lessons (45 minutes each). Students like this form of study based on a three stage model. They worked in groups of 3 to 4 persons. Students managed to complete all of the experiments and write down their observations and conclusions. They co-operated with each other and the teacher had enough time to observe the students' work. The three-stage model functioned well, the students learned the properties of sound, and three-stage model also supported students' thinking and decision making.

Study Module - What is the best way to spin a generator?

The study module concerning electromagnetism began with the scenario of a situation in which electricity should be ensured in the case of the usual mains supply being cut off.

Scenario

It is a grey and stormy autumn night. You have decided to arrange a party at home. Now it is not a question of any candlelight dinner, but you would like to get the "partyglitter" to glitter properly when the bright light reflects on it. For this purpose you need electricity. The room has environmentally friendly, small LED-lighting having a small energy consumption. Nevetheless, an autumn storm may knock down trees and damage the electricity supply. You wish that the evening goes to plan and so you ensure the function of lights by installing a generator to act as a spare-energy source.

Students' tasks: With the use of a board, construct a model of the place where the party is to be held and install one LED lamp on the ceiling. How can you light up a room without using the mains electricity?

Inquiry-based learning

Students experiment with electricity production and electromagnetic induction using coils, bar magnets, wires and voltmeters. Students explore what happens when a bar magnet moves inside and outside the coil and how the situation differs when the magnet is kept stationary. A second experiment, in which students try to find factors that influence the amount of voltage, is more open. The equipment is shown in Figure 2.

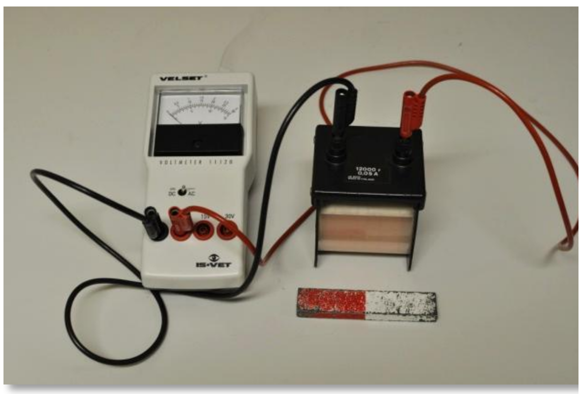

Figure 2. Equipment used in the generator module

Decision making stage

In the beginning, students decide what coil they should use to light a LED lamp. At the end of the study module, students use their knowledge about electromagnetism to decide what would be the best way to spin a generator and why. Some of students' models are shown in Figure 3.

Experiences

The study module takes about 5-6 lessons (45 minutes each). Working time can be shorter if the students are given the task of searching for information as their homework. Students start to work quite nicely. They do not complain about the method or the study module. First they search for information from the internet and from text books. After that, students gather their knowledge using an online note board called a Wallwisher. During the inquiry phase, everyone participates in the work. If someone in the group doesn't understand something, other students are able to help and the teacher has enough time to observe and evaluate the students' work. One important finding is that students, who don't normally participate in lessons, are eagerly involved in this study.

Figure 3. We actually got electricity! Some models of the party room which the students made

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2.15 A Module Entitled: Does it Really Give You Wings?

Ciara Hereward Ryan – University College Cork, Ireland (in association with ICASE)

Through a student motivational title, this module introduces students to chemistry learning in the following areas: Bonding, solutions, atomic structure, use of scientific apparatus, concept of current and charge.

This module was created based on the following objectives, giving students:

- an appreciation of the importance of each food type for the body.
- sufficient factual knowledge to allow them to investigate the daily energy requirement of a sedentary individual compared to an athlete in training.
- an understanding of the different types of energy drinks and sports drinks commonly available.

Learning Outcomes

On successful completion of this module students will be able to:

- Investigate food groups and discuss their requirements for exercise and activity.
- Compare the daily energy requirement of a sedentary versus an active individual.
- Research the range of sports drinks and energy drinks on the Irish market. Categorise these drinks as isotonic, hypotonic and hypertonic.
- Evaluate and design a sports drink.
- Design and conduct an experiment to examine the electrolyte content of a number of drinks.

What was the approach in the lessons?

The teacher explained the concept of inquiry-based learning to the class through a PowerPoint presentation. The teacher then gave out a scenario and gave the pupils time to read the set scenario and discuss it among their classmates. The teacher intervened to stimulate debate on the subject, often by asking questions.

The class was divided into groups where the teacher allowed the students to be active learners and only facilitated their work rather than controlling it. The teacher observed how students worked as groups, what types of research methods they employed and noted their enjoyment of the task. In this way, the teacher was acting as a facilitator to the student in these lessons. Once the students had researched their area, the teacher stepped in to brief the class on that area. When the teacher was satisfied that there was a suitable level of understanding, the students were encouraged to go back to autonomous work. The teacher was there for questions and assistance in setting up experiments, designing posters and preparing arguments. The teacher used mostly formative assessment for this module.

What the students did:

Group 1 worked to research and then design a poster based on the link between nutrition and athletic performance. They examined the food groups, food pyramid, benefits of sports drinks, importance of hydration and types of sports drink available.

Group 2 spent time researching the best types of sports drinks available and the benefits of each one. From this they designed their own sports drinks.

Group 3 planned and conducted an experiment to examine which type of drink contained a suitable amount of electrolytes to be considered to have a positive impact on dehydration and sport performance.

The teacher tried to promote Inquiry-based Science Education by means of a variety of activities, e.g. keeping questions open-ended, organising structured group work, acting as facilitator rather than instructor, promoting independent research, organising discussion and debate sessions, promoting and affirming student initiatives, promoting and praising creativity in the students.

Results

- After completing this inquiry-based module, it is clear that over 50% of the participants thought that the topic did relate to their own lives.
- The majority of the students reacted positively to the problem-based approach to a new topic compared to their previous experiences of introductory lessons.
- It was noted however that students may find a more open inquiry-based approach difficult to engage in immediately so a more structured form of inquiry may be the best approach as an introduction to the students.
- It was clear that the participants felt more active during the lessons compared with previous types of lesson.

Evaluation

- The topic was clear and relevant to the everyday lives of the students.
- It was not gender based and was equally attractive to both boys and girls.
- It included Chemistry that was part of the Leaving Certificate curriculum.
- It engaged the students through tasks and problem solving activities.
- The students' tasks were open to adaptation by the students or teacher.

Conclusions

It was clear that this type of resource, when designed well, has the ability to nurture a creative and stimulating environment for the students. Based on past student responses, the author was aware that students had been mainly passive learners in the classroom and had become disillusioned with the subject of science. Consequently many had opting out of Senior Cycle Science and thus reducing their options at the tertiary level. This study highlighted that inquiry-based learning could be a workable alternative to the current pedagogical settings of science in the classroom to engage students. Feedback from the students clearly showed that working in an inquiry-based setting allows students to feel that they have a greater chance to participate in scientific activities and conduct meaningful investigative work.

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2.16 A Module Entitled: Organ Donation – Opt In or Opt Out?

Sheena Walsh McQuillan – University College Cork, Ireland (in association with ICASE)

Through a student motivational title, this module introduces students to biology learning in the following areas: Human biology (organ donation, functions of organs donated); ICT (internet searching).

This module was created based on the following objectives:

- To encourage in students an attitude of scientific inquiry, curiosity and discovery through working individually (personal motivation) and within teams.
- To develop an understanding of organ donation and knowledge about the structure and function of organs which are donated and illnesses they are used to treat.
- To give students an understanding of role play through playing the role of the person assigned to them.
- To enable students to become familiar with searching for information on the internet, interpreting and analysing the information they select to best answer their questions.
- To enable students to experience group work, working as a team to come to an overall decision on the suitability of an opt out system for organ donation in Ireland.
- To give students an appreciation of the complex issues involved and the challenge of trying to reach a general consensus on the issue.

Learning Outcomes

On successful completion of this module students will be able to:

- Discuss the ethical issues surrounding organ donation and transplantation.
- Describe what organs are donated, their structure, function and the illnesses they are used to treat.
- Carry out a role play effectively.
- Prepare and present a report on their views on the potential impact of an “opt out” system of organ donation in Ireland.
- Carry out a data search, process the information, select and analyse data.
- Construct and present an argument for or against the introduction of an “opt out” system of organ donation in Ireland.
- Apply their scientific knowledge, and be empowered, to make informed choices about organ donation.

What was the approach in the lessons?

This teaching module enables students to join an investigative team to assess the potential impact of an opt-out system for organ donation in Ireland and report on their findings. The focus throughout the module is on developing reasoning skills in students, to guide them to develop argumentation skills, to draw conclusions and make judgemental decisions using scientific knowledge and ideas. Student activities include collaborative inquiry learning, incorporating group work, discussion, argumentation and decision-making; data search and analysis; the use of role-play; preparing presentations and report writing; use of data logging equipment.

Results

Results from the study indicate the module was both highly interesting and motivational for students and teachers alike. The overall view of the teachers on the success of the teaching module was very positive, reporting that the module was well received by students, who showed high levels of interest and motivation. The module stimulated intrinsically motivated learning.

The inquiry approach was valued by students who enjoyed the opportunity to be involved in role-play, decision-making, communication and collaboration-related activities. Such activities aroused their interest and participation. The results suggest that the majority of students feel comfortable with the change of the traditional approach to teaching and that the inquiry approach stimulates positive attitudes towards learning science. It is believed that the positive experiences developed during the module could be the foundation of a lasting positive attitude towards biology/science.

Evaluation

The relevance of the module to society and the students' everyday life increased enjoyment and interest in the subject which stimulated intrinsic motivation in the students.

- The teachers who taught this module believe that the module reinforced learning and enabled students to acquire knowledge, new skills and abilities.
- The teachers perceive the approach as valuable but identify two major obstacles to implementing inquiry in their lessons. The considerable amount of time required to plan and implement inquiry lessons is seen as a potential barrier and the issue of assessment also is an important factor. The traditional assessment system does not assess many of the skills and learning attributes which incorporate the PROFILES approach.
- Adapting to IBSE can be difficult for both teachers and students and due consideration should be given to their training needs. A small minority of the students were resistant to a change from traditional teaching approaches. This can be daunting for students initially and takes them out of their comfort zones and may diminish their levels of learning satisfaction and possible learning success.

Conclusions

The important role that teachers play in increasing students' engagement has been highlighted and the results emphasise the importance of providing and sustaining professional development training to science teachers. Planning and implementing teacher development programmes and interventions is required for successful implementation of inquiry-based science lessons.

Teacher networks need to be established operating on a local, regional, national and European scale, where teachers can access, discuss and share resources and ideas, discuss developments and provide support to each other.

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2.17 A Module Entitled: Grip it or Slip it

Simon Hill – University College Cork, Ireland (in association with ICASE)

Through a student motivational title, this module introduces students to physics learning in the following areas: Forces, friction, application of friction, lubrication, use of data logging sensors, IT and the analysis of quantitative data.

This module was created based on the objective to allow students to gain an understanding of the factors that affect friction by conducting a series of investigations.

Learning Outcomes

On successful completion of this module students should be able to:

- Discuss the factors that affect friction
- Design a mind-map illustrating the factors
- Design and plan an investigation into one of the factors affecting friction
- Carry out an investigation, record data and analyse the results.
- Draw conclusions based on those measurements
- Report and discuss the results finding

What was the approach in the lessons?

Following a short scenario discussing experiences in riding in buses, students were given the following set of tasks.

<u>Task 1:</u> As a group they were asked to identify, with the aid of a mind map, all the factors that contribute to a bus tyre gripping or slipping on a road.

<u>Task 2:</u> Each group was asked to choose one of the factors that they would like to investigate. They were guided to design an experiment that investigated whether or not the chosen factor affects the tyre's ability to grip the road. Once this has been completed, the group submitted their plans to the teacher.

<u>Task 3:</u> After the teacher had reviewed and agreed the plans, each group carried out the investigation. On completion of the investigation each group discussed their results and, through consensus, reached a conclusion.

<u>Task 4:</u> Each group gave a short presentation to their fellow classmates.

Results

- Analysis of the accounts of the investigations written up by the students shows that they engaged significantly during the lessons.
- Feedback received from the students showed that the module had a positive effect on student motivation.
- Students found that the science lessons were relevant for society.

Evaluation

Strengths

- The module placed a very strong emphasis on group work.
- This module was designed to build upon students' prior knowledge and skills. It is clear from the manner in which most students were able to undertake the tasks with relatively little help from their teacher, that the students did have the necessary prior skills and knowledge. The one exception be-

ing students' lack of experience using data-logging equipment, which did require some instruction from the teacher.

- One of the key components in any inquiry-based lesson is that the students are able to work independently from the teacher. In this respect the module was very successful, as students were able to undertake the planning and investigative tasks largely independent of the teacher. However when it was necessary, the teacher did intervene and offer guidance.
- The module was also successful in presenting students with a scientific problem to solve using a scientific process. The evidence of this is that students designed and carried out their own investigations, which allowed them to reach their own valid evidenced based conclusion.
- The defining characteristic of inquiry-based learning is that it places as much emphasis on the scientific process as it does on the resulting evidence-based theoretical learning. An excellent example of why this is so important was given by the students who investigated the effect of area of contact on friction. Due to their preconceptions they believed that they had carried out the investigation incorrectly when they found that the force of friction remained the same even though the area of contact was changing. It was only after they repeated the experiment and were encouraged to trust the process that they reached the correct conclusion. This gave the students an invaluable insight into how the scientific process actually works.
- One of the key strengths of the module is that it is relatively easy to differentiate the tasks according to the different ability levels of the students.

Weaknesses

- The scenario was not as effective as had been hoped in initially motivating students. Showing the students some video footage of formula one cars skidding before they read the scenario may help to stimulate their interest.
- The module involved extensive use of group work. Whilst this is largely positive it does come with the caveat that the group work must be organised effectively or it can lead to a chaotic classroom environment. As a consequence an inexperienced teacher with little practice in implementing group work may struggle.
- It can be difficult to keep all students on task because some groups will finish tasks quicker than others or students may be waiting to use equipment such as the data logger. As a result timing can be an issue.

Conclusions

The module was effective in promoting IBSE. The scenario and title were only partly effective in motivating students.

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2.18 Chemistry - What a Pizza!

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Introduction

With the aim of improving education, in our school, a group of teachers are participating in a European project called PROFILES (Bolte et al., 2011). As a component of the project, we received training in the use of cooperative learning method, to include a scenario and to introduce concept maps in our teaching to help students to be aware of their learning and to utilise problem solving methods. Since we believe it is necessary to increase interest and active student involvement in the processes of learning and studying, we have developed a didactic module suitable for learning important concepts in Biology and Chemistry, such as fermentations, chemical reactions, and the variation of the rate of reaction with the temperature.

Our idea was to develop a teaching module focused on increasing the intrinsic motivation of students (Ryan & Deci, 2000; Turner & Patrick, 2004; Holbrook, 2005), thus overcoming students' hostility towards science which often makes it difficult to learn complex concepts. Through the module, we wanted to introduce our students to the study of chemistry by means of daily life phenomena, viewing science education as 'education through science' (Holbrook and Rannikmae, 2007).

Our Goals

Because developing positive attitudes and interest in science is one of the key goals for science teaching and learning, we decided to develop a didactic module called "*Chemistry - What a Pizza*". In Italian language this title implies that the chemical is a subject the students find bothersome. Pizza is a food, very popular among teenagers and featuring strongly, together with pasta dishes, in Italian gastronomy. The module starts from a well-known food and seeks to analyse, from a scientific standpoint, the main chemical changes, physical and organoleptic characteristics that occur during its preparation by reflecting on the parameters that can affect the success of the final product. This activity also promotes observation and reflection skills of students through requiring them to approach a practical problem (how to make a good pizza) using a scientific method of investigation and an experimental approach. Scientifically, this grade 10 (second year of secondary school) science (biology and chemistry) module is about fermentation and chemical reactions, while the educational goals are to increase students' motivation, self-esteem, social abilities, leadership, and communication skills, through group work and experimental work.

Content

Specific objectives of the subjects:

- To use the inquiry scientific method to study a phenomenon (the leavening);
- To identify the variables that influence the success of a complex phenomenon;
- To study the effect of some parameters (such as the temperature, the sugar, the change of the ingredients), taking constant other variables, and to identify the most suitable experimental tests to verify the initial hypothesis.

The work was carried out in laboratories of chemistry and science, and in a kitchen for cooking pizza. Three classes were involved and, with reference to the educational needs related to ministerial programmes, emphasis to biological/biochemical aspects – and chemical kinetic was given. The high school students have performed the task by deepening their study of nutrients and transformations that occur during the leavening and cooking of a pizza, focusing on the fermentation of Saccharomycetes. Students attending technical/commercial course focused to the chemical aspects of fermentation, answering to the questionnaire formulated by the teacher and aimed to identify the reagents and the reaction products, as well as the effects that changes in the dosage of reagents may have on final the result. Also the effect of temperature on the leavening rate and on the products forming during the process has been studied. The classes were divided into several groups and each group was asked to plan an experimental activity with the aim to identify the reaction products and the influence of a particular variable on the reaction rate.

After introducing the project and issues to the classes, and after dividing students into several groups, the module was divided into three stages corresponding to the three processing phases (dough, leavening, cooking). A "map" to-do for each stage was provided to the students:

1. Several questions-stimulus, analysis and conceptualization of the phenomenon, to draw a concept map, to draw the flow chart (one hour in class), to do a web research (at home, about 2 hours)
2. Experimental activity in the laboratory, observations (qualitative research), data collection (quantitative research), photographic documentation, written report (3 hours)
3. Final discussion and comparison of results obtained by different groups (1 hour)

At the end of this module, students from two schools were hotel-management school's guests and they had the opportunity to confront with the chefs and technicians of the school, to ask questions and to explain what they had studied, as well as to prepare a pizza, using the cooking laboratory. Each group of students of the chemistry class presented its work to students of biology; then each group of students of biology presented its work to students of chemistry. In this way, the students improved their communication skills. We have developed a suitable assessment approach to evaluate positively the engagement and efforts of all of our students.

Evaluation

The strong points of the modulus are:

- versatility and opportunity to work on different levels of difficulty, as well as on different contents, based on the type and age of students;
- ability to work according to an interdisciplinary and multidisciplinary approach, ability to work with different topics ranging from food history (origin and spread of pizza), law and economics (European quality, product specifications and typical products, since 5th on February 2010 the Neapolitan pizza was designated the STG mark, traditional specialty guaranteed by the EU), biology (the alcoholic, propanoic and lactic fermentations). There are topics of biochemistry (Maillard reaction, caramelization, dextrinization of starch), physiology and pathology (gluten intolerance, yeast intolerance) as well as many aspects of chemistry, such as determination of the CO_2 produced and the search of ethyl alcohol.

Skills promoted for the students:

- ability to manage a project: to create the time-line of the project, to establish the times and the roles
- research skills: to determine the nature of the problem, to search information basing on different sources (web, interviews, books), to analyze and to understand data
- organization and production skills: to organize and to link information, to reprocess them using different linguistic codes and structures (writing, questionnaires, laboratory report, power point presentation).

The project has proven successful; the majority of students demonstrated great interest both in the research and in the reprocessing phase. Also, the experimental activity allowed students to learn in the laboratory, which otherwise would not be used during the regular school year. Students expressed their appreciation for this kind of learning which is different from the usual activity. They also provided interesting suggestions for the experimental activity. A gradual increase in motivation to study and research was noticed. The tasks were carried out rapidly and students worked autonomously, with the teacher playing a leadership and coordination role. From an evaluation of the MoLE questionnaire (Bolte & Streller, 2011) students indicated it is very important that the scientific theoretical knowledge provide a key to the surrounding everyday life and its phenomena.

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2.19 Video-Experiments: A Possible Apprenticeship of Awareness

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Goals

This communication is aimed to report the preliminary results and pedagogical perspectives of a mixed strategy for improving the effectiveness of IBSE organic chemistry laboratory experiences (but not only laboratory skills) through the planning, making and playing of videos with students in the three year high school, specializing in chemistry.

Content

"How can I tell what I think till I see what I say?" (Forster, 2005)

Origins of the idea

The idea of using videos as a learning/teaching strategy came up to me while I was occupied in shooting videos of lab experiments for pure documentation purposes. I acknowledged the great efforts that student-actors had in communicating through a meaningful speech or argumentation (sometimes I experienced similar difficulties when I had to play a part). While there were some improvised, unwilling actors who seemed perfectly prone to understand the role and able to talk and act from the first shot, others, like me, seemed unable to think, speak and act by following a script at the same time. I recognized that this wide range of aptitudes wasn't a problem of syntax, or language fluency, but of different "*mental managing*" (De La Garanderie, 1991) of the speech, of differences in nature and the speed for the language of reflection (inner language) and the language of external speech (Vygotsky, 1986), and maybe of an important role of auto-stimulation of one's own voice on associative and "*conceptualizer*" mechanisms and on consciousness (Dennett, 1993).

This simple switch in my perspective was enough to change what could be viewed as a weakness of the quality of videos for external watchers, to an interesting practical route to meaningful learning and deep understanding (Tifi, 2010).

In December 2011, an inquiry-based experiment was planned and carried on by five high school grade cooperative groups to determine the partition constant of adipic acid in diethyl ether/water. This was part of a theoretical and practical learning objective about solvent extraction technique. The students were already familiar with concepts such as partition constant, dynamic equilibrium, polarity of substances and molecules, and they were used to the normal laboratory practice and related calculations, such as for acid-base titration, analytical weighing, etc. The experiment was carried on without any 'cook book' type recipe, using a plan derived in a collaborative setting. At the end of the experiment, good results were obtained by the groups. I exploited them to introduce a Dixon text, which showed the students their oddest result could be included in the average calculation, and that the obtained mean result was compatible with literature data. But, in a subsequent assessment occasion, by checking the students' ability to redo the calculations from experimental data, and asking for oral recounts of the whole or detailed rationale of the experiment, I bitterly disappointed to learn that the students had not lived a true modifying, or inquiring experience.

Doing the experimental hands-on activity, with students expected to calculate the same steps, write similar reports, find, criticize, compare and draw conceptually the meaning to the experimental outcome, I realized sampling students to check their understanding during the experiment, was not enough for most of the students to become sufficiently aware conscious of the procedures and the related concepts.

The video play idea

It was clear that a different strategy was needed. So I decided to redo the experiment with a renewed plan, aimed to make a video. This proved to be worthy and to offer much promise. The screenplay was assigned to the five groups as a table of scenes with actions and speech that were elaborated as Google-docs and a calculation spreadsheet, and these edited at school.

The play objective was presented to the students not as a remedy to the failure of the previous experiment in terms of their learning, but as an educational video to promote the specialization of chemistry of our institute to younger students, and also to make non-experts able to understand what happens to invisible molecules during solvent extraction.

I wasn't surprised during the reviewing phase, when it became clear to everybody that the experiment should be changed. Instead of beginning with a water solution of adipic acid (that was a pre-condition in the first inquiry experiment) titrated before and after ether extraction, which would have made the substance invisible in each part of the video, the students decided to use visible, weighed-solid adipic acid and that also the extracted amount should also be made visible and weighed after solvent evaporation.

Collective reflection on how to make things understandable to others represented the true inquiring activity. This helped better representations of the phenomena and concepts, leading to better understanding.

This episode gave a true insight and deep understanding for all and showed this is possible in a inquiring context, but not necessarily in a straightforward sequence - that is: 1st assign the problem, 2nd assist and guide students with hints till they devised and understood how to obtain a possible procedural solution; 3rd apply the suggested solution.

Video interview

After the video (ITT Divini, 2012) was successfully made, and enjoyed by the students I decided to reveal that the true aim was to make them understanding better the practical and conceptual aspects of partition equilibrium. At the same time I gave them a series of questions to answer through a video interview. All students answered using a Google-Form to the questions and, as before, starting from the shared and reviewed answers, the students prepared their possible speeches for the answers in groups using Google-Docs. Their answers were reviewed at school. This editing step was a fundamental one: students couldn't simply read the answers, as the speech needed to be fluent and thus needed several rehearsals. The students were simply unable to say something until it wasn't completely understood by means of silent reading and discussion with classmates, or teachers. Due to being a minds-on task, this kind of text transformation activity had high impact in making students confident with the concepts and corresponding word-labels and "*language games*" (Roth, 1996; Tifi, 2010; ITT Divini, 2012). Subsequent assessment sessions and references to the activity revealed strong conceptual and practical learning associated to the topic.

Other related activities

Other experiments involved screenplay-making in English during "Content and Language Integrated Learning" activities (CLIL) through which CLIL can be viewed as a further type of disciplinary language transformation, helping construction of meaning. As an example, a 4th grade high school class video-synthesized the flavouring substance "champignol" (oct-3-en-1-ol), using a Grignard addition. Groups of two or three students trained themselves to recite and act for each shoot. The scenes were based on a collaboratively made script that underwent adaptations in each trial stage. As an enthusiastic teacher I can report the same atmosphere described by Pavisic: *"A good teacher has to be enthusiastic about his topic to generate an atmosphere that is open and positive. When students are treated well, respected, encouraged and the work has meaning, high levels of motivation will automatically develop."* (Pavisic, 2011)

But it should be noted that time of production was abnormally dilated, while the learning impact was weaker and engagement of students was more uneven in comparison to the previously described experience.

Other CLIL activities, screenplay representations of reaction mechanisms have been undertaken and a second interview about TNT (trinitro toluene) synthesis in 3rd grade high school class is planned for the first week of June.

Reflection

When students undertake an experiment for the first time they need the entire time to practice their process skills on different parts so as to make sense of a series of situated experiences that are very important to making oneself feeling "expert". But this is not the same as mastering the general cognitive insights of the inquiry experiment and the related conceptual frame. Experimental noise and working memory overload (Johnstone, 1997) is an aggravating circumstance that hangs over a general and unavoidable stance of 'apprentice' people tackling new situations. To ensure an inquiry orientation for the laboratory activity, it is important for a second round for actor-learners, where the minds-on activity is most relevant. But also, in this case, the inquiring experience is lived as a-posterior one. Guided inquiry-based experiences mean that the complete awareness of the problem, the comparable strategies and the solution may only be consciously rationalized, as a whole, *after* the experience is finished. Giving the students an opportunity to teach themselves, as described in this article, implies practice with, and rehearsal of key words, images, representations that form a detailed, holistic and indelible sense of the experience, and that cannot be yielded by a single inquiry-based experiment (as I had pretended in the past).

Outlook

After the scholastic year is coming to its end, I can reflect and compare the educational strategy of the adipic acid experiment with other subsequent experiences and attempt to understand why the former was better and to formalize the approach so as to make it transferrable to other learning activities. First of all, I intend to try to transfer the idea to inquiry-based, minds-on activities (i.e. true lessons for younger students), that could be less time demanding yet equally effective. All these efforts have been accompanied by a parallel PROFILES course and can be viewed as an attempt to put into practice PROLFILES philosophy. The MoLE questionnaire, which was assigned to all students, will be a further source of improvement.

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2.20 Science Teachers' Learning Team – A Powerful Tool to Improving Inquiry Teaching and Reflection Skills by Focussing on Teacher Individual Needs

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Background

While teachers' Continuous Professional Development (CPD) focuses on teacher learning (Fullan, 2011), teacher as a researcher gives a challenge for CPD experts to develop new tools according to teachers' needs. The individual needs to improve experienced teachers' (in this case, two to six years of piloting science curriculum and training; scientific inquiry, etc.) teaching skills, such as how to teach students to suggest a scientific problem, make a hypothesis, perform data analysis, draw conclusions, promote students' motivation, etc. were indicated by teachers themselves as an issue requiring attention. Evidence for the need to improve reflection skills derived from results of the teachers' needs questionnaire undertaken within the framework of PROFILES in October 2011. Action research was the preferred tool for teachers to improve their own practice and reflection skills, where *"the aim of the [action] research was to enable teachers to solve, or improve a problematic situation"* (Taber, 2007). Action research is *"like a spiral of self-contained cycles involving: planning a change, acting and observing, … reflecting … modifying, acting and observing…, reflecting"* (Kemmis & McTaggart, 2000, 595). Teacher learning teams for the action research were developed.

Preparing CPD expert team-leaders

The focus of the learning teams was to act as a teachers' professional learning tool to improve individual teaching practice and reflection by science teachers. This innovation was organized in Latvia for the first time. The initial training of the experts (potential learning group leaders) was undertaken in the spring of 2011, in close cooperation with foreign experts (PROFILES partners included) following a study visit to British Columbia, Canada, organized in January 2011. The group of experts was ready to pilot the new (for them) teacher CDP model in the summer of 2011 and a research and an experts operational methodology was created. The procedure for each workshop was developed by the experts and updated before the following workshop during seminars/meetings for workshop leaders, organized as in-between workshops. Group leaders participated as observers during the sessions with other groups and all group leaders made their own notes after the workshop. The feedback from participants, observers and team leaders were noted and discussed. The teachers presented their work, took part in the focus group discussions and completed a questionnaire during the final conference.

How the learning group works

We describe in this paper the work of one group of PROFILES teachers. In November 2011, twelve science subject teachers (6 biology, 4 physics and 2 chemistry teachers) teaching grades 7 to 12 in different schools in Latvia took part in a group session with the goal to improve their scientific inquiry teaching practice, according to their individual needs. Ten of them were to eventually present their work in a Latvian final conference in May 2012. This group was joined by experienced teachers who had already attempted to use scientific inquiry methods in their teaching practice, but had found weaknesses in their approach, especially related to not finding a clear understanding of student expectations regarding the tasks given by them. An individual research question was formulated by every participant. For example, "*If I gave students a task to undertake a short case study every two weeks, would they learn to formulate the research question and hypothesis?"* etc. The student tasks and action research methodology and instruments were prepared, discussed and updated on regular basis.

The teacher plan for group work consisted of five research occasions in the classroom with group working session workshops once a month, an action workshop and the final conference. The opportunity to communicate with the group leader electronically between workshops was offered. The planning for the workshops is shown in Table 1.

Time	Topics	Short description
16.11.2011.	Introduction. The goals. The procedure. The rules of group work. The first formulation of research question.	What is action research? How the learning team works? What the teacher – researcher is? Common understanding – what scientific inquiry is? What the reflection is? How to formulate the research question?
05.01.2012.	Reflection about first version of research question. The update of research question. Action research instruments.	What I have understood about my research question? What would be students' gains? What evidence do we need to see the improvement? What are the research instruments we could use? How to choose the appropriate tool? How to choose the task samples for students?
07.02.2012.	Reflection about research question, task samples and instruments has been chosen. Planning of data acquisition.	How to focus my research question? How to see are question, samples and data tools corresponding? How to improve them?
07.03.2012.	Reflection about task samples, evaluation. Reflection about progress of research.	How to improve task samples? How to improve my research tools? How to see what data show? What are my student's gains?
12.04.2012.	Reflection about progress. Conclusions. Planning of the presentation.	What are the conclusions from my research? How to present it to my colleagues? How to prepare the poster? What's next?
10.05.2012.	Final conference.	The presentation of posters. Focus group discussions.

Table 1. Content of learning group work

Each workshop included a similar procedure:

- Individual reflection (2 minutes per person, without questions and comments);
- Group reflection and discussion about the work undertaken between workshops;
- Focused input from the group leader according to the teachers' needs;
- Planning of the next steps;
- Follow-up Independent research work.

The rules under which the group worked were developed together with the teachers. The participants found it important to maintain confidentiality about problems discussed.

Results and discussion

The challenge of this CPD activity was that workshop leaders and teachers were both learners at the same time. Both of them – teachers and the group leaders - found that the learning group was a very powerful tool. The formal results on teacher gains showed that all of them found it a big or a very big gain[3] in the improvement of their skills, such as solving a research problem, analysing work undertaken, reflecting on one's own teaching, gaining evidence about improvements and cooperation with colleagues. Teachers pointed out the importance of the rules for the group leader in workshops, for instance in creating a positive atmosphere, keeping the appropriate focus during discussions, working as a coach, helping by providing support to individual teachers. The teachers mentioned the following as their individual gains: *"sharing with colleagues and not being self-conscious"; "I feel support to my ideas from the colleagues"; "it was the first time I focused on the evidence in the classroom with students to make conclusions and they did it"; "going step by step not in a campaign"; "making notes disciplined me"; "students mentioned that the new checklist is really useful and I found it was"; "there is the tendency for students' results to improve";* etc.

The group leaders commented that teachers became much more open during the learning period, they learned to formulate research question, to improve skills on using the instruments for the data, to analyse and reflect on their work based on evidence. One group leader wrote:

[3] 4 or 5 in Likert scale (1-5)

"I am glad they understood there is much to learn for them, a lot of things to improve; there was real reflection when they informed about their research; they are a team – they communicate and consult each other... they are ready to continue..."

At the same time, the group leaders reflected that many of the teachers found the main problem from the very beginning to be controversial to their expectations. All group leaders found one problem was formulating a good research questions – the teachers were too general or too obvious.

Teachers were used to being an empty vessel filled by others. The fact that they had to focus on their own very short research question was a real problem. It was not easy from the very beginning to keep rules, to have a common understanding for the meaning of inquiry teaching, what were real instruments to gather evidence about practice, etc. The teachers and group leaders both found the will to continue learning to use action research in the classroom during the next school year.

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2.21 Experiences from Latvia – Science Teachers Learning from other Teachers to Improve Teaching and Reflection Skills

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A group of experienced teachers was selected to participate in PROFILES in Latvia. These teachers had prior experience of teaching scientific inquiry during the piloting and implementation of local Science and Mathematics education reforms during the past years.

We thought it very important, for the dissemination of PROFILES ideas, to consider teachers as leaders – working with other teachers on how to implement scientific inquiry in the classroom; that is, how to help teachers build on being a teacher-learner, teacher-teacher and teacher reflective practitioner to a teacher-leader, according to the expressed PROFILES philosophy. One of the models for the teacher professional learning was created and described in this paper.

In the process of undertaking scientific inquiry, students obtain skills on how to form and answer questions, to conduct an experiment, to analyse data, to draw conclusions from data by thinking logically and critically, work in groups, etc. If the teachers have had teacher-directed teaching experience through lecturing, cookbook labs, etc. for a number of years, the real problem for them is to change their teaching practice to be more student-centred.

Our team – experienced members from the Centre for Science and Mathematics Education at the University of Latvia have observed more than 700 Science and Mathematics lessons during the last five years due to piloting local materials for scientific inquiry teaching and learning in schools. It serves as evidence to say that teaching scientific inquiry in practice means that the teachers not only learn a set of new teaching strategies, which they have not used before, but also change their beliefs about teaching, as stated by Fullan (1991). The first years of teaching scientific inquiry elements in the classroom show a gap between what teachers think they do[4] and what is really going on in the classroom during the lesson. The observation of lessons show a strong need to support the teachers to close this gap – to improve their teaching technique and to improve their understanding of the student-focused, teaching process. In order to learn this from others and to reduce doubts about students' outcomes, it is useful for teachers to observe and reflect on their colleagues' teaching.

The strong need to improve teaching and reflection skills

There are a number of chemistry, physics and biology teachers, who are mostly working alone in teaching their subject in their school. Our previous experience shows a strong need to have a team (a minimum of 3 people) of teachers working together for the successful implementation of the new ideas in the school. *"Well-developed teamwork improves the quality of practices as teachers work and learn from each other"* (Fullan, 2011, 34). How to organize an exchange of experiences between teachers to support them in the classroom practice was an issue to solve. Data from observing the lessons corresponds to the teachers' views. The PROFILES teacher needs questionnaire, utilised in October 2011, shows that not reflecting on the experience of teaching scientific inquiry for two or more years, teachers (21 participants) have found a strong need[5] to learn in order to promote higher order thinking amongst the stu-

[4] focus group discussions used
[5] teachers mentioned in the questionnaire very necessary and necessary

dents (86%), to guide students to ask questions and discuss (67%), to promote students' argumentation skills (67%), to provide suitable positive feedback (71%), to undertake a range of formative assessment strategies (67%), to create motivational changes (52%), etc. The teachers themselves have found a very strong need to improve their reflection skills.

The professional development model – the teachers learn from other teachers

> Despite the evidence and the fact that almost every other profession conducts most of its training in real-life settings (…), very little teacher training takes place in the teachers' own classroom, the place where it would be precise and relevant enough to be most effective. (Barber & Mourshed, 2007, 27)

How can teachers understand, whether, in the classroom teaching practice, they are on the right pathway to using strategies new for them? How can we help science teachers, working alone, in teaching the subject in their schools so as to have a different teaching experience? The model of school-based workshops, directly focused on the improvement of reflection skills and the way teachers can learn from other teachers to improve their inquiry teaching, was created within our teachers PROFILES CPD programme. The model for one group is described. This group of science teachers from 5 schools (the network of schools with innovative experience in science education from the National Education Centre was used for PROFILES) took part in the school-based workshops during the time period from November 2011 to April 2012. A set of 5 workshops per group was created. Every workshop was held in a different school. The workshop was open to science teachers from these schools. The CPD model included three phases: planning and preparation; workshop at a school; evaluation. During the preparation phase, teachers, together with the experts, planned and prepared open lessons according to the focus of the seminar. Experts planned the input sessions. Each workshop within the school consisted of three sessions:

Figure 1. Science lesson in Latvia

input about the teaching and learning skills of focus; observing teaching in practice (usually, two open lessons for a PROFILES focus on teacher as teacher); a focus group discussion to analyse and reflect on the teaching and learning practice observed (teacher as reflective practitioner). The procedure, specific worksheets for observation and the reflection guidelines were created by the experts. Feedback from participants was asked after every workshop. During the third phase, the experts' team worked on summarizing the feedback from the teachers and the experts and on planning the next workshop. The set of topics selected for the workshops, according to the teacher needs, were as follows:

- How to reflect on teaching and learning science. A model of analysis and reflection on the open lesson.
- Teaching scientific inquiry – student-focused teaching. Case studies.
- The development of HOCS (higher order cognitive skills) through scientific inquiry.
- Students' motivation for learning and feedback extended through scientific inquiry.
- Formative assessment in the science classroom.

Every teacher in the group took the role of a teacher-learner (from others experiences) and a teacher-teacher (with potential of becoming a teacher-leader) to open his/her classroom to colleagues learning and to be a leader of the group reflection session. Learning outcomes for students, argumentation and motivational teaching and learning strategies used by the teacher and students, alternative ways of teaching, assessment strategies used, etc. were discussed.

Results and discussion

We have found the developed CPD model successful for the teachers to learn from each other's teaching and reflection skills. The final questionnaire about the teachers' gains was organized in May and June, 2012. Teachers responded[6] that during the workshops they had improved their skills for planning and teaching scientific inquiry (90%), they had improved formative assessment strategies (86%) and formulated skills to motivate students (76%). Teachers fully agree that they had improved their reflection skills, had motivation to improve their teaching skills and they had learned to listen to their colleagues, able to professionally evaluate strengths and weaknesses in their practice (95%); had great satisfaction and self-awareness about their teaching practice after reflection (90%). At the same time, 33% mentioned they experienced some stress during the open lessons, which is considered to be the main risk for this model of CPD. It was mentioned by the experts that, during the period of changes, teachers first of all try to focus on the formal procedures and not on the essence of the new-for-them teaching strategies, as was mentioned in the introduction. It takes time for real changes in teaching practice to take place. The successful organisation of workshops depends on understanding by school leaders on the importance of this kind of CPD and the agreement gained, within the innovative school network, to dedicate one day per week for teacher CPD was helpful in order to manage practical risks.

Experts have found this model very successful for teacher CPD – to learn from each other by working together – using teachers of different science subjects from one school and one subject teachers from other schools. It gives the teachers more experience in teaching a subject and self-awareness that their experience is useful to other teachers in the school at the same time. The next steps could be more focused workshops for improving teaching technique in more detail.

[6] 21 respondent; strongly agree or agree, Likert scale used

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2.22 Developing Students' Key Competences Using PROFILES Modules

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Today's society places challenging demands on individuals, who are confronted with complexities in many parts of their lives. Being able to deal with these require suitable adjustment/modification of the educational process in order to prepare students in the best way for their future professional, social and private lives. This requirement became the base from which to elaborate the conception of the so called "key competences." In fact, the European Council and Parliament accepted the European frameworks of key competences (European Council, 2006), defining competences indispensable for citizens for self-fulfillment, social integration, possessing active civic attitudes and obtaining skills appropriate for the job market in their society.

The Reference Framework (European Commission, 2007) sets out eight key competences:

1) Communication in the mother tongue;
2) Communication in foreign languages;
3) Mathematical competence and basic compe tences in science and technology;
4) Digital competence;
5) Learning to learn;
6) Social and civic competences;
7) Sense of initiative and entrepreneurship;
8) Cultural awareness and expression.

During enactment of the PROFILES project, participating science teachers use specially prepared modules, mostly adapted from those exemplary from another project, PARSEL (www.parsel.eu). Each module contains an introduction to familiarize students with a specific everyday situation which is connected with the necessity of solving an actual real life issue. Based on engagement with the initial 'scenario,' students first recognize the scientific element involved, and then attempt to solve the associated scientific problem, in groups, looking for needed information, planning suitable investigations, recording the obtained results, drawing conclusions based on them and finally presenting them to other groups.

Largely, these modules refer to the key competences, as illustrated below. This realization suggests that application of these modules in the education process should significantly affect development of students' key competences.

Key competence 1: Communication in the mother tongue

Modules assists the development of the efficient use of the mother tongue because, through conscious application of language, it means adjusting to the situation and purpose of views, description of the world, precise wording of thoughts, employing rich vocabulary, as well as effective and respective to the recipient communication.

Key Competence 2: Communication in foreign languages

Searching for information needed to solve problems may demand also using sources in foreign languages.

Key competence 3: Mathematical competence and basic competences in science and technology

In the inquiry-based section of many of the modules, the problem solving requires calculation and formulating conclusions based on mathematical reasoning.

Key competence 4: Digital competence

In searching for information, students are mainly likely to use the Internet and through collecting, as well as processing information, they will learn how to apply it in a critical and systematic way. While communicating with each other during learning through the module and preparing presentations of the obtained results they can also be expected to make use of information technology.

Key competence 5: Learning to learn

In the course of meeting the module competency targets, students become aware of the learning outcomes they are to achieve which can positively guide students in organizing their own learning processes through effective management of time and acquiring skills and cognitive information both individually and in groups.

Key competence 6: Social and civic competences

PROFILES modules are initiated from social, or other student familiar, situations. The outcomes obtained, due to the enactment of modules refer to everyday situations and student engagement will require students making socio-scientific decisions thus promoting engagement in social and civic activities.

Key competence 7: Sense of initiative and entrepreneurship

Undertaking learning through PROFILES of modules will require student involvement in planning enterprises, leading to achievement of the intended learning outcomes, as well as managing, controlling, commissioning tasks, analyzing the obtained results, making reports and communicating.

Key competence 8: Cultural awareness and expression

If PROFILES modules achieve their target of intrinsically motivating students, tasks performed by students should get them involved emotionally which many a time will be connected with the creative expression of ideas and awareness of national cultural heritage and their place in the world.

As follows from the analysis, the application of modules in the enactment of the PROFILES project and the associated student learning is directly geared to the development of all key competences. The success of PROFILEs depends on the teacher realization that the key competencies are important and this in turn depends on the teacher ownership of the additional possibilities created by the use of these modules.

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2.23 The Needs and Expectations of Polish Science Teachers related to Professional Development

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The major aspect of the PROFILES project is developing the professional skills of science teachers so as to raise their self-efficacy to take ownership of more effective ways of teaching students. Each project partner is expected to prepare their own teacher continuous professional development (CPD) programme, reflecting the range of needs of the participating teachers. The CPD is intended to guide teachers to enhance students' motivation for science learning, both in terms of intrinsic motivation (meaningfulness, relevance, importance, as considered by students) and extrinsic motivation (teachers' encouragement, class-room environment and reinforcement of learning).

In order to create a programme that would, to the greatest possible extent, accommodate the needs of the Polish science teachers involved in the project, the teachers' opinions were collected by means of a 'gateway' questionnaire concerning self-assessment, didactic skills and their wish to improve themselves. A draft version, proposed by the leaders of the relevant Work Package, was used as a base to prepare this questionnaire in the Polish language. From an analysis of the factors included, which could affect the efficacy of the typical science teacher in junior secondary school, their needs and expectations concerning professional development were determined. Also used for comparison were outcomes from another questionnaire with similar aims, prepared during undertaking another project, in which science teachers in junior secondary school also took part (Janiuk & Samonek-Miciuk, 2012).

The PROFILES 'gateway' questionnaire comprised 50 items covering the following 9 thematic groups:

- Nature of science.
- Scientific and technological literacy (STL).
- Goals and process of education/ science education.
- Inquiry-based science education.
- ICT in science education.
- Integration of science knowledge/ educational projects method.
- Classroom learning environment.
- Student motivation and interests.
- Assessment.

Respondents were asked to indicate their *confidence* in utilising the given skills based on a 3-point scale (good – medium – poor), as well as their *level of interest* in improving a given skill, using a 5-point scale (1 = very high ↔ 5 = not at all/very low).

An analysis of the responses showed that, in general, teachers evaluated their skills as quite good, with differences between the above mentioned thematic groups not great; means were in the range 1,80 to 2,04. Confidence in the ability to promote "student motivation and interests" was the most highly evaluated skills and "Inquiry-based science education" and "Integration of science knowledge/ educational projects method" the lowest.

Levels of interest in improving a given skill, evaluated on a five-point scale, paralleled, in many cases, the teacher's level of mastering a given group of skills. For example, the greatest interest was shown by the teachers in professional development to improve the skills in "Inquiry-based science education," one of the items given the lowest level of confidence. This is not surprising as Polish teachers have been required, in the past, to acquaint students with the largest possible amount of information, thus forcing "learning by heart" methods. However, at present, more and more attention is being paid to methods encouraging active acquisition of new knowledge by students. This is, among others aspects, a particular effect of outcomes from the PISA study which has been carried out in Poland since 2000. This research indicated that Polish students obtain very good results in memorising information, but their ability to use science knowledge to acquire new knowledge and solve problems was much worse (OECD, 2010). The above goes some way in justifying science teachers' interest in participation in the PROFILES project, where they perceive the aim as promoting and implementing inquiry-based science education.

A comparison of questionnaire outcomes provides interesting conclusions about the skills of applying ICT in science education. Here the teachers evaluated their skills highly (1,84). This outcome was perceived to result from teacher interest in acquiring qualifications in this area, where possibilities to participation in various courses and projects supported by the Ministry of National Education and computer firms have been promoted. It is thus not surprising that the teachers stated, out of the nine skill groups, they are the least interested in additional training in ICT. (It should be pointed out that the above mentioned results were not seen as typical of an average teacher because, as a rule, better qualified teachers take part in projects such as PROFILES).

From a comparison of the results of this study with those obtained in the CROSSNET project a few years ago, great similarities were found as far as the teachers' evaluation of their professional skills is concerned. In both cases, Polish science teachers, in junior secondary schools, evaluate their skills in integrating science knowledge and individualising students' processes of learning as relatively low.

It is also worth mentioning that the teachers participating in the above mentioned CROSSNET project positively evaluated its effect on development of their professional competences. There is thus great expectation that similar outcomes will result in the case of the PROFILES project.

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2.24 Discover Introductory Organic Chemistry with PARSEL Module "Chemistry and Oral Hygiene"

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Considerations and goals

An adapted PARSEL (2009) module was named "Chemistry and oral hygiene" instead of the original "Brushing up on chemistry". In this module, applied to ninth-grade classes, students were faced with the fact that chemistry is present in daily hygiene products and that analysis of these can promote a critical attitude and influence their choices as consumers.

In the original PARSEL module, students were expected to:

1. Relate chemistry with everyday life and thus increase students´ interest in chemistry.
2. Find out about the role of numerous substances that are ingredients of toothpastes.
3. Prepare toothpaste in the laboratory and compare it with commercial products.
4. Analyse various kinds of toothpastes.
5. Discuss the importance of dental care.

In the ninth-grade, students are expected to learn about chemical bonds and gain an introduction to the world of organic chemistry. By the end of the year they are expected to be able to:

- Recognize the constitution and the importance of hydrocarbons;
- Distinguish various kinds of hydrocarbons;
- Identify some compounds with functional groups;
- Recognize through structural formulas, more complex carbon compounds such as synthetic polymers.

In the ninth-grade, Portuguese students don't usually show much enthusiasm in the study of concepts, such as in organic chemistry, or chemical bonding. The PARSEL module was an opportunity to undertake a different approach, so that these concepts would appear in a context of everyday life, showing that chemistry is a powerful tool to increase the knowledge about the natural world in which we live.

In this paper we discuss the application of the module to ninth-grade students and critical analyse achievement towards the overall objectives.

IBSE and "Chemistry and oral hygiene": the implementation experience

The suggested teaching-learning approach included four stages:

1. A relevant context for students.
2. Inquiry-based problem solving.
3. Socio-scientific decision making;
4. Introducing relevant chemical concepts.

In the first stage, a question was put to the students: "Is chemistry present in everyday products?" and, guided by the teacher, more specifically focusing on, "What are the chemical compounds present in toothpaste?" After a general discussion, a task was given to all students (previously organized in groups) to select and bring to class a commercial brand of toothpaste. The teacher suggested that students should also study a commercial brand of toothpaste, produced in Portugal since 1932. This discussion stage took about 20 minutes.

The review of the labelling on product packages and consecutive systematization of the ingredients into particular groups was the next phase.

The students were given a support document, in digital format translated from the original PARSEL module, and some Internet websites were suggested, so that they could find answers to solve the initial problem.

In the ninth-grade, students are about to make a choice regarding their professional future. It is thus very important to show them (even for those who are about to stop studying chemistry) that science is essential to the understanding of

the world in which we live. In this context, the study and preparation of toothpaste was focused and also motivating.
Nevertheless, the chemical compounds that exist in the toothpaste are very complex for 14-year-old students. They do not have previous knowledge of organic chemistry and so they are discouraged by the names of the chemical compounds.
After the investigation took place in the classroom, students prepared their own toothpaste in the laboratory and compared it to the chosen commercial brand. For this last task coloured eggs are needed, but because this procedure would imply the use of another lesson (without meaningful relevant learning), the teacher provided the coloured eggs.
The second stage took one lesson of forty-five minutes and for the laboratory work one lesson of ninety minutes was used.
While preparing the toothpaste, students also answered a series of questions regarding the interpretation of the laboratory work. Then, at home, they prepared an oral presentation, to show their classmates the results of their investigation and the conclusions they had reached. The final presentation took one lesson of ninety minutes.
Students were now ready for some relevant chemical concepts to be introduced, such as chemical bonding, and through highlighting aspects of the formula of SLS (Sodium Lauryl Sulphate), other more complex carbon compounds were presented.

Students' reactions, reflection and evaluation

When the project was presented to the students, they showed enthusiasm, especially concerning the laboratory work. However, self reviewing of the labels was not a very motivating experience. Students found very complex chemical names which they didn't understand. A question which often emerged was: "Why do we need to know what these names mean?"
However, it was not difficult for them to group the majority of the ingredients and identify their role/function. Nevertheless, some ingredients with complicated names, such as *PEG-6 or cocamodopropyl betaine* were simply ignored by the students. The laboratory work was exciting and most students participated with enthusiasm. Most of the students were able to answer the questions about the laboratory work.
It was an opportunity to apply concepts of acidity and alkalinity of solutions.
This module was also interesting in terms of the interdisciplinary work that can be developed with other members of the school community. The students developed a project in Art Education that consisted in drawing the package of the toothpaste and one of the parents who was a dentist, offered to come to school and talk about oral hygiene.
Students were assessed taking into account the pre-experimental work, the practical work and the final presentation. Here it was found that the majority of the groups had difficulties in terms of autonomy, especially in the laboratory. One issue was that they did not read the instructions carefully and, because of that, they didn't execute all the required laboratory procedures. During the final presentation, students also experienced difficulties in the interpretation of the laboratory work.
Overall, the initial goals were partially achieved, but, after analysing the various commercial brands of toothpaste, the students did not gain sufficient learning to be able to choose the best one for their needs.

Conclusion and outlook

Overall, it is indisputable that the application of this module contributed to the development of scientific literacy. Despite the difficulties, the analysis of a product in daily use led the pupils to inquire, promoting the development of a critical reasoning and creative thought. Students' questions stimulated their curiosity, thus encouraging their learning.
This module aroused students' curiosity for further projects. *"What if we select other products we see around us, for instance, natural gas?"*

From such a module we can study organic chemistry, chemical bonds, distillation, and so on. In this way our slogan becomes: *'Let´s take the students to chemistry and not the chemistry to the students*'.

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2.25 Do You Need Chemistry in order to Be a Good Bone Surgeon?" Using a PROFILES Module to Contextualize and Promote the Study of Introductory Electrochemistry

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PARSEL module: presentation and goals

A PARSEL module (2008), adapted for use by us in the PROFILES project, is designed to motivate students for the study of introductory electrochemistry – a chemistry field normally difficult for students (Burke et al., 1998). The module concerns a study of concepts of oxidation and reduction reactions, electrochemical series and reactivity of metals and is intended to promote pedagogical approaches through Inquiry-based Science Education (IBSE), a focus, albeit in a motivational way, of the PROFILES project (Branch & Oberg, 2004; PROFILES, 2010).

The new approaches through the module are:

- the application of new methodologies in the teaching of chemistry, such as the use of Information and Communications Technology (ICT), in particular, a computer simulation, before laboratory work;
- an IBSE methodology, arousing scientific curiosity both individually and in group, promoting interaction with scientific materials in order to independently seek evidence for the solution to scientific problems and recognising whether the area is chemistry or other sciences, thus promoting interdisciplinary.

Development stages: selecting and preparing the module

This began by interest in PROFILES, the available information (the official website and the adjustments made to the Portuguese site) and by consultation of existing materials. We then proceeded to the choice of module, constrained by the timing of its implementation in a programme already developed and its ready integration and/or adaptation into the curriculum.

Our personal choice derived from its immediate application after adaptation, plus inclusion of one of the issues where we felt it more difficult to attract students and an area where there were a large number of alternative conceptions yet an inability to organize the concepts in a logical manner.

The translation of the module was fast and the most time consuming phase turned out to be the choice of a motivating scenario that would attract students. The adaptation was chosen, based on a soccer player, well known worldwide (Ronaldo Lima, known as “the phenomenon”). The scenario proved to be an immediate success based on its easy recognition, its intrigue for the person and also students’ individual characteristics (not forgetting the social and vocational issues). The first "inquiry brainstorming" brought about numerous questions (around 20 different ones), with approximately the same number of questions, divided between biology/medicine and chemistry.

The application of the module was perhaps the easiest part and it was a surprise to see the collaborative activity of students in undertaking different initiatives. Careful guidance for carrying out the procedure for the activities (guided IBSE) ensured that this initial natural interest, ably supported by new technologies, did not slipped into dispersion. The freedom given, in the operation of the computer simulation, was very useful for all students to adjust the time spent on the different computer applications and the proposals for different activities (such as the macroscopic and microscopic analysis of the reactions of metals in different solutions). In response to questions asked in the student guide, it was found that almost all students resorted to the information contained in different parts of the application, mainly on the microscopic analysis. In the second session, students tried to answer the questions mentioned above, with the teacher having two roles: to present three more questions (which would complement the missing content) and guide the students’ review work, remembering experiences from the previous class, in a logical and coherent way (net gaining of concepts). As many issues within the area of Human Biology and Medicine were likely to arise, there was a need to use supplementary texts in order to clarify and help the students to work independently. At the end of the application of this module, it was useful to perform an experimental activity proposed in the official programme to seek further evidence to support the results already obtained and the accuracy/prediction of the same. This method responded well to learning expectations from the official programme and cemented the concepts preciously learned.

The sharing of these successes with colleagues from the project was very important; the feedback received and the encouragement to continue working, to improve it, was very motivational. This was further facilitated by making two presentations: the first referring to the initial stages of implementation of the module and the second, made during the final stages of implementation, on the main constraints, the resulting adjustments and complementary methodologies, such as summarizing a slide to create a methodology for IBSE, or an improvement to the initial scenario.

Reflections, concerns and evaluations

Reflection on the module focused on three distinct components:

(a) the initial part consisted of an analysis of the results obtained by the students and detection of bottlenecks in the implementation of the module;
(b) recognising where adaptations to the original draft could be made, so as to meet the students’ expectations and foster improvement in the emerging results;
(c) explanation of outcomes to the PROFILES group, with a presentation of the different stages of implementation of the module, the results obtained in the teaching of chemistry bearing in mind the constraints of the senses and improvements of this action-research methodology.

Summarising, the weaknesses of this methodology were found to be:

- too little information on scientific content (especially the content related to Biology);

- the short duration of the initial motivation by the students;
- the limited capability of students to handle autonomy in solving calculation problems;
- poor ability to reflect on the initial question, and even a huge gap between the main objective of using the module and the outcome derived from implementation of the module.

What stood out as positive was the intrinsic interest of the students by the initial scenario; their inter-collaboration at the different stages, the felt freedom to explore different techniques, the guiding of their actions by the issues raised, not only from the questionnaire proposed by the module, but also from the questions raised by the initial brainstorming, which were answered, selectively, after the application of the module.

Also important was the predictability of results in laboratory activity proposed in the curriculum, not only for the experimental results as in answers to questions before and after laboratory, which appeared in the report during the day of the experiment. It appears then that the constraints are clearly diminished in relation to positive opportunities, stressing the usefulness of reinforcement methodology in IBSE, which is one of the key project fulcrums of PROFILES.

Next perspectives' outlook

Suggested further development of this module is divided into three parts:

- The first phase of development requires an improvement in the implementation of the module by the students of the next school year. A suggested alternative for the scenario is to focus more on metallic structures and metal restoration/ conservation;
- Another aspect is undertaking the dissemination of the module to other teachers, thereby allowing the contribution of other colleagues, with possible adjustments to cope with new samples of students (as is the case with possible differences in the implementation of co-education and single-sex education in schools);
- The third stage (at the very heart of PROFILES), is the training of teachers thus promoting the sharing of knowledge, applications and reflections.

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2.26 The PROFILES Model – A Trans-disciplinary Integrated Approach Centred on Relevant Aspects of Daily Life

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Introduction

IBSE[7] has been considered as one of the most important approaches for improving science education in Europe (Rocard et al., 2007). In this respect, the PROFILES project promotes IBSE through raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students, supported by stakeholders (The PROFILES Project, 2011).

In Romania, the *PROFILES - Education through Sciences* training programme, as a specific part of the project, strives to meet the training needs of the Physics, Chemistry and Biology teachers, and thus to support students by promoting reflection oriented teaching and learning, with the aim to improve the scientific literacy and thus to achieve a relevant science education, appropriate for the 21st century.

From another perspective, IBSE is recommended also for implementing ITST[8], and within this context, teachers specialized in one of the science areas have the opportunity to become teachers of Science and Technology. They must take into considerations various teaching approaches such as multidisciplinary, interdisciplinary, or trans-disciplinary, and also different teaching strategies to include thematic subjects, educational ideas including learning projects and IBSE practice in an integrated curriculum (Drake, 1993; Coquidé et al., 2011).

[7] Inquiry-based science education
[8] Integrated teaching science and technology

Content

One important approach, mentioned above, is *trans-disciplinary*. This is of much interest to the approaches within PROFILES as it appeals to a general theme from different perspective of curricular areas, by trying to build learning to create a complete picture – the 'education through science' component stressed by the 'ES' in PROFILES. Trans-disciplinarity represents the types of activities which transfer the knowledge and skills from one curriculum area to another, seeking to achieve the objectives of all curricular areas in an integrated context. In this manner it recognises that the goals of education apply to all curriculum areas.

From the PROFILES perspective, the trans-disciplinary specific integrated approach is centred on real, relevant aspects of daily life, presented as they affect and influence our lives. In fact, through such a trans-disciplinary approach, students' integrative and sustainable competencies can be acquired in an intellectual, personal and social manner (Holbrook & Rannikmae, 2007). Trans-disciplinary teaching is, in fact, organized, throughout the educational process, on the gaining of intellectual, affective and psychomotor skills of the student rather than solely on the scientific content. Active methods of teaching, within the trans-disciplinary approach, transform students as learners, make them co-participants in their own education, and provide them with opportunities to develop both as individuals and as members of a team. The students are encouraged to learn by taking initiatives, having positive attitudes towards the discussed topics, making presentations in front of their colleagues, finding/retrieving/evaluating more and more information, and finally creating overviews of the studied subject.

It seems that students aged 11-14 year old, are the main beneficiaries of the trans-disciplinary learning, at a moment when they have not yet defined their future career. They become interested in many things, but also they gain the intellectual capacity to understand and integrate the information and to use their learning in new situations, with clear benefits for their lives.

The organization of the curriculum content in a trans-disciplinary or an 'education through science' way is based on the teaching, learning and assessing of the students' mental conduct, from the perspective of the effective integration, carried out with respect to all educational stages (design, development, evaluation). Trans-disciplinary themes help students to learn at their own pace and to be evaluated according to what they know, stimulating also the cooperation among them; it gives students the opportunity to create their own strategies to deal with various situations through active learning. In this respect, they become active participants and use strongly their imagination, inquiry and creativity.

From the constructivist perspective, the building of the students' knowledge is achieved by:

- direct involvement of the subject;
- search, retrieve and selection of relevant information;
- critical analysis of the information – from wherever it comes;
- reformulation, analysis and comparison;
- classification, evaluation and hypotheses formulation (for which evidence needs to be gained and subject to testing);
- experimentation, concluding and generalization;
- customization of the working methods;
- devising action strategies (problem solving, decision making) adapted to their self-training and personalities.

The IBSE methodology offers an internal flexibility that allows the student to balance the learning experience in different science disciplines, but also to integrate into this, technological, economic, political, environmental and social issues. In this respect, the *PROFILES - Education through Sciences* training programme raised the importance of implementing the IBSE approaches, with the declared aim to advance students' understanding of scientific concepts and enhancement of scientific literacy.

Reflection

In Romania, the first edition of the *PROFILES - Education through Sciences* CPD training programme has been carried out with 60 hours duration. 35 science teachers started the training sessions, with 32 finalizing the activities and implementing their new designed PROFILES modules in the classrooms. In the end, more than 1000 pupils were involved in the implementation process.

From analyzing the outcomes of the implementations – taking a *trans-disciplinary integrated approach* perspective, important facts and considerations emerge, presented here like a *SWOT analysis résumé*:

Strengths

- allows students to express themselves (valorizing at a maximum level the pedagogical value of the *trans-themes*);
- maximizes the possibility for each student to learn at his/her own pace and to be evaluated on performances;
- gives students the opportunity to fully manifest their capacity in the areas in which they are most capable;
- places the students in the centre of the action, enabling them a main active role in order to: imagine, build mentally, investigate, explore, create, put into practice, find means and resources to translate what they have prefigured;
- fosters cooperation and not competition;
- involves students in an authentic situation to solve a specific task, having a real purpose or meaning.

Weaknesses

- difficult communication within the group - in some cases (due to shyness, superficial understanding of specialized terms, lack of scientific knowledge);

- lack of similar experiences;
- improper use of some concepts;
- lack of a reflective debate.

Opportunities

- existence of EU funded programmes - in partnership together with local / regional / national / European educational actors;
- integration of new technologies in the actual education process;
- access to the specific information that increases the level of reflectivity and critical distance from the problems met by the actual society;

Threats

- emergence of a recorded motivation crisis due to the erosion of the traditional values system;
- increase of the social environment complexity (excessive administrative tasks for teachers) with clear effects on the reduction of teaching and research quality;
- continuity of the policy that sub-finance the educational system;
- unstable legislation.

Conclusion

As enhanced scientific literacy represents an important element that allows citizens to play an active role in the society, science teachers have the responsibility to promote, within students, the scientific knowledge and the related educational skills not only in order to understand the natural world, but also for reasoning, solving problems and taking decisions. In this respect, the trans-disciplinary approach proposed by implementing PROFILES modules, has proved to be an important step forward for developing students' scientific knowledge, their self-reflection, their socio-scientific awareness and above all, their ability to think critically.

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2.27 Considerations Related to the PROFILES Module: "What Are the Uses of Nuclear Power? How Does Nuclear Energy Affect our Environment?"

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Introduction

Science education involves knowledge acquisition on important scientific issues, as well as its content, research methods, applications and shortcomings. In this respect, it is essential to enhance students' scientific literacy by developing teaching strategies through which students can critically discuss contemporary scientific achievements and their implications.

However, scientific literacy characteristics are not taught directly, but are embedded in a lived curriculum, where students are engaged in solving problems, undertaking investigations, developing projects, or experimenting in dedicated laboratories (Hurd, 1998).

PROFILES promotes the professional development of teachers on four specific levels - *teacher as learner*, *teacher as effective teacher*, *teacher as reflective practitioner*, *teacher as leader* – (The PROFILES Project, 2011), so as to implement IBSE[9] and other approaches, with a view to advance students' understanding of scientific concepts, as a result of the PROFILES Continuous Professional Development programme. To facilitate this, a teaching module was designed and implemented called "*What are the Uses of Nuclear Power? How Does Nuclear Energy Affect our Environment?*"

Having IBSE as a main component, the specificity of the module is given by the use of the *Structured Academic Controversy* (*SAC*) *method*, a type of cooperative learning strategy in which - through a sequence of scaffolded steps - small teams of students learn about a controversial issue from multiple perspectives and increase their understanding of a community (shared) problem (Structured Academic Controversy, 2003; 2012). In this sense, students consider alternative perspectives and engage in a shared decision-making process.

Content

One objective of the module is to evaluate the uses of nuclear energy and to assess its impact on the environment in general, through a socio-scientific role playing and decision-making scenario, through which students conclude whether building a nuclear power plant near their town is beneficial for the community, or not.

In this respect, the process of investigation involves students in forming '*decision committees'*, each of them being composed of: physicist, doctor, biologist, historian, mayor. The committee is tasked with deciding on the advisability of building a nuclear power plant, taking into account the need for a considerable foreign investment.

Each student must edit a report related to the effects of the nuclear power plant on the environment, emphasizing advantages and disadvantages by answering specific questions:

- Doctor – How will the presence of the nuclear power plant influence the health of citizens? What are its effects in the long run on the population?
- Biologist – What is the impact of the use of nuclear energy on plants and animals? What criteria should be adopted to avoid a serious imbalance of the environment?
- Physician – What are the processes by which nuclear power is produced? In what way will all the necessary measures be taken for the safely operation of the power plant?
- Historian – What positive and negative consequences of the use of nuclear energy have been recorded?

[9] Inquiry-based science education

- Mayor – What would the existence of a power plant mean for the local community? What advantages and disadvantages would this include?

The designed activities for students involve:

- Analyzing recommended information related to the proposed questions;
- Retrieving specific information from indicated websites;
- Producing an individual report which contains the assumed decision and its justification;
- Group decision-taking in a specific session on whether to build or not to build the nuclear power plant near the city;
- Identifying the possible impact of nuclear energy on human health, the environment and on society, in general;
- Discussing on the right to work, to have a healthy environment, to start an economic activity, to live in a democratic society;
- Analyzing the pros and cons concerning the building of the nuclear power plant near the city;
- Analyzing the solutions given by certain countries for the same problem;
- Presenting the consensus class decision.

The decision is taken in the last lesson of the module, under the form of a deliberation. Each group representative accompanies the justification of decision by a final product (poster, collage, drawings).
At the end of the lesson, the students are asked to fill in an assessment form proposed by the teacher.

Reflection

The module activities – implemented at the eighth grade level[10] – made an important impact on students. In this sense, a series of strong points can be emphasized:

- using their real life perception and own life-experience as children/ teenagers (especially linked to their reading or movies);
- acquisition of necessary skills and capacities in their new quality: as active responsible citizens;
- maximizing the level of their involvement in the proposed scenario;
- being eager to express their own opinions related to civic issues and to present their findings within group and to the whole class;
- being capable of gaining a deeper understanding of the current socio-scientific issues;
- good communication between teacher and students.

But beyond the gains, it is important to mention that several students communicated with difficulty inside their groups (shyness, lack of scientific knowledge, superficial approach for some proposed problems). An explanation could reside in the fact that the presented concepts seem to be difficult to be understood by students aged between 14-15 years old.
However, students' feedback was positive and encouraging. They expressed a higher interest in the activities and stated clearly that they enjoyed the proposed way of conducting the lessons. Here are some remarks related to their feedback:

- Real and actual issues have been discussed;
- They had the opportunity to work in groups and better know their colleges;
- They were able to express their own opinion on certain issues;
- They had the possibility to communicate without fear with their colleagues, and also with their teacher;
- They were able to argument their own opinions, as well as listening patiently to others;

[10] The Romanian curricula for 8th grade (Physics, Chemistry, Biology, Maths & Civical Education) provides enough information to students and thus enables them to fulfill the challenging tasks this module demands.

- They voted on the final decision, within their own group;
- They have compiled documents themselves and found out things that otherwise they would not be expected to know.

On the other hand, the proposed approach offers clear advantages:

- increased students' interest in civic issues as well as principles of democracy;
- drew on theory and related documentation which could be accessed from manuals;
- identified ways to express an idea and justify a point of view;
- empowered the students to work in groups;
- developed students' socio-scientific skills, abilities and knowledge;
- stimulated students' interest and self-confidence to deepen their understanding of the current social issues.

Conclusion

The proposed module has sought to develop the knowledge, skills and attitudes of the students involved in the process of taking a decision whether building a nuclear power plant near their town is beneficial or not for the community. They were asked to effectively participate in the discussions, through direct exchanging of ideas and experience, having – in this sense – a clear picture of the *democracy in action*. All the lessons' objectives were achieved, first from the scientific point of view, and second, from the social perspective, contributing to the formation of young people as unique individuals, able to discern and to take responsible decisions.

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2.28 Slovenian Reflection on the First Year of the PROFILES Project

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Introduction

The PROFILES project is a four-year Framework Program 7 (FP7) project funded by the European Commission. The PROFILES project promotes IBSE (Inquiry-based Science Education) through raising science teachers' self-efficacy and promoting a better understanding of changes advocated in teaching science in schools and the value of stakeholder networking. Initially, PROFILES involved the development of teachers on three fronts – teacher as learner, as teacher and as reflective practitioner and eventually, in a fourth front, teacher as leader (Hofstein & Mamlok-Naaman, 2012) – consolidating their ownership of the context-led approach and incorporating use-inspired research, evaluative methods and teacher networking. The PROFILES project focuses on students' motivation for science learning, both in terms of intrinsic motivation (relevance, meaningfulness, as assessed by the students) and extrinsic motivation (teacher encouragement and reinforcement) and attempts to make school science education more meaningful (Devetak et al., 2011; Bolte et al., 2011; Bolte & Holbrook, 2012).

After the first year of PROFILES experience, we can conclude that, among Slovenian science teachers involved in the project, the IBSE approach has been well accepted; teachers report that it presents a positive challenge for them as well as for the students. However, there are also some shortcomings detected, which must be reflected on and elaborated before the second year PROFILES round implementation.

Goals

The main purpose of the presentation is to illustrate the Slovenian PROFILES project and to evaluate and reflect on the project's outcomes in the first year.

Content

In the 2011/12 school year, 41 teachers (35 from primary school and 6 from secondary school) were invited to participate in the project in the first round. The national PROFILES group organised a Professional Development Programme that was designed to meet the criteria of the PROFILES philosophy (Bolte & Holbrook, 2012; Hofstein & Mamlok-Naaman, 2012); all of the national material for this course is available in Slovenian on the national project's website (e.g., Presentation of the PROFILES Project; Inquiry-based Science Education – What is the Meaning?; PARSEL Modules; PROFILES Modules; Science Literacy and Pseudoscience; Portfolio and Evaluation of the PROFILES Method; Action Research – An Important Factor in Teacher's Professional Development; Motivation for Science Learning, etc). The materials have been developed according to the data provided by the teachers in the Needs for Professional Development Questionnaire, implemented online at the beginning of the 2011/12 school year.

Teachers formed groups according to the level of education (primary and secondary) and according to the subjects they teach (biology, chemistry or physics). A consultant (a member of the national PROFILES team) was assigned to each group of teachers and each group selected its leading teacher. Each consultant was in constant contact with the leading teacher, who then disseminated important information to the other teachers in the group. Each teacher also had to recruit at least one teacher for the second round of professional development in the 2012/13 school year, or to provide us with at least three e-mail addresses of potential teachers for that round.

In the first round, we invited teachers to six face-to-face seminars, and, in the periods between meetings, consultants were in constant contact with the group leader via e-mail (in one group a Moodle environment was created for easier communication).

With the consultants' support, the teachers in each group developed three PROFILES modules according to the PROFILES philosophy (Rannikmae & Holbrook, 2012), with elements of GALC science learning (Devetak et al., 2011; Kolbl & Devetak, 2012) and meeting the aims of the specific national curriculum. In all groups of teachers, two or three modules (3-6 school lessons each) were applied in the school environment. The MoLE questionnaire (Bolte & Streller, 2011) was used at the beginning and end of each module application. Data from these questionnaires were electronically gathered to evaluate students' attitudes and level of motivation for learning science, and paper-pencil pre-knowledge and post-knowledge tests were used to evaluate student knowledge achievements.

Reflection

The main tool for following professional development and reflection on PROFILES application in the school environment is the teacher's portfolio (Juriševič et al., 2011), 35 of which have already been submitted by teachers, with the remaining 6 expected by the end of August. In their portfolios, teachers expressed their views and concerns, as well as their positive experiences with the development and application of the modules. The portfolio serves two purposes:

1. procedural, in order to develop the science teachers' reflection, encourage their professional development and their self-concept, as well as to improve the quality of learning and teaching, and
2. evaluative, thus being a tool for science teachers to present their pedagogical competences and knowledge of the new professional experiences related to the project goals through the process of action research, following the main principles of the PROFILES approach.

From follow-up monitoring and partial evaluation of the portfolios, we can conclude that the portfolio played a vital role in the first year of the project and performed its function relatively well, despite being their first experience with portfolios for most of the teachers. Besides several identified benefits (e.g., enhancement of the reflective teaching approach, sensitivity to students' learning needs and motivation, increase in the use of meta-cognitive strategies), we also observed some problems (e.g., difficulties expressed directly by the teachers with regard to time management, thinking effort and professional self-concept). On the other hand, certain issues were perceived that arise implicitly from the performed evaluation – teachers involved in the project had a very different knowledge of research theory and the psychology of learning and teaching. Nevertheless, on the basis of our first-year PROFILES experience with the portfolio, it should be emphasized that the teachers did care about the quality of the teaching process, although they should not be left unsupported.

Teachers expressed some concerns regarding the application of questionnaires and knowledge tests, as well as about data gathering, data analysis and the presentation of results. They also lacked experience in developing educational materials (PROFILES modules) following socio-scientific issues, IBSE and decision-making problem-solving. Teachers expressed their views and concerns, as well as their positive experiences with the development of modules and their application in schools. Their main concerns were that they had to do extra work to develop the modules and knowledge tests, to analyse the data from knowledge tests and to prepare the portfolio. They pointed out that some of them had to spend 30% of all of the lessons per school year per class on implementing the PROFILES modules, and that there is no payment provided for their participation and for making copies of the modules, knowledge tests and questionnaires. We managed to reduce school costs by applying the MoLE questionnaire online.

Outlook

Experiences from the first year of the PROFILES project will be used in the second round of the project. Teachers involved in the second round will develop their own modules or adapt the modules developed in the first round. They will implement the modules differently than in the first round, where students were learning cooperatively in groups of four. In the second round, teachers will be free to use the PROFILES modules as in the first round, or to adapt them as additional material for their teaching. Some teachers from the first round will join the second round and assist members of the national PROFILES group in the professional development programme in the second round.

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2.29 Experiences of a Group of Slovenian Teachers in the Development and Implementation of PROFILES Modules

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Introduction

Numerous activities, based on the PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) philosophy, are currently being implemented in Slovenia (PROFILES in Slovenia, 2010). The present article focuses solely on the experiences of one group of Slovenian chemistry teachers (the authors) from the viewpoint of their pupils' gain in their chemistry class.

PROFILES is one of several European FP7-funded projects in the field of "Science in Society" and aims, in a unique way, to promote IBSE through raising the self-efficacy of science teachers to take ownership of more motivational, student-relevant ways of teaching, while supportive of stakeholders' views.

The PROFILES project is based on 'teacher partnerships', implementing existing, exemplary, context-led, IBSE-focused, science teaching materials, guided by long-term teacher professional development (CPD). The CPD focused on meeting challenges identified by participating teachers, in order to raise their skills in developing creative, scientific problem-solving and socio-scientific related learning environments. These learning environments embrace students' intrinsic motivation to learn education through science and enhance competencies in undertaking scientific inquiry and socio-scientific decision-making. Measures of success are determined by

(a) the self-efficacy of science teachers in implementing the PROFILES approach, and
(b) the attitudinal gains by students towards learning science (PROFILES Consortium, 2010; Bolte et al., 2011).

PROFILES evaluation focuses on students' cognitive and affective learning, as well as on the teaching methods, approaches and materials used within PROFILES intervention lessons. By means of PROFILES evaluation, the intention is to indicate where improvement is justified and where additional efforts are necessary to improve IBSE in order to meet stakeholder wishes, as well as teacher and student needs (Bolte et al., 2011).

One approach to PROFILES project evaluation is designed as a pre-post-intervention-and-control-group study. Before the start of the intervention phase of the CPD, data is collected from the participating teachers' classes (pre-test; intervention group) and from classes of teachers who are not participating in the PROFILES CPD programme (control group). At the end of the school term, both groups are retested with the same instruments (post-test; in the intervention group and the control group classes) (Bolte, 2006; Streller, 2009; Bolte & Streller, 2011).


PROFILES učno gradivo, navodila za učitelje
Oblikovali so ga člani projektne skupine PROFILES Univerze v Ljubljani

SE SEGREJE ALI OHLADI?

Modul za poučevanja KEMIJE – 8. RAZRED

Pripravile: Barbara Šket, Polona Petrica Ponikvar, Nataša Podgorec Intihar, Dominika Mesojed, Suzana Klopčič (2011)
Inštitucija: Univerza v Ljubljani, Pedagoška fakulteta, Kardeljeva pl. 16, Ljubljana
Konzulent: Vesna Ferk Savec, UL-PROFILES projektna skupina (2011) na osnovi priporočil PROFILES konzorcija – www.profiles-projects.eu

Figure 1. Front page of Module 1: "*Will it Cool Down or Heat Up?*"

Goals

Within the framework of the PROFILES project, a group of four chemistry teachers, in collaboration with the PROFILES team at the University of Ljubljana, developed three PROFILES modules (from October 2011 to July 2012). The modules covered the following topics within the National Curriculum: "Will it Cool Down or Heat Up?" (topic: Chemical Reactions), "Indicators - Chemical Detectives" (topic: Acids, Bases and Salts) and "Who Wins in the Chemical Laboratory?" (topic: Acids, Bases and Salts). The first two modules have been implemented in school practice as a pre-post-intervention-and-control-group study.

The following research questions were posed:

1. Will pupils attain better achievements in chemistry by learning with the use of PROFILES modules in comparison to the traditional teaching approach?
2. By learning with the use of PROFILES modules in comparison to the traditional teaching approach, how do pupils' achievements in chemistry change as they get more experience with the PROFILES approach?

Sample

Participating in PROFILES were 171 8th grade Slovenian primary school pupils (13-14 years). The pupils' success through the modules was monitored using a pre-test and post-test protocol with control groups (traditional teaching approach) and intervention groups (learning using PROFILES modules), whereby 88 pupils participated in the control group and 85 in the intervention group.

Content

The following modules were developed and tested in school practice so far:

***Module 1* – Will it Cool Down or Heat Up?**

Topic: Chemical Reactions of the National Curriculum.

Duration: 4 lessons (2 lessons experimental work, 2 lessons pupils' work with sources and educational materials).

Module 2 – Indicators – Chemical Detectives

Topic: Acids, Bases and Salts of the National Curriculum.

Duration: 4 lessons (2 lessons experimental work, 2 lessons pupils' work with sources and educational materials).

Research results

Research results are presented with regard to the posed research questions.

1st research question: Will pupils attain better achievements in chemistry by learning with the use of PROFILES modules in comparison to the traditional teaching approach?

After Module 1, there was no significant difference in scores for the control group (M = 14.20, SD = 4.87) and the intervention group (M = 15.54, SD = 4.88); t (171) = 1.803, $p > 0.005$. However, after Module 2, a significant difference in scores was observed between the control group (M = 11.05, SD = 3.67) and the intervention group (M = 13.68, SD = 4.05); t (168) = 4.448, $p < 0.005$.

2nd research question: By learning with the use of PROFILES modules in comparison to the traditional teaching approach, how do pupils'

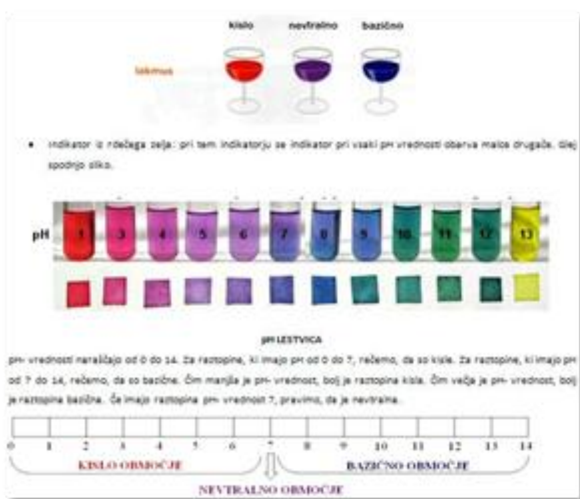

Figure 2. Section from Module 2: "*Indicators – Chemical Detectives*"

achievements in chemistry change as they get more experience with the PROFILES approach?

The results (presented in the 1st research question) indicate that pupils needed some time to get used to the PROFILES approach, which then – in the 2nd module – contributed to their better achievements in chemistry.

Reflection

Preliminary results indicate that there were significant differences in achievements in chemistry between the control and intervention groups of pupils after the completion of Module 2, whereas significant differences were not observed after Module 1. The results indicate that the pupils needed some time to adjust to the PROFILES approach, which then eventually contributed to their better achievements in chemistry. However, most probably the pupils' better achievements were also due to the teachers' adaption to the PROFILES approach, as has been reported in their reflections.

Outlook

Due to time constraints at the end of the 2011/12 school year, teachers will only be able to implement the 3rd module with the same group of pupils in September 2012. It will be interesting to see whether the trend of improvement in the pupils' achievements from the 1st to the 2nd Module continues in the 3rd Module and to get final results about correlations with MOLE questionnaire.

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2.30 Extending Inquiry-based Science Education to Teacher Training through the PROFILES Project: An Experience

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Introduction

The novel experience of applying PARSEL-type teaching-learning materials with students of the Degree in Teacher Training (Primary Education, grades 1-8) of the School of Education at the University of Valladolid (Spain) is presented here. In particular, a module developed by Galvão et al. (2006), involving an analysis of newspaper/magazine news about socio-scientific issues was conducted in the context of the compulsory subject "Curricular development of Experimental Sciences", and in particular, in a part devoted to Science, Technology, and Society (STS). The use of such modules allowed us to follow an inquiry-based strategy in science education under the PROFILES project.

The convenience of approaching science education from an inquiry-based strategy has been underlined by several studies (National Research Council, 2000), which adduce that both the level of interest (intrinsic motivation) and the achievements of students are enhanced, as well as teachers' motivation (Holbrook et al., 2008; Ainley et al., 2011). Moreover, some authors consider that such shift must be extended to University teachers in charge of training future teachers:

> It does not make any sense to recommend, insistently to primary and secondary teachers, to introduce orientations based on inquiry and to allow the University to continue practicing the chalk and talk with the future teachers (Vilches & Gil-Perez, 2007).

Objectives of the Module

The module "*Analysis of Newspaper and magazine news about socio-scientific issues*" (Galvão et al., 2006) is based on the spread of publications dealing with science and technology to facilitate student comprehension of the tensions occurring between science, technology, society and the environment, and to treat socio-environmental conflicts in class.

The inquiry-based strategy promoted by this module constitutes the central axis of the European project. PROFILES, which aims at raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students. Importantly, PROFILES seeks to meaningfully raise teacher skills in developing creative, scientific problem-solving and socio-scientific decision-making abilities in students.

Overview of the Module

The implementation of the module consisted of gathering news related to science, technology, society, and the environment by the professor, who afterwards handed them to students. News was selected in such a way that a variety of topics were treated, and that specific substantive knowledge on science and technology was developed, together with content relating it to the society and the environment. Students worked in small groups consisting in 2 or 3 people and read, discussed, and reflected around one aspect in the news, to finally expose and discuss its basic content and their reflection on the news to the rest of their classmates. Moreover, the professor took advantage of the substantive knowledge raised by ever newspaper/magazine to review or further develop content included in the curricula of the subject, "Curricular development of Experimental Sciences".

The module was designed for the students to improve the following competences:

1. development of substantive knowledge,
2. development of epistemological knowledge,
3. development of reasoning competences,
4. development of communication competences, and

5. construction of a reflexive and critical attitude in relation to the ethic and moral consequences of the scientific and technological development.

In advance, students were given the criteria that would be later used to assess their performance in such competences, which included: correct use of the concept, STS-E relations, comprehension, information selection, critical analysis, conclusion quality, and presentation and discussion of the conclusions.

The application of the module "Analysis of newspaper/magazine news about socio-scientific issues" was satisfactory, since it allowed the development of the above-mentioned competences, and moreover promoted a very "natural" revision or extension of curricular content. Notably, the construction of a reflexive and critical attitude in relation to the ethic and moral consequences of the scientific and technological development was the competence worst evaluated overall. This fact supports the need for developing activities in which this competence is promoted also in University students.

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2.31 Adaptation of Teaching Modules, under PROFILES, as a Tool for Initial Teacher Training

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Introduction

While it is true that the application of PARSEL-type (Bolte et al., 2009) modules is designed primarily for students at secondary school level, the method based on inquiry science learning makes them potential tools for use in other educational areas (Bolte et al., 2011). In this way they have the potential to generate new and innovative learning processes at all educational levels under the PROFILES project.

Because of the need and importance of quality training, one of the areas that can benefit from the use of these modules is higher education. Since these activities have great training power, the preparation of future teachers is, specifically, an ideal area for using PROFILES modules (Kenny, 2010).

Therefore, this paper is a pilot for possible future applications. This study is framed in the activities developed during the teaching practices for the Degree of Elementary Teacher Education, along with traditional practices.

Description and development

The module chosen to use in the classroom was "Can Lake Water Be Made Save?" It claimed that from the beginning, students had cleared both, the objective and the basic concepts that were to be treated.

Because the students that addressed the activity were college students, times were shortened and the whole activity was performed during 2 hours. This started with 4 groups of about 20 students, working pairs so as to optimize the available materials. In addition, and because of the lack of some resources, forced changes were introduced. For example, additionally, boiling water was also suggested to students as a way to purify. The activity was undertaken, maintaining the objective of the module and stressing the importance of using inquiry-based teaching-learning strategies.

Subsequently, the corresponding evaluation of the results was obtained through examining students' books recording the practical activities, in as much as they reflected student learning.

Discussion

The ultimate objective was not only practical development through using an inquiry teaching method, thus giving evidence of its effectiveness beyond learning in secondary education in Spain, for which the modules were initially designed. On the contrary, our intention was to use this activity to introduce to students who are preparing to become teachers, so as to give them tools for future educational innovations in the classroom, while hoping that in future they can develop activities with their students to follow an inquiry-based learning approach.

Along with enhancing learning of concepts like water pollution, purification of water, microorganisms and environmental conservation, and apart from encouraging the use of new technologies and critical thinking of students (Skamp, 1989), the modules gave an opportunity for the students to reflect on pedagogical aspects related to the teacher as teacher in the classroom situation and the role of the teacher in stimulating a motivational learning environment that promotes 'education through science.'

Finally, another important aspect that was intended to be achieved is the approach which future teachers can use in the laboratory, because of the limited background from lack of handling their own investigations and realising collaborative working as a team, presentations of their work and opportunities to reflect on standards obtained (McIntyre et al., 1996).

From reflections on the adaptation of PARSEL modules, and even more so, the design of more specific modules for use in the frame of a European Higher Education Area. PROFILES has the potential to offer real innovation for the training of students, not solely directly related to scientific topics.

To determine the impact of PROFILES on the motivation of students during the invention programme, the MoLE questionnaire was administered to students. The MoLE questionnaires, in its different versions (such as the REAL-Version to assess the students perceptions in general and the IDEAL-Version to analyze the students expectations how they wish their science lessons should be), allowed evaluate of their perception of the specific contents involved in this part of the biology science.

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2.32 Improving Teaching and Learning of Science: A Spanish Delphi Study within PROFILES

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Introduction

Many authors agree on the importance of improving and enhancing science literacy in society in general and more particularly for high school students. However, it is difficult to disentangle those aspects which fail in educational practice and components considered as good cultural science education. So the question arises - what are the main reasons why students wish to pursue deeper studies in science subjects in high school? And are these considered a matter of highest priority over others in the development of the teaching-learning process? PISA tests (Program for International Student Assessment) examined the performance of students in key subject areas and also studied a wide range of educational outcomes, among which were: the students' motivation to learn, conceptions they have about themselves and their learning strategies (Fensham, 2009). This report highlights the poor performance of Spanish students in science, and it seems that there is reason to believe that these are factors that influence the learning of science (Bybee et al., 2009).

Under this scenario arises the FP7, European project PROFILES. This is a cooperative network project consists of 21 institutions from 19 countries, including the University of Valladolid, Spain. This project, among other objectives, seeks to get to determine what aspects would be most relevant and desirable for the formation of the individual (Smith & Simpson, 1995) in the current and future society, in the field of science education. This analysis is carried out through a Delphi study (Bolte, 2008; Osborne et al., 2003).

Methodology

The methodology used in this study is a survey undertaken in various stages with a sample of stakeholders through the Delphi technique. Therefore, the use of this technique for studies in educational research will be useful and novel (Osborne et al., 2003).

The first step in the study was an analysis-diagnosis, to disclose, within the teaching of the sciences, which aspects might be most relevant. The collection of data for research was conducted via a questionnaire to the various stakeholders: students, high school teachers, university faculty and teacher educators, scientists and researchers and educational policy makers. In the first round, open questions about general aspects were presented to participants. The most valued set of items provided a second survey to establish what would be of interest at the practical level, and in a more theoretical level or priority, defined as those concepts that are relevant for the individual to develop competencies and skills in today's society. The 2nd round questionnaires were structured based on several categories, each one with a list of related items. In the second round answers to, the question: 'why is it important to study / teach science?' were solicited. Answers focused on motivation. The second category corresponds to concepts that should be taught and learned, while the third category was made up of items related to the different scientific fields. The fourth category looked for required abilities and skills that the student should achieve in order to get a scientific culture, allowing them to participate in a highly scientific and technological society. And finally, strategies were asked which would be most appropriate for teaching and learning in science.

Results of the Delphi Study in Spain

For motivation (first category) in the study of science, the greatest interest was in the overall individual intellectual development by all groups of stakeholders consulted. With respect to concepts (second category), energy and the environment were very generally referred to by teachers as well as scientists. In the scientific fields (third category) teachers of both groups highlighted human biology and earth sciences. Furthermore, the skills (fourth category) most valued by students and teachers were critical thinking, reasoning and the ability to analyze and draw conclusions, along with comprehension. In terms of teaching and learning strategies (fifth category), science inquiry-based learning was highlighted the most by the group of scientists

Conclusions

In most cases, the categories were consistent with those established in previous Delphi studies for science education (Bolte, 2008). These refer to the guidelines and teaching of aspects of modern science, as authors have pointed out in the teaching literature (Bybee et al., 2009; Fensham, 2009). In view of the results, the Delphi study is presented as a good tool for learning about key aspects that may be improved in science education. The Delphi process allows individual responders a considerable degree of freedom in the expression of views on a topic, often offering researchers an opportunity to explore their consciousness. The Delphi technique is an interesting approach halfway between a qualitative and quantitative methodology.

Prospects

The main difficulty for undertaking the study was to find, students, teachers, faculty and policy makers willing to answer the questionnaires, because of its length.

View of Science Teachers

The rigidity of the Spanish curriculum in secondary schools complicates the task of teaching. Some science teachers expresses very similar opinions: for example, on the importance of teachers being flexible and dynamic professionals in order to meet the new generations of young people who go through the system in the context of a school that assimilates the changing circumstances in a slow, but progressive way. This means they valued teachers being prepared for their teaching duties and facing the challenges of today's society. Although teacher training is conceived as an indispensable requirement, concrete progress in lifelong learning has been scarce. Assured of competences that will be required over their careers, teachers can increase their self-esteem and restore their professional identity. Similarly, improving their knowledge and skills to address the difficulties of learning can reduce the failure and neglect of students.

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2.33 Designing an IBSE Module: A Task for Pre-service Teacher Training

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Introduction

Several studies have shown the convenience of approaching science teaching from an inquiry-based method, because it increases students´ interest and attainment levels and stimulates motivation for both students and teachers (National Academy of Sciences 1996). This change in science teaching, from mainly deductive to inquiry-based, inductive methods, applies directly to teachers, key players in the science teaching process. A teacher's abilities, self-efficacy and ownership in the implementation of new methods of teaching and their motivation and collaborative reflection with other teachers are essential elements for the success of any scientific education renewal (Rocard et al., 2007).

Vilches and Gil (2007) consider that change in teaching training must be extended to University teachers in order to train future teachers:
"It does not make any sense to recommend consistently to primary and secondary teachers to introduce orientations, based on inquiry and to allow the University to continue practicing the chalk and talk in the preparation of future teachers."

In this work, we present an experience carried out with the Master of Secondary Teacher Education students, future secondary teachers, in the subject of Didactic of Chemistry and Physics. This pre-service teacher training course gives knowledge on the principles of PROFILES and the PARSEL modules and finally, as a personal task, students design a module following the three stages model. To assess student achievement, a questionnaire is used (Padilla et al., 2012).

Objectives of the IBSE Module

PROFILES promotes IBSE[11] through raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students, supported by stakeholders. The proposal innovation is through working with 'teacher partnerships' to implement existing, exemplary context-led, IBSE focussed, science teaching materials, enhanced by inspired, teacher relevant, training and intervention programmes. This is undertaken by reflection, interactions and seeking to meaningfully raise teacher skills in developing creative, scientific problem-solving and socio-scientific decision-making abilities in students. The measures of success are through:

(a) determining the self-efficacy of science teachers in developing self-satisfying science teaching methods, and
(b) in the attitudes of students toward this more student-involved approach.

The project focuses on "open inquiry approaches" as a major teaching target and pays much attention to both intrinsic and extrinsic motivation of students in the learning of science. The intended outcome is school science teaching becoming more meaningful, related to 21st century science and incorporating interdisciplinary socio-scientific issues and IBSE-related teaching, taking particular note of gender factors.

Overview of the Module

In this work, we present a new module, developed by the Master of Secondary Teacher Education students in support of the PROFILES Spanish group, entitled *"Will our coastal areas be submerged because of Global Warming?"* Pre-service teachers were asked to plan an investigation in order to identify the main reasons of the Global warming. The competences involved were identified as: investigative skills, manipulative skills, cooperative-working skills,

[11] Inquiry-based science education

conceptual understanding, theoretical development and application, experimental-error analysis, and communication skills. The curriculum content is related to Chemistry, and in particular to the study of the water properties in the solid state, density, hydrogen bonding, and others. The module follows the PROFILES three-stage model. This module begins with a scenario (Stage 1), where the teacher describes in a few words global warming and presents to the students the problem: What is the probability of losing our coastline if the sea level increases? In Stage 2, students have to resolve a proposed inquiry-based problem by utilizing a problem-solving activity. This activity consists of searching pertinent information that supports student's knowledge and implementing an experimental plan, in order to know more about the water-ice mix properties. Lastly, at Stage 3 (socio-scientific decision making, Fortus et al., 2005), students relate data collected from their search and investigation (observations in the lab and several calculations) in order to give an informed opinion to the initial question posed (Bond-Robinson, 2005).

The training course positively influenced the teachers' competence and confidence to promote IBSE-related science teaching and hence raised their self-efficacy to teach in an innovative – more student centred, context-led IBSE manner, as well as in valuing use-inspired research ideas. Within this intended outcome, and by means of the training/ intervention, linked to stakeholder support, a key target was to convince teachers that the methods they have studied and tried in the pre-service training course can and will strongly improve the quality of their own science teaching (Michelsen & Lindner, 2007). Furthermore, teachers who participated in the training programme course appreciated the need to convince other teachers to interact and seek support (e.g. colleagues in their schools, or from 'nearby schools') by disseminating their new experiences and the PROFILES IBSE-modules through informal and/or formal teacher forums. This can both be through activities organized by the PROFILES consortium partners, or follow-up to the longitudinal training programmes at a national and Europe-wide level (Bolte et al., 2009; 2011).

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2.34 Biodiversity and Education

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Value Discussion

Can we protect the diversity of habitats and species by means of legal regulations? Do we want to make sacrifices voluntarily in order to grant the possibility of survival for other species? Are invasive species threatening or enriching the native diversity of species? Each of these questions is part of a value discussion. But in order for this discussion to make sense, the parties involved need to know about specific circumstances and the arguments for or against the matter in discussion. Information and know-how are essential.

It is interesting for students to realize how biodiversity functions in the background. Inconspicuous grass growing on an erosion edge reducing erosion damage or a rather unprofitable rice variety reducing the need for fungicides and increasing the harvest if skillfully planted in a mixed cultivation are topics that spark the students' interest and help them form their own opinions.

If teachers take the opportunity to not only study species, sharing a habitat in the classroom, but also explore and document them in the course of excursions, this becomes possible.

These ideas are taken on board by the PROFILES project. The project recognizes the need to stimulate students' motivation for the study of science in school and what better way than to interrelate the science learning with the familiar everyday surroundings of the students. In PROIFLES, this is promoted through an initial scenario, which is intended to stimulate students to become involved in the inquiry-based science learning that stems from the scenario, through asking and seeking solutions to scientific questions.

Concrete Examples in Practice

The following examples have been tested in the classroom and have proven valuable at various levels of education.

Sweet Herbs

Students begin taking an interest in botany and the diversity of flora when they establish a personal relationship with them. This becomes possible when adolescents find out which substances are hidden within various herbs and shrubs. It is beneficial that one can get to these substances easily and that it is possible to make cosmetics, tea and ointments oneself. Cough syrup can be made from the brew of ribwort leaves, a perfume from the steam distilled essential oil of lavender and it is possible to make many ointments and oils for medical complaints.

Picture 1. Sweet herbs produce

Picture 2. Looking for invertebrates to assess the health of a river

Picture 3. Provided with tools for maintaining a nature reserve

Bioindication

Discovering species' adaptability (increasing knowledge), conducting investigations as a team (communication) and being able to comment on the health of a river (evaluation), already cover many of a biology education's main objectives.

Outdoor Missions

Students are eager to roll up their sleeves when they learn of incidents where Mother Earth is in danger. "What can we do about it?" is often their first reaction and it shows their need to become active in these matters.

When it comes to global issues, their wish cannot be granted directly. Locally, however, things can be done. Local environmental organizations must have projects in which the cooperation of a group of students is welcome. This local commitment automatically raises awareness of global issues.

Learning Environments outside the School

Excursions offer various possibilities to get firsthand experience and to become aware of the diversity of species and their habitats. The possibilities are numerous: the farm close-by which still fosters high trunk trees and thus provides the habitat for many organisms or serves wildlife conservation by having ecological buffer areas; visiting a zoological garden, a museum or a botanical garden which are all proof of national and international efforts to preserve biodiversity.

Discussion

Biodiversity is the variety of life which can be described at different levels: the diversity of eco-systems, species and genes. What all aforementioned examples have in common is that they raise awareness of functional biodiversity (the variety of interrelations within and between the three levels). An awareness that helps to identify connections, to develop arguments for the discussion mentioned above, to process information and gain know-how. For, *"education is all that's left once we have forgotten everything we learned at school."* (Werner Heisenberg)

Picture 4. Learning outside the school: the zoo

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2.35 Bionics – Teaching Ideas for Different Levels of Education

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Introduction

Creativity is seen as an important learning area within school science. This applies both to the students and the teacher. Many bionic ideas can be used to stimulate creative teaching which, if used as a stimulating scenario can have a strong motivational affect on students – a key component of the PROFILES project. These same ideas can be used to stimulate creative thinking by students and in initiating scientific investigations, once students begin to ask the appropriate scientific questions.

Classic Examples

There are many fascinating examples from bionic research and some of those have already entered the curriculum: the versatile Velcro strip which was copied from the seed dispersal mechanism of burs (Arctium lappa); the riblet foil which is attached to airbuses to decrease fuel consumption, or to the swimsuits of athletes (both are products inspired by sharkskin, or, more specifically, by the transverse grooves of the shark scales); the washer drum (built according to honeycombs); the lotus blossom with its self-cleaning surface; or the bulbous bow of seagoing vessels which decreases wave drag up to 10 percent. These examples surprise students and encourage them to dig deeper. They are reason enough to engage in nature-oriented learning and rediscovering, according to Hill (2003), in the framework of science education.

Picture 1. Washed up bladder wracks

In this paper, examples of teaching are presented which contain bionic aspects. They range from sequences, for easy imitation to long-term projects and to independently formulated, inquiry-based investigations, which can result from the students' curiosity.

Concrete Examples for Implementation

The Art of Folding

Using a sheet of paper, the folding of the wings of certain insects or the artfully folded petals in a plant's bud can be rediscovered. An impressive example of such an implementation is the solar sail for a space station by the physician Miuro, which unfolds easily after a pull.

Folding Profiles

The folding structure of the fan palm is also highly impressive. The aim is to guarantee maximum stability with minimum effort. The folding provides high carrying and bearing capacity. This aspect is used in many technical implementations, for example in corrugated roofs. Students can reconstruct and understand this in an experiment by comparing bridges made using a 'folded' and non-folded sheet of paper and loading each with weights.

PET Bottle Raft

The inflated structures of the bladder wracks (eg. Fucus vesiculosus) give the organism considerable uplift in the ocean. In the course of the project "Lernen am Projekt" ("Learning from a project") four 9th grade students collected the material necessary to build a PET bottle raft.

Picture 2. PET Bottle Raft

Picture 3. Polystyrene model of the newly combined flying object

The uplift of the 300 bottles, which were screwed onto a board, made it possible for the person to cross a river without getting wet. Directly experiencing the uplift created awe and curiosity among the students. They were especially fascinated by the fact that only one third of the PET bottle raft sank into the water. Understanding the physical processes became important for them and they voluntarily made it the topic of a discussion.

Hot-air Balloon

Once broken off from the stem, the petals of the dandelion (Taraxacum officinalis) can travel long distances.

A hot-air balloon built from soft tissue can make it possible to feel the lightness of flying. When experimentally implementing the lightweight construction, it is easy to motivate the students to find solutions by themselves: either when planning the pattern of the two-dimensional soft tissue which has to be shaped into a ball, or when designing the heat source and discussing the ideal moment of launching the flying object.

Energy-efficient flying

For his school leaving exam, Oliver Heinimann constructed a flying object from polystyrene which was based on the shapes of the Zanonia seed (Zanonia macrocarpa), a swordfish (Xiphias gladius) and a penguin (e.g. Pygoscelis papua). The friction factor of his construction, which was measured in a wind tunnel, was impressive.

Discussion

Understanding the classic examples previously mentioned, rediscovering and reinventing different structures, principals and laws of nature helps to find further solutions for technical problems. This approach to nature sparks the students' interest concerning the beauty, functionality and efficiency of biological structures.

Through this activity-orientated, experimental approach it becomes possible to encourage creativity based on previously raised scientific questions, pique students' curiosity, help them acquire knowledge through seeking evidence based solutions to their problems and develop a sense for interdisciplinary problems or issues and their solutions.

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2.36 PROFILES Continuous Professional Development Workshops in Turkey

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Continuous professional development (CPD) is a crucial component of the PROFILES project. By means of teacher development, PROFILES aims first at improving teachers' self-efficacy in implementing PROFILES modules based on a philosophy of a motivational inquiry-based science education through a socio-scientific approach which recognises the importance of science education as more than content and skills and the need for an education through science perception. Second, PROFILES strives to provide teacher ownership of the project intentions through understanding and appreciating the philosophy of the project. For this reason, PROFILES project partners have organized a series of specially designed CPD workshops for science teachers in their countries within a 'teacher needs' related CPD programme based on:

- Updating science background (especially in an interdisciplinary sense).
- Enhancing PCK (Pedagogical Content Knowledge) teaching skills with corresponding theoretical ideas.
- Promoting teacher reflection on their classroom interventions using PROFILES modules as part of the CPD programme.

Turkey, as one of the project partners, held workshops with 40 science and technology teachers, who teach at elementary schools (grades 6-8) in two capital cities. There were 4 CPD workshops held during the first year of the project stressing the need to build up a common understanding and to be on the same target.

PROFILES Continuous Professional Development (CPD) workshops in Turkey were structured in the light of several perspectives. To begin with, Kennedy (2005) suggested that the theoretical base (research ideas) should be presented to teachers and then they should be invited to 'explore' how those ideas might be 'translated' into their classroom practice. Teacher empathy with project aims and teacher motivation to engage with ideas through reading and discussion were fundamental for transformational teacher learning.

First CPD workshop

With this in mind, the first CPD session was held twice as a one day seminar for two groups of teachers. Teachers who were interested in inquiry-based science education and 'education through science' (Holbrook & Rannikmae, 2007) were invited to collaborate in the PROFILES project using online mailing list and individual contacts. In this introductory seminar, teachers were introduced to the PROFILES project, its philosophy, its educational model, its work plan, and its perspective about CPD for teachers.

Second CPD workshop

The second workshop was a two-day interactive and collaborative meeting. Borko (2004) takes a situative perspective on teacher learning, emphasizing the need to take into account both individual teacher-learners and the social systems in which they are participants. Supovitz and Turner (2000, p. 964) identified that engaging teachers in concrete teaching tasks as critical to high-quality professional development.

Throughout the second workshop, teachers were called on to share their understanding about the project goals, such as inquiry-based science education and 'education through science'. Thus, on the first day, a major task for the CPD providers was to ensure that all teachers shared a common understanding of the project aims and components. For this, teachers were engaged in a series of small group workshops about types of inquiry (structured, guided and open), identification of science process skills, the ability of asking investigable questions, and implementing an inquiry-based science lesson. On the second day, teachers interacted with PROFILES science education modules and were introduced to the ideas and intentions associated with the three-stage model on which the PROFILES approach is based.

Teacher development, especially in the areas of teaching methods and practice as advocated in PROFILES is a hard task for teachers since there is a strong likelihood that they need to change their instructional strategies (e.g. moving from teacher-centred to more student-centred teaching). It requires teachers to share the values of the new motive and be prepared to deal with threats (Loucks-Horsley, Hewson, Love, & Stiles, 2003), have a desire to widen their range of current practices, willing to be involved in opportunities for action, share their experiences with a 'community of practice', reflect in order to understand the emerging patterns of change, extend their knowledge and experiences; and finally make time to adjust to the changes made through a continuous professional support (Hoban, 2002). Moreover, it takes significant time to begin to use new instructional practices in a competent manner, and teachers require support through continuous reflection and feedback in order to feel self-confident to introduce new practices in their classrooms (Clark & Hollingsworth, 2002). Therefore, in the third workshop, teachers' self-efficacy was very much addressed.

Third CPD workshop

The third CPD programme was a one day seminar. Other PROFILES project partners (ICASE and UTARTU) contributed to this workshop through their presentations about teachers' self-efficacy, students' intrinsic and extrinsic motivation, and the applications of PROFILES project in other country settings.

According to Hoban (2002), the challenge can be best supported by establishing collaborations with other teachers or experts within a community of professional learning. A professional development that aims a transformative change in elementary teachers' current instructional practices, according to Bell and Gilbert (1996), should include development in social, professional and personal areas. So teachers should experience collaborative ways of working with other teachers, develop ideas and actions in collaboration with other teachers as well as experts, and attending to their feelings through reflection. Within PROFILES this conception is introduced through the setting up of networking at the school, group of schools and later, regional and national levels.

Fourth CPD workshop

The fourth CPD program was a one-day intensive package of collaborative interaction. Teachers carefully examined the science and technology curriculum, noting the range of competencies intended, so as to decide on good topics/learning areas for module development. They collaborated in six groups to develop three stages, PROFILES educational, modules which they could implement in their science classrooms. The CPD providers guided teachers in determining the title and scenario writing, clarifying the socio-scientific issue, and developing and/or adapting activities to ensure they focused on inquiry-based science learning. In total, six modules were initiated by PROFILES teachers in addition to the two modules initially developed and adapted by CPD providers.

Reflection

In sum, PROFILES teachers in Turkey have high motivation towards participating in the CPD workshops. They are highly devoted to actualizing inquiry-based science education not only in their science classrooms but also in their schools and in other schools. They appreciate the value of PROFILES philosophy and share our efforts to an education through high quality science and technology courses.

The major challenge now facing the Turkish PROFILES partner is the question if the CPD is of sufficient strength and worth to be successful in inspiring the teachers towards gaining the degree of self-efficacy desired. One positive indicator will be the number of teachers wishing to be involved in the next stage of PROFILES development – gaining ownership of PROFILES through becoming, as expressed by PROFILES a 'teacher as leader'. Such teachers will be expected to be motivated to assist with CPD for new PROFILES teachers, participate in seminars and workshop to disseminate PROFILES ideas, and besides creating or adapting further modules to be interesting in exploring ways to reduce teacher constraints and enhance student feedback on the implementation of the PROFILES intended, more motivational and student centred approach to science education. And the goal - to truly teach the students, not just the curriculum!

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2.37 Clothes – The Second Skin. Cosmetics: Between Hope and Effect – What Do We Put on our Skin?

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Background and scope

Recently the German Federal State of Bremen established a new type of secondary comprehensive school (‘*Oberschulen’*). One of the goals of the reform was to implement science as one integrated subject, for students in grades 5-8, where Biology, Chemistry and Physics were formerly three separate science subjects.

Science teaching in this new subject is outlined by the governmental syllabus to be operated by different framing contexts with the intention that these contexts are taught through the integration of sub-topics from the different domains of science. Pedagogies, which follow student-active and problem-based learning, as well as an inquiry-based and societal-oriented science education, were suggested.

According to this educational reform project, different groups of science teachers and science educators under the PROFILES-Bremen project, have been developing new lesson plans which fit the new syllabus. One aspect of PROFILES-Bremen, in recent months, was a teacher group working on a lesson plan framed in the context of ‘Skin and Cosmetics.’ The module is intended to promote students’ experimental and communication skills. This module also aimed to encourage societal-oriented evaluation and decision-making abilities through analysing media advertising (which included the internet, TV spots and printed media).

Figure 1. Different advertisings on cosmetics

Another focus of the development was helping teachers to cope with the high heterogeneity in language abilities and achievement in the Bremen *Oberschule*. Therefore, the lesson plan used different pedagogies for inner differentiation, especially while conducting practical work. One of the approaches was to give alternative experimental tasks with different degree of guidance and demand within different worksheets, according to the abilities of different achieving students.

The lesson plan

The structure of the lesson plan is modularized and consists of three sub-modules. It is possible to use parts of this unit, as well as the whole unit. A modularized structure gives the teacher the option to tailor the materials to the specific circumstances in her or his school. Planning the lesson with different sub-modules also allows teachers from other German Federal States (which follow different syllabi and work under varying conditions) to adopt the materials, or parts of them that they may deem relevant.

The first sub-module “Cosmetics: Between hope and effect – what do we put on our skin?” consists of several components which can be small taught successively, or separately.

They can also be combined individually, depending on the school curriculum, students’ prior knowledge and abilities.

The sub-module starts with a collage of different cosmetic products (Figure 1), such as shower gels or body lotions, whereby particular emphasis is placed on the information on their packaging, which infers that the product is "skin friendly" or "pH-neutral". But what does this mean in practice? This question is answered through laboratory work arranged according to the method of learning-at-stations (Eilks, 2002). Within this phase, the students have to complete different experiments (in groups or in pairs), e.g. exploring the pH-values of different skincare products, producing their own lip balm, hand cream or effervescent bath salts, looking at the ingredients of a peeling using a microscope, etc. A central focus of this sub-module is aimed at the pH-value of the skin and how different products can affect it. If the "pH-value" has not been introduced before, or where it is not applicable, respective learning materials are provided on demand. In addition to the pH-value, another fundamental content is introduced following the experimental phase: the structure of the skin. For this purpose, a "skin puzzle" is created. With the help of short hints, the students put together the different components of the skin and learn about their functions.

All experiments and activities are assigned to a certain level of difficulty. Additional help for lower achieving students is provided in the form of flowcharts (Figure 2), in which the steps of a particular experiment are presented in brief.

The aim of the whole module is to conduct an open, flexible, practice-oriented and student-centred learning environment. At the end of the sub-module, the learning returns to the issue of advertising. The students watch several advertising spots on products they worked with during the experiments and judge them with the help of a list of criteria so that they can see for themselves the sheer number of factors which play a role within a successful advertising campaign. After this the students then develop their own advertising campaign for a self-made soap. They imagine themselves as advertising experts (Lippel, Stuckey & Eilks, 2012) and discuss questions like: What information do I want to give to

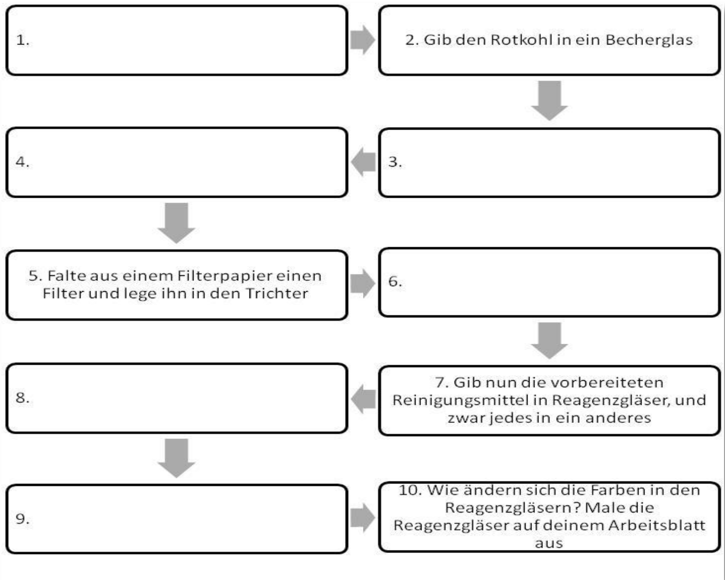

Figure 2. Flowchart for internal differentiation

the consumers? How many arguments can I use? Do I want to employ scientific content in my advertising, or is an attractive appearance more important to me? This method helps to promote the evaluation competence which is listed as a crucial competence in the national curriculum of Germany and an important component of PROFILES.

As already mentioned, the lesson plan has a modularized structure consisting of three parts. The first module, which concerns the structure of the skin and the impacts of cosmetics, has been already explained above. The lesson plan also consists of two other sub-modules. One of them deals with impairment of the skin by parasites, such as lice or scabies. The students are split into groups and provided with a multimedia-based learning environment consisting of pre-selected materials, including texts, short videos and some inquiry questions. Each group investigates one specific parasite using these materials. The learning focuses the development of a fictional flyer for the Ministry of Health aimed at warning the population of this type of parasite. The flyer needs to contain different categories of information, such as protection, prevention and medication. At the end, the students can present their flyers to each other, exchange them and their views.

The focus of the third sub-module is about fibres and their properties in the context of protecting the skin by means of clothes. This part is called: “Cool outfits for every day – which fabrics are the best?” The students conduct several simple laboratory tasks to get to know properties of materials such as thermal isolation, (water) resistance, or structure. Other aspects, e.g. the price or environmental factors can also be taken into account. Also the module considers the difference between natural and artificial fibres. In the end, the students put together outfits for different situations, taking the following into consideration: What fabrics do I prefer when I'm involved in sporting activities? What keeps me warm? Which clothes are the best choice for particularly hot weather? Again, there is a presentation of the results at the very end of the module.

Reflection and outlook

The lesson plan was developed by Participatory Action Research (PAR) as described for science education by Eilks and Ralle (2002). Teachers and science educators are working together and exchanging their experiences and theoretical framework to develop teaching materials, classroom practices and contribute to teachers' continuous professional development (Mamlok-Naaman & Eilks, 2012).

Three professional development providers, one Bachelor-candidate, and six teachers worked on developing the material. Development of the lesson plan took roughly nine months, with meetings every four weeks. In the meetings, the teachers and the team from the university exchanged their ideas, views and worked on the teaching and learning materials.

A special focus of the group work was implementing pedagogies for inner differentiation, too. Teachers provide experiences and information on demands concerning heterogenic classes and their difficulties in the specific case of the Bremen *Oberschule*. Through cooperation of teachers and university educators, different pedagogies were analysed and finally suitable suggestions were adapted for the topic and the specific requirements. Since the topic was also a new field of content to many of the teachers, experimental workshops were undertaken in the university to raise teachers' knowledge about potential laboratory activities, but also promoting their self-efficacy in implementing the module in their classrooms.

The complete module is now to be tested and implemented in different schools by the PROFILES-Bremen network. The cooperation of teachers with curriculum developers from the university provided a valuable framework for developing feasible teaching materials. Presentations to teachers from other schools provoked great interest in adopting the materials even beyond the PROFILES-Bremen schools. From the next school year, more schools are expected to enter PROFILES-Bremen and will benefit from the developed materials.

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2.38 Energy around the House. A Lesson Plan for early Secondary Science Education, with a Focus on Contemporary Energy Use

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Background, scope and method

In the year 2010, the state of Bremen, within Germany, undertook a school reform to implement a thorough system of comprehensive schools. Within the reform, the three science subjects, namely biology, chemistry and physics, were integrated into one subject, 'science', for the early years of lower secondary education (grades 5-8, age range 11-14).

PROFILES-Bremen is supporting schools through this reform process. By forming teams of science teachers from different subject areas and schools, PROFILES-Bremen seeks to help teachers in meeting the challenge of the curriculum shift by integrating the science subjects.

This paper reports on the work of a group of teachers focusing on a syllabus unit for grades 5/6. Utilising the model of Participatory Action Research in science education (Eilks & Ralle, 2002) the group structured an 8-12 weeks lesson plan on basic content of energy, utilising the everyday life context of energy in the house.

Objectives of the lesson plan

The lesson plan "Energy around the House" for comprehensive schools in the state of Bremen (Germany) deals with the syllabus over-arching issue "energy from the sun". In the PROFILES-Bremen project group, this issue is connected with the everyday life context "around the House." The focus of the lesson plan is on alternative energy supplies and energy saving by insulation.

The lesson plan is divided into segments which allow for modular use and given the high levels of heterogeneity in Germany's urban comprehensive schools (as in the case in Bremen), is important.

The modular structure provides an option for teaching the whole unit, selecting different aspects, or combining both for inner differentiation. In each phase, optional activities are included if time allows, or for differentiating for the faster learners and higher achievers. The lesson plan also focuses on a societal orientation of science education (Hofstein, Eilks & Bybee, 2011), referred to as socio-scientific in PROFILES, by reflecting upon the political situation in Germany, which has placed emphasis on intensifying house insulation and promoting more thoroughly the use of renewable energy sources. The latter aspect is dealt with through focusing on solar and wind energy. In this case, the use of energy conversion by windmills, photovoltaic devices, and solar collectors are to be discussed.

The lesson plan is designed to allow for student-active and cooperative pedagogies, e.g. the learning at stations mode or the jigsaw classroom structure. It applies problem-based and inquiry-oriented learning, in combination with cooperative tasks throughout the course. The single activities include a wide range of tasks, such as creating charts, experimenting in groups with open cooperation, or developing and optimizing a model of a solar collector.

Overall the students are taught to think about energy from the sun as an important basis for life on earth.

They also should learn that nowadays the sun's energy can become an important source as an energy supply for household and technical applications in the future, such as supporting energy for heating, mobility, or electrical devices.

Central elements of the pedagogy

Prior to the lesson, the students are asked to measure and record the daily outside temperature in their local environment for two weeks. The analysis of the data functions as the introduction to the topic. If insufficient time is available for individual measurement, default values can also be evaluated. The motivation for the discussion is the need for the use of heat in the house and the demand for cheap and environmentally friendly technologies.

The first major segment of the lesson plan is the creative inquiry to re-invent an effective solar collector. Before this is possible, the students need to develop relevant basic knowledge. To allow for self-directed creation of the model, this phase is embedded into a jigsaw classroom (Eilks & Leerhoff, 2001). For this purpose five equally sized groups are formed.

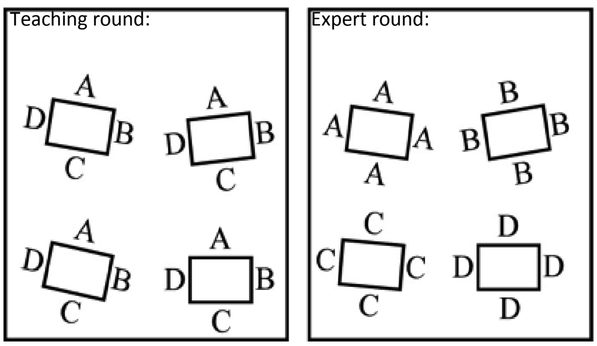

Figure 1. Method of the jigsaw classroom

Each student receives a subtopic. Students with the same topic form a joint group in the expert round. The students learn about different aspects important for understanding a solar collector. The expert groups use experiments such as the greenhouse effect of flow velocity of a liquid to collect thermal energy in a warm compartment as a basis for their inquiry.

After finishing these topics, the 'teaching round' groups are formed by having, in each group, one expert from all the groups of the expert round. Within the 'teaching round', the students are asked to report the experiments which they did and to teach the others about the learned content. The joint task they have to accomplish is the development of a solar collector by combining the knowledge from the different expert topics. From a list of materials the students select the most appropriate materials and explain to the other group members why they rate certain materials to be more suitable than others. The groups' work is supported by a competition inspired by the idea of the egg-races. The different groups compete with each other to find out which solar collector is the most effective. The goal is to achieve the highest temperature increase for a given amount of water.

The second major segment of the lesson plan focuses on heat conduction and thermal insulation. It is not the energy production, which is now the focus, but the reduction of heat loss in and around the house. The students compare two detached houses with each other with the help of a thermal image. One of the houses is provided with thermal insulation and the other is not. Based on the image, the students are expected to recognize the weak points of a house, where the heat escapes to the outside.

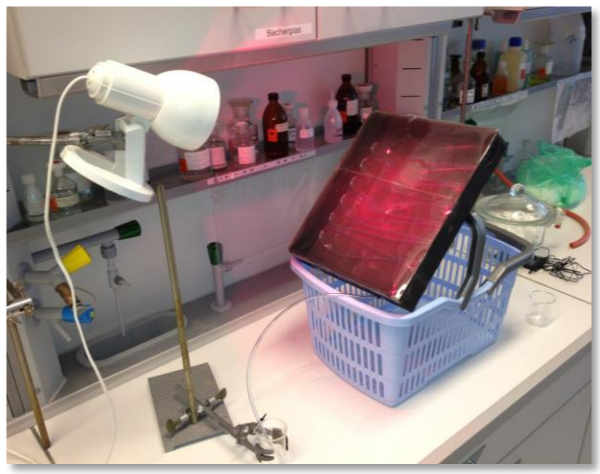

Figure 2. Example of sun collector model

The experimental and inquiry learning in this phase is based on the learning at stations pedagogy (Eilks, 2002). The weak points of the house are the individual stations for the 'learning at stations'. The insulation needs to be tested for the roof, the windows and on the outer wall. There is another station working on the thermal insulation in the animal world.

In the overall lesson plan, more options for inner differentiation are embedded, e.g. inquiring the effect of the sun on the phenomenon of sea and land wind, or on the influence of the solar altitude for the effect of solar radiation and thus the efficiency of photovoltaic devices on roofs of houses.

At the end of the unit, all the learned contents are combined. Tasks to repeat and consolidate were developed. A complex task, on the situation from the animal world, functions as a link between the previously learned contents. The question is how a polar bear protects itself from the cold. The task combines both the content from the construction of a solar collector and

Figure 3. Model of a photovoltaic energy converter

the thermal insulation in a house, so the contents of the jigsaw classroom and the learning at stations are connected. Thus, students can repeat and reinforce what they learned.

Implementation

Following the model of Participatory Action Research in science education (Eilks & Ralle, 2002) the first draft of the lesson plan was developed over a time period of about 9 months. Continuous influence from the literature and the ongoing negotiating and refining of the lesson plan and teaching materials took place in meetings of the teachers' group.

From spring 2011, systematic testing started in different schools in Bremen. Within PROFILES Bremen, testing is not only operated in the learning groups of the teachers involved in the energy topic. Also members from other subgroups of PROFILES-Bremen intend to use the materials and will provide information for further development and thorough implementation. Implementation actually takes place in five learning groups and it is planned to broaden this in the coming school year.

In addition to developing and implementing the lesson plan, working on this topic allowed for networking the teachers with the university and to establish a partnership which allows for further cooperation.

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2.39 The Treasure in My Drawer – What to Do with My Old Cell Phone?

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Introduction

Since the last school reform in the German Federal State of Bremen, there are two types of schools: (i) grammar schools (Gymnasium) and (ii) secondary comprehensive schools (Oberschule). There is a long tradition of grammar schools in Bremen, and as such there are plenty of materials available for this type of school. Oberschule now offer a new governmentally mandated syllabus, with science being offered as an integrated subject until grade 9 (age 13-14). This is new for both the German schools and the teachers. However, teachers have not been educated to teach this new integrated science subject, with most only having studied one or two of the three traditional science subjects (biology, chemistry and physics). Furthermore, no lesson plans exist for this type of lesson.

Starting from this point, the PROFILES group in Bremen decided to develop teaching materials for integrated science lessons in the Oberschule. Different group of science teachers and science educators are developing new lesson plans which fit the new syllabus for Bremen Oberschule. The present paper is based on a lesson plan developed within the framework of the PROFILES project. The lesson plan is about the topics of metals, and reduction and oxidation within the topic "Treasure of Earth" and is for grade 7 (age 12-13). The developing the background of the lesson plan, the lesson plan itself and the evaluation of its implementation, are presented.

Participatory Action Research

This project is based on Participatory Action Research (PAR) in science education (Eilks & Ralle, 2002). PAR is a joint effort between teachers and science educators for curriculum development, educational research, and classroom innovation.

This paper reports on a group of three chemistry/physics teachers, who are collaborating with a university researcher in a PAR project within PROFILES. The group meets regularly, every three to four weeks, and has been developing the lesson plan. At the group meetings, changes in teaching practice are proposed, negotiated, and refined so that they can be tested and applied in classroom situations, before being reflected upon and improved.

Description of the lesson plan

The lesson plan was developed following the ideas of socio-critical and problem-oriented approaches to chemistry teaching (Marks & Eilks, 2009). More detail on these approaches can be found in Figure 1. These approaches were deemed sufficiently close to the PROFILES 3 stage model as to be taken to be the same.

During the initial textual approach and problem analysis, students work on a developed newspaper article. The article poses a question about having a treasure in a drawer, because of not taking care of old cell phones. Furthermore, the article is based on content that is new for the students. The students are expected to develop questions that should be answered during the science lesson. Following this, students work on clarifying the chemistry background in a laboratory environment. Students are evaluating different metals and their properties. This is followed by an egg-race experiment where students develop an experiment for the production of copper starting from copper oxide.

Concept of the socio-critical and problem-oriented approach to chemistry teaching

Objectives	Criteria for selecting issues and apporaches	Methods	Structure of the lesson plans
Allgemeinbildung/ education through science	Authenticity	Authentic media	1. Textual approach and problem analysis
(Multidimensional) Scientific Literacy	Relevance	Student oriented chemistry learning and lab-work	2. Clarifying the chemistry background in a lab environment
Promotion of evaluation skills	Evaluation undetermined in a socio-scientific respect	Learner centred instruction and cooperative learning	3. Resuming the socio-scientific dimension
Promotion of communication skills	Allows for open discussion	Methods structuring controversial debating	4. Discussing and evaluating different points of view
Learning science	Deals with questions from chemistry and technology	Methods provoking the explication of individual opinions	5. Meta-reflection

Figure 1. Socio-critical and problem oriented approach in chemistry teaching (deemed to be very similar to the PROFILES 3 stage approach) ©Marks & Eilks, 2009

Furthermore, in this phase, students are provided with texts about the production and recycling of gold and aluminium. In the next phase, students prepare for the discussion through a role play. In the role play, four roles are represented, with each standing for a different viewpoint
about how to handle old cell phones. Finally students reflect on the role play and the lesson plan itself.

Implementation and Results

The testing and evaluation phases took place in four learning groups (grade 7; age 12-13) with a total of 92 students. The four groups were continuously accompanied and observed by university researchers. After each lesson was finished, self-reflection was performed by the teachers and documented using narrative reports. These experiences were regularly discussed by the entire PAR group. All students took a cognitive test and were asked to fill in a student feedback tool consisting of a combination of both an open and a Likert-type questionnaire. Finally, the MoLE questionnaire prescribed by PROFILES, was collected from all four groups.

All teachers welcomed the experimentation when it came to applying the developed lesson plan. After carrying out and reflecting on the lessons, the teachers were very enthusiastic about the lesson plan. They were happy with the product they had produced, with the openness of the lessons and with the overall motivation of their students. This reaction consistently fitted with the feedback given by the students. The learners judged the lessons to be remarkably good. The students said that they had more fun during the lessons than in other lessons. This is also supported by the MoLE questionnaire. Furthermore, they enjoyed the discussion at the end of the lesson and found it was easy for them to participate. When it came to the cooperative learning, students liked the idea of teaching other students and being responsible for their own and the other students' knowledge. The results of the MoLE questionnaire supported this point as well. When students were asked about their opinion about learning the content during the lessons, more than 70% of them agreed that they learned a lot. Students agreed that they had studied an interesting topic, which was also important for their lives and their future. Finally, almost 90% of the students agreed that the lessons made them think more about their environment and their behaviour, especially when it came to handling old cell phones. This point was triangulated by the MoLE questionnaire.

Furthermore, the results of the MoLE questionnaire showed that the students had more time during the lesson to think about the content of each lesson. The same questionnaire showed that students were more active during the lessons and tried more frequently to participate and understand the subject.

Finally, the expectations of the teachers, which had been set down in the form of a pre-structured test, were exceeded by the students, most of whom achieved unexpectedly positive cognitive results.

Conclusions and implications

The process of collaborative development, utilising the model of PAR, was new for both chemistry/physics teachers and students. Each group dealt with it in an autonomous fashion, aided by the newly-created teaching materials based on the lesson plan. The students were able to co-operatively manage the lesson plan, despite initial doubts expressed by some of the teachers. More important, the lessons made students more conscious about the environmental problems and issues, made them think about these issues and maybe change their behaviour when faced with handling old cell phones.

The initial data seems very promising and motivating for the implementation of further teaching approaches, which are based on the socio-critical and problem-oriented approach on chemistry teaching.

Cooperative efforts between science teachers and teacher educators appear to offer attractive possibilities for developing new teaching materials in chemistry/science lessons. Furthermore, cooperation between experts stemming from multiple disciplines seems to offer a promising path for creating motivating and highly attractive learning environments, which allow science teachers to use successfully socio-critical and problem-oriented approach in PROFILES science teaching. Finally this indicates that the work of the group is a promising way of conducting CPD (Mamlok-Naaman & Eilks, 2012).

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2.40 Teaching Science in a Foreign Language using PROFILES Modules

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The PROFILES ICASE-MICE group

PROFILES ICASE-MICE involves fifteen science and math teachers from the Nantes area in France. On top of teaching science, they have a common interest in teaching science in a foreign language. The group was created in September 2011 by ICASE and is supported by the local science inspectors.

So far, the MICE members have undertaken CPD through three meetings. For its first seminar, the group had the great opportunity to welcome Jack Holbrook and Miia Rannikmäe, who shared their knowledge on the PROFILES activities and teaching methods. The two following meetings focused on PARSEL modules and their assessment. The members also shared teaching experiences and tools used in bilingual classes.

The group is keen to invite new members to join for the new academic year. The members are also interested in meeting teachers from other countries in order to share their views on education, and also to make contacts for further school exchanges.

Interest generated by PROFILES modules in our teaching

Our teachers have tried out a range of chemistry, physics and biology modules mainly in the upper school. While student interest has been very positive, the teachers, themselves, were also interested in bringing new aspects to their teaching which the modules could provide and on which they could reflect as a group.

We emphasize four major contributions of the PROFILES modules which have impacted on our teaching:

- an inquiry-based method,
- assessment by skill,
- a way to diversify our teaching, and
- an interdisciplinary approach.

These four points are in complete coherence with the educational approach promoted by our hierarchy.

- *Inquiry-based Science Education* has been progressively introduced in the science syllabus of secondary education since 2008. Therefore PROFILES modules provide a lot of examples that can be used with our students.
- In 2010, a new reform came into effect in our high schools. At the same time, a new science syllabus has been established: promoting learning through *skills*. The assessment, based on skill acquired, is exactly one of the interests of the PROFILES modules. As we are not self-confident with the assessment of general skills, PROFILES modules can be a way for us to improve our practice.
- We need to *diversify our teaching*: PROFILES provides great opportunities for teachers to use different ways of teaching and especially to reflect on IBSE. Thus we have diversified our teaching by:
    - using various situations, not only scientific, but also connected to socio-cultural issues. And that contributes to make science teaching more meaningful;
    - using unusual methods like a scenario to initiate the science topic.
- PROFILES modules allow us to include an *interdisciplinary approach* that is not common in our education system.

Interest of PROFILES modules for Teaching Sciences in a Foreign Language (TSFL)

All the teachers involved in our group have a common interest in teaching science in a foreign language (English, Spanish and in the next future German as well).

In France, we can teach a subject in a foreign language as long as our language level has been confirmed through a specific test organized by the inspectors.

We can teach in another language during our usual classes. That means that some of the course or the entire course is taught in a foreign language, within the usual curriculum.

Or we can teach in a specific context, called the European Section. In that case, students volunteer for an extra two hours course. In that extra course, a subject is taught in a foreign language. The linguistic difficulties make our progression slower, and make us usually work on scientific concepts that have already been studied in the native language.

Some of the PROFILES-MICE members piloted a few PROFILES modules in those classes during this school year (2011 – 2012). In fact, as the programme to be studied in that course is not strict at all, we can use those hours with a rather wide educational freedom. Thus, we can use PROFILES modules in accordance to the instructions from the Ministry more easily than in the normal course.

Let us underline some specific reasons for using the PROFILES modules in this context.

Having scientific resources written in English or German at our disposal is, of course, an indisputable advantage. However, many of them are already available on the WEB; so why are PROFILES modules particularly beneficial for teaching science in a foreign language (TSFL)? The following rationale is put forward:

- ***Comprehensive and reliable resources***

First, those resources are really comprehensive: students sheets, protocols, but also teacher's documents (proposals of progress, assessment, further information, etc.). From a scientific point of view, – as well as linguistic – the modules are reliable, homogeneous and attractive.

- ***Adaptable levels***

Generally, the levels proposed match our students' well, but we need to adapt our course to both their scientific and linguistic difficulties. By their conception, PROFILES modules can easily be studied more or less thoroughly; moreover, we can also mix the 2 levels proposed.

- ***Oral and written expression incited***

The main interest of using PROFILES modules in TSFL is certainly the fact that it incites pupils to express themselves. Indeed, the modules focus on the comprehension of scientific phenomena much more than calculus. Then, pupils have to make sentences, even when writing.

Inquiry methods raise questions and doubts, making pupils talk to one another.

The socio-cultural frame enlarges the vocabulary needed. The students who are not aware of scientific concepts or vocabulary can participate, using the everyday-life vocabulary learnt in the English or German course.

Lastly, PROFILES subjects systematically link a scientific study to a social issue. Debates, where choices have to be argued on scientific facts and made in the light of socioeconomic aspects, help some of the students to get rid of their inhibitions. Feeling concerned, students participate more spontaneously. The discussion can involve a large group, but can also take place in a role playing game. In a role play structure, students are generally well involved and creative; furthermore, each student has to speak.

- ***Cultural opening***

Even if we study the same scientific concepts, topics and manipulations are not tackled the same way as we are used to in France. That is thanks to the fact that this is an international production, rich in different cultures. That makes our teaching more creative, and opens our student's minds to other ways of reflecting on a common scientific point.

Thus, based on our experiences, we can wonder: Why couldn't we exchange our points of views across countries? Here, we envisage the PROFILES networking going across borders. And what about the opportunity to obtain modules in other languages? We welcome the opportunity to seek modules and experiences from the other consortium partners.

2.41 A Delphi Study in Sweden: Probing Different Stakeholders' Viewpoints on Science Education

Carl-Johan Rundgren – Stockholm University, Sweden;
Shu-Nu Chang Rundgren – Karlstad University, Sweden

Abstract
The purpose of this presentation is to present a design of a Delphi study to investigate different stakeholders' consensus viewpoints on science education in school at the age of 15-16 in a Swedish context. A three-round Delphi approach will be adopted, and the results of the first round of data will be the focus of this poster presentation. A total of 25 participants in each group (students at junior high level, science teachers, science educators at universities and scientists) were invited to provide their viewpoints. The implication for science education is presented.

Background
The declining interest in pursuing science studies in the majority of developed countries during recent years (George, 2006) has made it necessary for science educators to reconsider how science is taught at school and the picture of science that is conveyed to students. The international ROSE study has shown that 15-year-old students in developed countries find many of the themes and questions of science interesting and important (Jidesjö et al., 2009), but at the same time, they failed to see school science as meaningful, and rejected science and technology as possible future careers (Oscarsson et al., 2009). However, the goal of science education in school is seen as not only to educate and recruit the next generation of scientists and engineers; the aim is seen also to provide all citizens with a level of scientific literacy through which they could cope better with modern society. Even though different opinions have been put forward as to what abilities a scientifically literate person would need to have and how to achieve the learning related to those abilities (Shamos, 1995), there has been a consensus among science educators that scientific literacy was important. Furthermore, the problem of relevance of current science education in many countries has necessitated a discussion about how to achieve a relevant and meaningful science education which could facilitate the spread of scientific literacy.

To make school science more relevant for educating young people for the society of today and tomorrow, many authors have suggested that some of the solutions for the dilemma may be found in:

- increasing contextualization of the content (Nentwig & Waddington, 2005),
- connecting more to societal issues and the link between science and modern technology (Aikenhead, 1994),
- connecting to socio-scientific issues with ethical implications (Zeidler et al., 2005), and
- involving inquiry-based science education (Gyllenpalm et al., 2010).

In the same line, Bolte (2008) conducted a curricular study using the Delphi method on different groups of stakeholders' (students, teachers, educators, and scientists) views on how science education could be made more relevant, and the same approach was adopted in an EU project, PROFILES.

Purpose
The purpose of this presentation is to present a design of a Delphi study to investigate consensus viewpoints on science education in school at the age of 15-16 from different stakeholders' in a Swedish context.

The design of the Delphi Study

The Delphi method is used as a method to find group consensus among an expert panel (e.g. Murry & Hammons, 1995), which is composed by an iterative process and conducted in several steps (rounds of questionnaires). Delphi studies are used in science education research to explore different stakeholders' view on certain themes in science education. For instance, Osborne et al. (2003) have conducted a Delphi study on experts' views on what ideas about the nature of science that should be taught in school. A three-round Delphi approach was adopted in this study. The outline of the Delphi study followed the curricular Delphi study undertaken by Bolte (2008). For the first round, the questionnaire agreed upon within the PROFILES consortium was translated into Swedish and distributed to stakeholders (students, teachers, educators, and scientists). A total of 25 participants in each group of students at junior high level, science teachers, science educators at universities and scientists in Sweden were invited to provide their viewpoints.

Expected outcomes

It is our hypothesis that many of the themes discussed in the literature on how to make science education more relevant (e.g. contextualization of the content, connecting to societal issues and the link between science and technology, socio-scientific issues, and inquiry) will appear in the views expressed by the stakeholders. Furthermore, some differences will also be expected to be found between the four different groups of stakeholders.

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2.42 Matching Inquiry- and Context-based Science Education to Swedish Curricula

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Abstract

This presentation aims to present the new Swedish curricula, launched in 2011 and how we adapt inquiry- and context-based science education (IC-BaSE) to this. An example of a teaching module and the teacher training programme for IC-BaSE will be presented in this poster.

Background

Inquiry-based science education (IBSE)

Inquiry has a long history as a central word used to characterize good science teaching and learning (DeBoer, 1991). But in spite of its ubiquitous use, there are still many questions surrounding inquiry (Anderson, 2002). What does it mean to teach science as, through, or with inquiry? Is the emphasis on science as inquiry, learning as inquiry, teaching as inquiry or all of the above? Inquiry has its value in making connections between content, learning and teaching, but this also has been, and still is, a source of confusion and ambiguity in both the literature and teaching practice.

The heart of inquiry-based science teaching and learning is the diverse ways in which scientists study the natural world and propose explanations based on evidence. However, this does not imply that there is a single approach to teach inquiry-based science. There is no, and cannot be, a clear common definition or method describing what and how to work with inquiry-based teaching. The design will always depend on the teachers' interpretation of what inquiry is and other local factors like teachers' beliefs and values (Keys & Bryan, 2001). In other words, inquiry-based teaching is not just a matter of teaching-skills, but also dealing with teachers' beliefs, values and understanding related to teaching, learning and the purpose of education.

Adapting IC-BaSE to Swedish curricula

The new Swedish curriculum for compulsory schools was launched in 2011 (Skolverket, 2011). In the same direction as IBSE, it puts forward that teaching in science aims to develop *"curiosity and interest in studying the surrounding world*" that is supposed to give students "*opportunity to put questions (…) based on their own experiences and current events*" and the opportunity to *"use and develop knowledge in a well-known context*" (Skolverket, 2011 p. 111, 127, 144). These examples not only highlight the importance of providing a familiar and relevant context to students, but also encourage teachers to consider the "student voice" (Jenkins, 2006; Jidesjö et al., 2009). The syllabuses also promote the involvement of activities associated with inquiry like: "*ask questions; look for answers by using systematic studies and different types of sources; developing critical thinking over their own results, the arguments of others and different sources of information; and understanding that statements can be tested and evaluated by the use of scientific methods*" (Skolverket, 2011 p. 111, 127, 144).

The nature of science is also highlighted in the stated aims:

- be able to differentiate between scientific and other ways of describing the world;
- gain an insight into the world view of science;
- appreciate how science has developed and the cultural impact it has had.

The subject aims are summarized in three learning goals formulated as abilities:

(a) use knowledge to examine information, communicate and take a standpoint on views (…),
(b) carry out systematic studies, and
(c) use concepts, models and theories (…) (ibid).

The assessment requirements are closely connected with these goals and formulated qualitatively, which is hard for teachers to implement in their teaching practices. A central part of the knowledge requirements is to ask scientific questions, plan, carry out and evaluate a systematic study.

From the Swedish new curriculum, embedded IBSE in science teaching and learning is not hard to find, and at the same time, providing students with a familiar and relevant context is also highlighted. Accordingly, developing IC-BaSE instruction and the related teacher training programme in Sweden is seen of importance for science educators to put efforts into today.

Defining inquiry-based teaching

Anderson (2002) has suggested that some form of operational definition was necessary, though not sufficient, for persons wishing to communicate with teachers about the essence of inquiry. He has identified in the literature some common prevailing features connected to inquiry-based teaching (Abell & Lederman, 2007). These are:

(a) characterized by inquiring into **authentic questions generated from student experiences** as a central strategy for teaching science;
(b) **activities** in which students are developing knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world;
(c) students **working together in groups and cooperating to solve common problems.**

Bell et al. (2005) characterize inquiry instruction as involving students in a form of active learning that emphasis **questioning, data analysis and critical thinking** (Bell, Smetana, & Binns, 2005). They suggest a framework to simplify inquiry instructions, which focuses on two main traits: whether the students are answering a research question through data analysis and whether the activity involves analyzing data. Inspired by Schwab (1962) and Herron (1971), they use a four-level model including confirmation, structured, guided and open inquiry to guide teacher to evaluate to which extent an activity is inquiry (Herron, 1971; Schwab, 1962). Although this is a simplified description, it truly catches and presents the core ideas of inquiry-based science teaching and can work as a starting point in the communication with teachers. In the teacher training programme, we adapt the simplified inquiry instruction to discuss, with in-service teachers, about inquiry-based science teaching.

The teacher training programme in Sweden

A total of 25 science teachers will be invited to take part in the teacher training programme lasting for six months, organized in five four-hour-workshops. The participants will be teachers from two primary and three lower secondary schools in a region located in the middle of Sweden. The description of the training programme will be as follows, although according to needs in reality, more workshops will be provided during the semester.

Workshop 1: Anchoring inquiry to the curricula

The teachers inspect the aim, goals and knowledge related to inquiry and argumentation in the new curriculum, and reflect on how these are made visible in their current teaching. They can discuss any barriers, dilemmas and needs related to the curricula demands. Introduced, through an example module, is the three-stage model (scenario, IBSE, argumentation) developed by the PROFILES project. This is used as a reference while discussing how the different stages can be connected to the aims and assessment matrix addressed in the Swedish curricula. More PARSEL-type modules (develop by the PARSEL project: www.parsel.eu) are introduced and the teachers start the process of co-constructing their own three-stage teaching.

An example of the three-stage model applied to a module

Stage 1	**The "What?"-generation** Read news-paper article

Stimulating student motivation	about: EU-initiative to limit the MP3 volume-level; a young girl with tinnitus due to MP3-music listening; a psychiatrist arguing it is up to the individual to decide the volume-level; Student group discussion about their own habits and sound environment and what they associate with risk-behavior/environment.
Stage 2 **IBSE related science learning**	read/seek information about what happen in the ear when we can hear a sound, what can be damage, what kind of sound environment representing a risk and why, different opportunities to protect the hearing; Students investigate their own sound environment, e.g. volume in MP3, from CD-player speakers; students investigate their own hearing: frequency-range and lowest volume (use t.ex. phet, http://phet.colorado.edu/en/simulation/wave-interference).
Stage 3 **Transferring the science learning to a social situation**	Discussion about a class-disco/rock concert: who decide the volume-level and what should it be? Argument and counter-argument. Consequences of different decision. Discuss the scenario: The "What?"-generation.

Workshop 2: Developing teachers' language

Teachers participate in inquiry-oriented activities, and discuss how to assess and develop activities that are inquiry-oriented. Teachers are urged to test in their own teaching practices. They also work on developing the central concepts associated with scientific inquiry e.g. scientific question, control experiment, variable, hypothesis, and evidence and reflecting on the use in science contrasted to the pedagogical use. They continue developing their own module – starting with a motivational (familiar, socio-scientific) activity which leads to the need for IBSE learning as the heart of the three-stage module.

Workshop 3: Creating the learning environment

This workshop includes: teaching strategies and skills associated with the learning environment and inquiry: how to ask productive question, help students make focused observation, how to use dialogic interaction-patterns. The teachers continue also their work from workshop 2.

Workshop 4: Talking about assessment

Assessment activities and how to assess inquiry and argumentation will be discussed. Teachers finish their design of teaching modules. Reflect together on barriers and dilemmas. Teachers try out their own modules in their teaching.

Workshop 5: Presenting, evaluating and reflecting stage

Teachers come back to the workshop and share their experiences, with the whole group, about their implementation of modules. The whole group evaluates the implementation and reflection on barriers and dilemmas together.

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2.43 Active O2® – The Power Drink with Oxygen. A Lesson Sequence in Science Education for Upper Secondary School

Sabine Streller, Angela Hansen and Thomas Schulte – RWTH Aachen, Germany

Introduction

The University RWTH Aachen offered the seminar "PROFILES – Inquiry Learning in Science Education" to prospective biology teachers in the winter term, 2011/12. The aim of this seminar was to familiarize students with the basics of the PROFILES approach and to guide them in the development of modules complying with the PROFILES criteria. Students were presented with different ways to plan and develop PROFILES learning environments. One possibility was to critically analyze and revise existing materials, such as PARSEL or PROFILES type modules, another to use everyday products as a starting point for inquiry-based learning. 'Product inquiry' (as it was introduced by the Weizmann Group during their PROFILES workshop in Tallinn 2011) is an approach, based on the idea that different products of everyday life are useful to raise and work on scientific questions in class. In the seminar, four groups of students chose both ways and developed different modules with the following topics: "Sagrotan soap" (hygiene and microbiology), "The Polar Bear" (adaptation to habitats), "My ear" (hearing and hearing sense) and "Active O2" (gases in liquids). These were presented on posters and then discussed and evaluated by all participants on the pre-service, CPD course at the end of the term. These evaluations were based on the criteria of the PROFILES approach, which students needed to keep in mind during their planning phase. There were: high level of student activity, inquiry-based and autonomous learning, references to everyday life, communication, central concepts of science, personal relevance and/or social importance of the content, interdisciplinary aspects (PROFILES 2010; Bolte et al. 2011). Additional, more general evaluation criteria such as creativity and presentation were used. Finally, all seminar participants agreed in their assessment that the module "Active O2" corresponded best with the PROFILES approach.

Conception of the module: ACTIVE O2

The product, Active O2, is oxygenized mineral water, which is distributed in many European countries under various trade names. Active O2, which has been available in Germany since 2001, is sold in plastic bottles, contains - as stated on the label - 50 mg/l oxygen, and promises to effectively improve performance and provide an optimum of strength and endurance (website Active O2). A bottle (750 ml) costs about € 1,00.

In our CPD course, the product, Active O2, is used as a starting point for the developed module. The main goals of the modules are to:

(a) deduce scientific questions from everyday contexts,
(b) design and implement experiments,
(c) promote communicative competences, and
(d) critically evaluate products from everyday life and advertising claims.

The module consists of four phases in total, which correspond to the three-stage-model (PROFILES 2010). The amount of time each phase requires depends on the learning group and the teacher.

Phase 1 – Analyzing the product, collecting and grouping questions

In the first phase, students are given time to explore the product. They should take note of all questions that come up in their group. Together, the questions are collected and grouped afterwards. Depending on the number of questions, a different amount of clusters are formed. In our case, we have grouped the participants' questions into four clusters (see Table 1).

Question examples	Scientific content / Cluster
How much oxygen does Active O2 contain compared to other mineral waters? How much oxygen escapes when the bottle is first opened?	I: Measurement of the oxygen level
On what factors does the oxygen solubility in water depend? Is it necessary to produce Active O2 at a specific temperature?	II: Temperature dependence of oxygen solubility
Why is Active O2 recommended during exercise? Is there really an increase in performance when drinking Active O2?	III: Improvement of performance
How is Active O2 produced?	IV: Production

Table 1. Clustering questions concerning the product Active O2 in four areas (example)

Phase 2 – Designing and conducting experiments to investigate the questions above

In this phase, students are asked to choose a topic they want to examine, thus forming groups I to IV. Each group is advised to first think about a strategy to investigate the questions from their topic. Naturally, some groups might have problems with the design of their experiment and the use of appropriate methods and materials. In order to meet these difficulties and support the students, we have developed learning aids of different degrees (Stäudel, 2008). In this case, five envelopes for each of the groups were prepared and displayed on the teacher's desk, containing tips and hints on how to solve the tasks experimentally. The learning aids include a progression: while the first hints are seen as rather general, the last envelop provides the complete instructions for an experiment. All of the suggested experiments can be easily used in school as they do not require much material.

For example, the oxygen level can be determined with an O2 test kit for oxygen measurement for aquariums. This method can also be used to determine the temperature dependence of oxygen solubility in water. With a finger pulse oximeter, testing can show if the water actually improves the performance as advertised. The instrument, which can be bought or rented in pharmacies, registers the pulse and the oxygen level of the blood with a clamp on the finger tip. During exercise (such as climbing stairs), students can measure the oxygen level in their blood before and after drinking Active O2. The possibilities of producing the mineral water can be investigated with medical low-cost instruments. After connecting two syringes gastight, pure oxygen is pressed from one syringe into the other which is filled with boiled water, and then the oxygen level in the water is measured (see Borstel et al., 2006).

Many other experiments and investigations are possible. With these examples, we wanted to show some ways in which the questions raised by students can be answered.

Phase 3 – Protocols and Research

After the experiments, the students of each group write protocols. They evaluate their experimental results and realize they might have to research further in order to compare their results with values from literature. Every student of each group prepares to present their research questions and experimental results to their fellow students. Now one "expert" from each group meets with the experts from the other groups so that new groups are formed. Each expert informs his fellow students about their accomplishments. This way, all students will have the same level of knowledge by the end of the phase.

Phase 4 – Transfer

In the final phase of the module, students work in their new groups on a problem in the field of water ecology. All participants should bring in their knowledge from previous phases. In order to find a solution together, the students are instructed to transfer their knowledge to the new situation. The starting point for the question is a newspaper article that reports on widespread deaths of fish. The students' task is now to discover the reasons and conditions for those deaths and work out a solution how the deaths could be prevented or reduced.

Summary and Outlook

The module "Active O2" presents a very open and highly student-oriented planning. As the students are required to pose and work on their own questions to a product, they can shape the lessons according to their interests. The design and planning of experiments is one important part of the IBSE approach in general and the PROFILES conception in particular. The module we developed takes various degrees of previous knowledge into account and can therefore be used flexibly in different grades or heterogenic learning groups. In addition, either a more classical scientific discipline or interdisciplinary education can be put into focus.

The presented module can be expanded further, for example with a close examination of the advertisement for this product. The product Active O2 is considered national market leader in the segment "flavoured water" since its introduction. Active O2 is advertised vigorously and partly with misleading slogans: The water contains "15 times more oxygen" (in comparison with what remains unclear). It is also stated that Active O2 is "the ideal training partner for maximum performance in sports". These advertising statements could be tested and evaluated critically – on the basis of scientific evidence – in reference to the module work.

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CHAPTER 3: SHARING EXPERIENCES FROM THE PROFILES PROJECT – WORKSHOPS

3.1 Working Towards a Common Language for PROFILES Modules

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Abstract

If one studies the range of PARSEL modules that are presented on the PARSEL website (www.parsel.eu), one is stuck by the wide range of terminology used to give an indication of the purpose of each module. Terms such as *aims*, *objectives*, *competences*, *competencies*, *learning outcomes*, *goals*, *knowledge*, *understanding,* etc. are all used to indicate the intentions of the various authors of the modules. In addition, both within the same module and across different modules, the terms 'aim' and 'objective' are often used synonymously.

What terminology should we use in the PROFILES modules? Should we use aims, or objectives? What does the term competence mean? What is the difference between the term competence and competency? Why is there so much confusion in the literature about the meaning of the term competence? How are competences related to learning outcomes? Should the PROFILES modules be aligned with the terminology of Learning Outcomes as used in the Bologna Process?

This workshop will discuss the answers to the above questions and will consider the best way to ensure that there is constructive alignment (linking of Teaching and Learning Activities, Learning Outcomes and Assessment) in all of the PROFILES modules.

Background events

In June 1999, representatives of the Ministers of Education of all EU member states convened in Bologna, Italy to formulate the Bologna Agreement, leading to the setting up of a common European Higher Education Area (EHEA). The overall aim of the Bologna Process was to improve the efficiency and effectiveness of education in Europe. One of the main features of this process was the need to improve the traditional ways of describing qualifications and qualification structures. As a step towards achieving greater clarity in the description of qualifications, it was specified that, by 2010, all modules and programmes in third level institutions throughout the European Higher Education Area had to be written in terms of learning outcomes.

To date, all 27 countries of the EU and 18 other countries have signed up to the Bologna process. In addition to these, 45 countries, many countries outside the Bologna process, are aligning their educational systems to be compatible with the Bologna process in order to facilitate description of qualifications, mutual recognition of degrees and mobility of students.

Thus, the Bologna Process has put the focus on learning outcomes in terms of this concept being a "common language" to describe the curricula in countries throughout the world. Whilst the Bologna Process was initially targeted at third level institutions, its influence has now spread to second level institutions and primary level (elementary) institutions. For example, in Ireland, all syllabi are in the process of being written in terms of learning outcomes.

How are learning outcomes defined?

The traditional way of designing curricula was to start from the content of the course, i.e. teachers decided on the content that they intended to teach, planned how to teach this content and then assessed the content. This type of approach focussed on the teacher's input and on assessment in terms of how well the students absorbed the material taught. Course descriptions referred mainly to the content of the course that would be covered in the classroom. This approach to teaching has been referred to as a 'teacher-centred approach'.

International trends in education show a shift from the traditional teacher-centred approach to a student-centred approach, i.e. the focus is not only on teaching, but also on what the students are expected to be able to do at the end of the module, or programme (Kennedy et al., 2006). Hence, this approach is commonly referred to as an 'outcome-based approach.'

Statements called **intended learning outcomes**, commonly shortened to **learning outcomes**, are used to express what it is expected that students should be able to do at the end of the learning period.

There are various definitions of learning outcomes in the literature (Jenkins & Unwin, 2001; Moon, 2002; Morss & Murray, 2005), but they do not differ significantly from each other. The following definition (ECTS Users' Guide, 2005, p. 47) of a learning outcome is considered a good working definition: *"Learning outcomes are statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of a process of learning."* The 'process of learning' could be, for example, an individual lesson or a PROFILES module.

It is important to distinguish between the terms aims, objectives and learning outcomes. The aim of a lesson, or module is a broad general statement of teaching intention, i.e. it indicates what the teacher intends to cover in a block of learning. Aims are usually written from the teacher's point of view to indicate the general content and direction of the module. For example, the aim of a module could be 'to introduce students to the basic principles of inquiry in science.'

The **objective** of a module, or programme is usually a specific statement of teaching intention, i.e. it indicates one of the specific areas that the teacher intends to cover. For example, one of the objectives of a lesson could be that 'students would understand the concept of chemical bonding.' Words such as 'know', 'understand', 'be familiar with', 'be acquainted with' are commonly used in writing aims and objectives. But these are very vague terms. One of the great advantages of learning outcomes is that they are clear statements of what the student is expected to achieve and how he or she is expected to demonstrate that achievement.

What are the guidelines for writing Learning Outcomes?

The work of Benjamin Bloom (1913 – 1999) is a useful starting point when writing learning outcomes. Bloom identified three domains of learning – cognitive, affective and psychomotor - and within each of these domains he recognised that there was an ascending order of complexity. His work is most advanced in the cognitive domain, where he drew up a classification (or taxonomy) of thinking behaviours from the simple recall of facts up to the process of analysis and evaluation. His publication *Taxonomy of Educational Objectives: Handbook 1, the Cognitive Domain* (Bloom et al., 1956) has become widely used throughout the world to assist in the preparation of curriculum and evaluation materials. The taxonomy provides a framework in which one can build upon prior learning to develop more complex levels of understanding.

In recent years, attempts have been made to revise Bloom's Taxonomy (Anderson & Krathwohl, 2001), but the original works of Bloom and his co-workers are still the most widely quoted in the literature. Bloom proposed that the cognitive or 'knowing' domain is composed of six successive levels arranged in a hierarchy as shown in Figure 1.

Bloom's taxonomy is frequently used for writing learning outcomes as it provides a ready-made structure and list of verbs. Bloom's original list

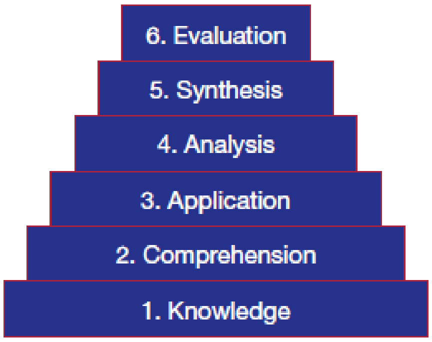

Figure 1. The levels in the cognitive domain of Bloom's Taxonomy

of verbs was limited and has been extended by various authors over the years. Whilst the list of verbs in a recent publication (Kennedy, 2007) is not exhaustive, it is hoped that the reader will find the lists in the above publication to be reasonably comprehensive.

In this short article, it is not possible to discuss the rules for writing learning outcomes, but these rules and many examples are given elsewhere (Kennedy, 2007). Some examples of learning outcomes for various areas of Bloom's Taxonomy in the cognitive domain are given in Table 1. Note that each learning outcome begins with an action verb.

- Locate the main parts of the eye on a model or diagram and describe the function of the cornea, iris, lens, pupil, retina, optic nerve and ciliary muscle
- Describe and discuss the impact of non-biodegradable plastics on the environment
- Examine weather charts to observe variations in atmospheric pressure and relate these to weather conditions
- Identify good and bad conductors of heat and compare insulating ability of different materials

Table 1. Examples of Learning Outcomes from the Junior Certificate science curriculum in Ireland

The affective domain deals with beliefs, attitudes and values and the psychomotor domain covers the area of practical skills. Some examples of learning outcomes in the affective domain and psychomotor domains are shown in Table 2.

Affective Domain

- Accept the need for ethical standards in scientific research.
- Display a willingness to participate in group work.
- Embrace a sense of responsibility for the environment.

Psychomotor Domain

- Use equipment safely in the school science laboratory.
- Construct simple scientific sketches of geological features in the field.
- Deliver an effective presentation to your fellow students on the investigation that you have completed.

Table 2. Examples of Learning Outcomes in the affective and psychomotor domain

Further examples of learning outcomes, as well as a discussion on programme learning outcomes, are covered in more detail in a separate publication (Kennedy, 2007).

Learning Outcomes and Competences

In some papers in the literature, the term "competence" is used in association with learning outcomes. It is difficult to find a precise definition for the term competence. The confusion regarding the term competence is nicely summarised by Winterton et al. (2005) as follows: *"There is such confusion and debate concerning the concept of 'competence' that it is impossible to identify or impute a coherent theory or to arrive at a definition capable of accommodating and reconciling all the different ways that the term is used."*

The confusion is further compounded by the fact that the interpretation of the term competence varies from country to country. Since there does not appear to be a common understanding of the term competence in the literature, learning outcomes have become more commonly used than competences when describing what students are expected to know, understand and/or be able to demonstrate at the end of a module or programme. In essence, learning outcomes bring clarity to what has been described as the "fuzzy concept" (Boon & van der Klink, 2002) of competence.

Linking Learning Outcomes to Teaching and Learning Activities and to Assessment

Science teachers are challenged to ensure that there is alignment between our teaching methods, assessment techniques, assessment criteria and learning outcomes. Toohey (1999) recommends that the best way to help students understand how they must achieve learning outcomes is by clearly setting out the assessment techniques and the assessment criteria.

It is important that the assessment tasks mirror the Learning Outcomes since, as far as the students are concerned, the assessment **is** the curriculum: "*From our students' point of view, assessment always defines the actual curriculum*" (Ramsden, 2003). The linking of the learning outcomes, the assessment and the teaching and learning activities are commonly referred to as "constructive alignment" (Biggs, 2003b). Hence, it is clearly important that all PROFILES modules are written in a way that clearly demonstrates evidence of constructive alignment.

Some concluding points

International trends in education show a move away from the sole emphasis on a "teacher-centred" approach to a more **"**outcome-based" approach to education. This movement has gained increased momentum from the Bologna Process with its emphasis on student-centred learning and the need to have more precision and clarity in the design and content of teaching modules. From one perspective, learning outcomes can be considered as a sort of 'common language' that helps us to understand curricula at local, national and international levels.

International trends also suggest science education embraces a range of learning attributes, going beyond the learning of cognitive science and skills. PROFILES addresses this through the inclusion of 'education through science' and clearly learning outcomes need to be included in the range of intended learning attributes through learning within science lessons.

The requirement to make the teaching and learning process more transparent and more explicit presents a challenge to all of us involved in science education. The adoption of the learning outcomes approach has the potential to help us to embrace a more systematic approach to the design of PROFILES modules.

This workshop strives towards making recommendations to the consortium on the inclusion of learning outcomes, the manner in which they are written and the scope of coverage intended.

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3.2 Analyzing PROFILES Data Using the R-Commander

Thomas Mühlenhoff and Vincent Schneider – Freie Universität Berlin, Germany

Introduction

Quantitative methods are getting more and more important for researchers in the field of science education. They are mainly used in evaluations of interventions and in developments of measuring instruments. Therefore it is essential for researchers and their students to make use of these different methods and applying statistical software solutions to do their analysis.

In this workshop we present quantitative analyzing applications by using the Open-Source Software R and the R-Commander. Especially we want to show how to analyse PROFILES MoLE data sets. At the beginning of the workshop there will be a short introduction into the interface of R and R-Commander and the basics of quantitative analysing methods. Afterwards participants will have the opportunity to analyze a specific MoLE data set.

All in all, we will have a closer look on how to enter the data in spreadsheet software like Excel or Open Office Calc read it into R-Commander and calculate statistics and new variables.

R and SPSS

Many people know the statistical programming language "S" which is used in programs like SPSS and SAS. This is the typical software for empirical analyses in many research groups.

However, there are some disadvantages of these programs. First of all, such programs are quite expensive, which makes it difficult for some research groups to afford and in addition for some students as well, who have been trained to use this software. Another disadvantage is the time in which new developments in statistics are implemented into the software.

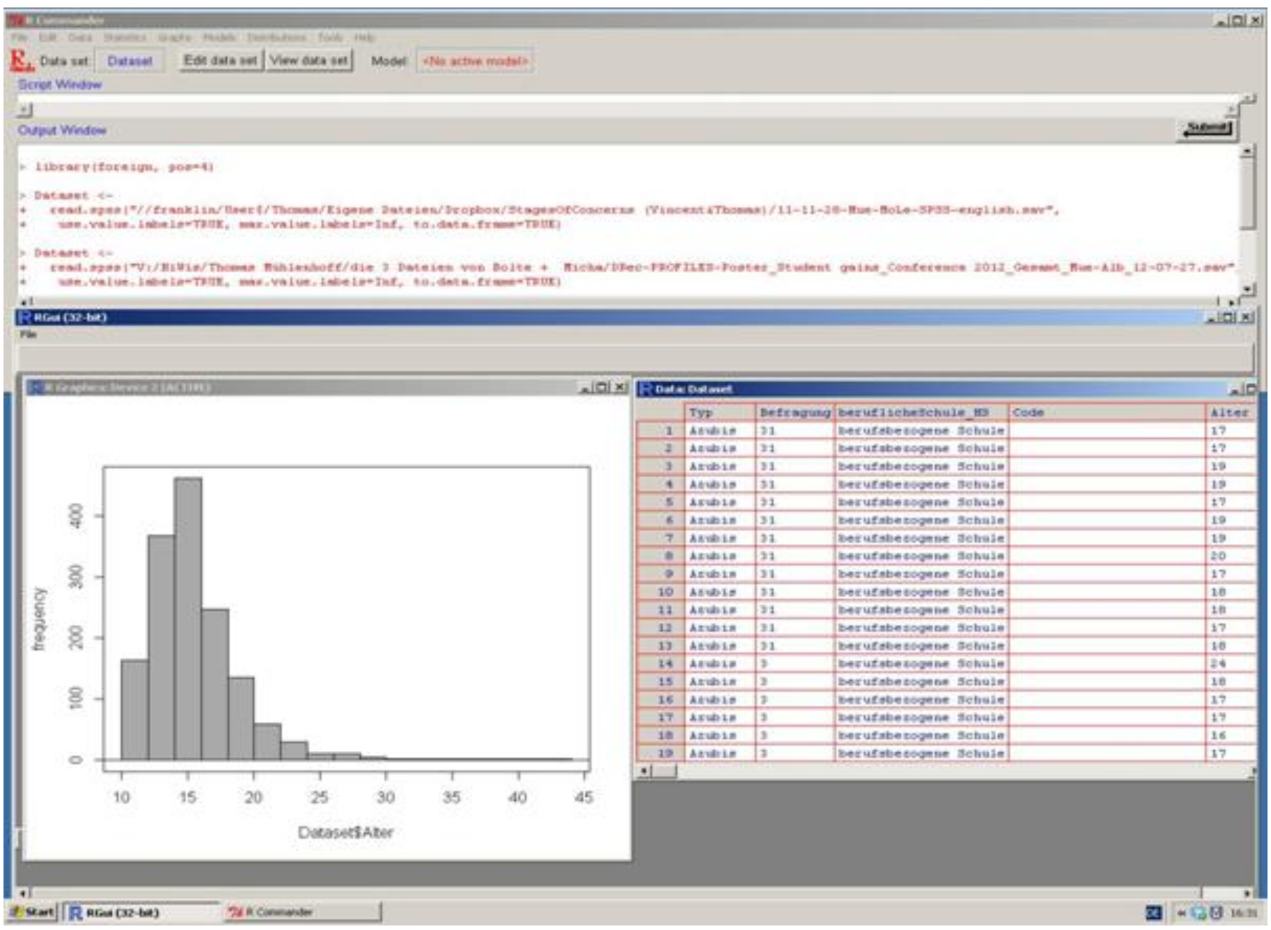

Figure 1. Screenshot of a R-Commander Session using PROFILES data

Using “R” as a statistical programming language is completely free; it is an Open-Source software. Anyone can write so called “packages” which can include different kinds of statistical algorithms. Many statisticians all over the world do that, so there is an abundance of packages for the standard algorithms and new developments are implemented very quickly.

The main reason why many researchers still use commercial software is that they are used to it, they can afford it and it is more user friendly. “R” is mostly used by entering text commands or writing small scripts like the Syntax in SPSS. Most people like to use their programs in a graphical interface with their mouse. This is why we use one of the several graphical interfaces for “R” - the R-Commander (see Figure 1).

The advantages of the statistical programming language "R" are that it is for free and almost anything which is possible in programs like SPSS is also possible in "R". Many users are concerned about the graphical interface. In SPSS you can choose most commands by clicking through menus, only in few cases you have to write the syntax yourself. "R" itself is pure syntax commands. Since this is difficult for many researchers, we are going to use the R-package “R-Commander”, which is basically a graphical user interface which allows clicking through menus using the mouse.

There are a lot of tutorials avaible for the R-Commander on the internet. "Getting started with the R-Commander" (Fox, 2004) is a good example.

If you want to learn how to use R without a graphical user interface, a good place to start is "An introduction to R" (Venables, Smith, & Team, 2002).

A very easy to understand german book would be "R für Einsteiger" (Luhmann, 2010).

A wonderfully organized simple online introduction is availabe at www.statsmethods.com („Quick-R: Home Page“, n.y.).

If you would like to get more serious about R, the book "R in a Nutshell" (Adler, 2010) is a must-have.

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3.3 The Use of Robotics in Inquiry-based Science Education

Bulent Cavas, Yasemin Ozdem and Pinar Cavas – Dokuz Eylül University, Turkey;
Jack Holbrook – ICASE, UK

Abstract

In many research reports, robotics is seen as intellectually rich and a popular science and technology activity to reach goals defined in many science curricula. Robotics applications include mainly hands-on and minds-on activities that are an essential part of science teaching and learning, yet are largely being left out in many national science curricula. Robotics-based education offers students multiple opportunities to design, build and program a robot within the learning of science topics. The aim of this workshop is to show participants how robotics can be integrated into a science course to increase students' motivation and better science learning. The Lego Mindstroms NXT 2.0 Kits will be used to build robotics in the workshop. The main science learning will be reflection of light at the grade 6 and 7 level. The activity will build on previous knowledge on:

- Reflection when light encounters matter
- Light absorbed by matter as a result of interaction between matter and light
- More light being absorbed by dark objects

The workshop will include the construction of robots which are able to read different wavelengths of light using a light sensor. A scenario is used based on traffic accidents and the solutions for eliminating traffic accidents will be posed as a socio-scientific problem. The various tests are carried out on the constructed Robots (designed as a model car) to seek ways to prevent traffic accidents. It is expected participants develop important ideas about preventing traffic accidents which are the most important problems in some countries like Turkey. It also provides opportunities for participants to test / control their robot's speed when it travels along different-coloured roads.

An equipment constraint means that only 25 participants will be accepted for the workshop. It is expected participants are able to use a computer at a moderate level.

Introduction

Many countries have tried to develop and re-design their science and technology curriculum to accomplish the goal of being scientifically and technologically literate students. Although the term 'scientifically and technologically literacy' could be defined in many ways, many definitions include utilizing appropriate evidence-based scientific knowledge and skills, ability of problem solving in daily life and making decisions in socio-scientific issues (Holbrook & Rannikmae, 2009). Since science is an integral part of daily life, most science classrooms suffer from students' low interest in science. Research has shown that if students do not link between science taught in school and daily life, they do not want to choose a career related to science and technology (Smithers & Robinson, 1988; Cavas, Cakiroglu, Ertepinar & Cavas, 2010, OECD, 2010).

The use of robotics in educational settings has assumed great importance in recent years. The development of the technology has led to utilizing robots applications in classrooms. The research literature regarding robotics in education suggests that robotics can be used to engage students (Barnes, 1999; Mauch, 2001; Nourbakhsh et al., 2005; Robinson, 2005; Rogers & Portsmore, 2004; Miller & Stein, 2000), to teach scientific and mathematics principles through experimentation (Rogers & Portsmore, 2004), to promote maths and science careers (Barnes, 1999; Rogers & Portsmore, 2004; Miller & Stein, 2000), to develop problem solving skills (Barnes, 1999; Mauch, 2001; Nourbakhsh et al., 2005; Robinson, 2005; Rogers & Portsmore, 2004); and to promote cooperative learning (Nourbakhsh et al., 2005; Beer, Chiel, & Drushel,

1999) (cited in Barker & Ensorge, 2006). Many schools and educational institutions provide learning environments for children that allow them to build their own computer-controlled robots, using programmable construction kits such as LEGO MINDSTORMS and LEGO ROBOLAB™ icon-based programming software. These technologies allows children to build autonomous robots that can solve fairly sophisticated tasks such as locating and removing objects from a defined space. The roots of the Lego instructional material are based on Jean Piaget's theories of cognitive development (1966), as revised by Seymour Papert (1980; 1986). The central idea of Papert's research was the development of a constructionist learning/teaching environment that provides children with the possibility to interact with technology on a number of different levels (concrete to abstract). In this approach, students are the centre of all kinds of activities and they extend their knowledge through the manipulation and construction of objects.

In many research reports, robotics is seen as intellectually rich (Barnes, 2002; Beer, Chiel & Drushel, 1999; Chambers & Carbonaro, 2003; Weinberg, White, Karacal, Engel & Hu, 2005) and a popular science and technology activity to reach goals defined in many science curricula.

Robotics applications include mainly hands-on and minds-on activities that are an essential part of science teaching and learning, yet are largely being left out in many national science curricula. Robotics based education offers students multiple opportunities to design, build and program a robot when they are learning science topics. According to Sullivan (2008), there are strong relationships between the goals of scientific literacy and robotics. She further mentions that four of the six thinking skills characteristic of scientifically literate people are key elements for robotics studies. These characteristics are defined as: computation, estimation, manipulation and observation, in her study. She continues that science inquiry through both technological design and computer programming activities has positive effects for students to learn science concepts better.

Another important study by Chambers, Carbonaro and Murray (2008) at elementary level was carried out to explore the effectiveness of robotic technology with elementary age children, specifically focusing on the children's conceptual development concerning gear function and mechanical advantage. They found that the robot sessions helped to develop students' understanding of gear function in relation to the direction of turning, relative speed, and number of revolutions.

As a result, technology alone does not affect the students' cognitive and affective skills and cannot provide learning directly. Appropriate educational philosophy, curricula and learning environments are some of the important factors leading to success. For this reason, all teachers and educators need appropriate teaching methods to be formulated for using robotics in education.

LEGO Mindstorms

Lego Mindstorms was originated by Papert's studies at the MIT Media laboratory in 1998. Lego Mindstorms is a line of programmable robotics/construction kits and include 619 pieces, such as programmable sensor blocks (touch, light, sound and distance) and the NXT Intelligent Brick. The first version of Lego Mindstorms, Robotics Invention System (RIS) was released in 1998, another in 2006 named Lego Mindstorms NXT, and the latest version, entitled Lego Mindstorms NXT 2.0, released in 2009. This latest version of the robotics kits with programmable bricks, such as Lego Mindstorms NXT 2.0 and Pico-Crickets, provide students with the ability to control the behaviour of a tangible model by means of a virtual environment and to conduct science experiments, in which young students can investigate a socio scientific issue using their scientific process skills, both in and out of the classroom (Resnick et al., 1996). For example, a young student struggling in science and maths courses might focus and concentrate on the mathematics and science skills needed to program a robot that will move in a desired manner (Rogers, 2010; Garrigan, 1993).

The Workshop Programme

In the workshop, the following activities will be carried out for the teachers (see Table 1).

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The name of the activity	The type of activity	Time	Expert
Introduction to the use of Robotics for Inquiry-Based Science Education	Lecture	30 min	Yasemin OZDEM
Introduction to the Lego Mindstorm NXT 2.0	Lecture	30 min	Bulent CAVAS
Building a demo robot to learn properties of Lego Mindstorms NXT 2.0	Hands-on activity	30 min	Bulent CAVAS
Programming robot	Hands-on activity	30 min	Bulent CAVAS
Socio-scientific issues and the use of robots	Lecture	30 min	Jack HOLBROOK
Working on a socio-scientific problem with Lego Mindstorm NXT 2.0	Hands-on activity	30 min	Yasemin OZDEM

Table 1. Workshop programme

The Prerequisites for participants

The participants will work with robotic applications and computer software. It is expected participants are able to use a computer at a moderate level. This does not mean that the participants must have advance level computer usage ability.

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3.4 Social Software in Primary Teacher Education – Collaborative Learning with ICT in Science Education

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Introduction

Nowadays, young people get most of their information through information and communication (ICT) technology. This is a challenge for Finnish teacher education and Universities need to place particular emphasis on instructing the use of social software and mobile technologies, which up to now have had only a minor role in university studies (Valtonen et al., 2012). The field of social software covers hundreds of online tools intended for different purposes: social games, communication tools, file sharing, blogs, social networking, video sharing, collaborative authoring, image sharing, calendaring and social bookmarking (White, 2007).

These days, collaboration seems to have a central role in teaching and learning with ICT (e.g. Alexander, 2006; Ferdig, 2007; Looi et al., 2009; Scardamalia and Bereiter, 2008). Both in teacher education as well as in Finnish schools, the goal is to use ICT for developing teaching and learning methods and supporting the skills required of citizens in our information based society. In the context of science education, several elements of social software are suitable for supporting teacher students' collaborative learning online, as well as in face-to-face teaching situations. These elements provide users with an active role as creators and publishers of content. Its users are able to produce materials online, provide feedback on each other's work and in particular, create opportunities for communicating and collaborating (Valtonen et al., 2012; Cress & Kimmerle, 2008; Dron, 2007; Ferdig, 2007).

Social software provides different platforms for collaborative activities, supporting the building of teacher students' shared knowledge within classrooms, for field work, as well as on online courses. As resources for further learning, these provide the possibility to capture, arouse and share teacher students' knowledge, knowledge gaps, unique interpretations, and their opinions. Teacher students can express their ideas and thinking by writing, taking pictures or videos in different learning situations, ranging from lectures to work practices and then share them with their peers and teachers. This also opens up interesting opportunities for teacher educators to get a better understanding of teacher students' learning processes.

Using Google tools in field work courses on biology and geography

On teacher students' field work courses, we used Google Site, Google Docs and Google Blogger as tools for inquiry and collaboration. The main idea was to use this social software for building shared knowledge about the forest ecosystem. The field work course was conducted during the autumn of 2011 at the University of Eastern Finland, an obligatory course of biology and geography students. The course consisted of lectures (2 hours) and also teacher students working in groups in the field, as well as in the classroom (24 hours). It comprised of three phases: a) field work, b) laboratory work (analysis of empirical data), c) report and presentation of the main results. The participants were 98 second-year primary school teacher students who were enrolled in three science education courses.

Collaborative inquiry-based learning approaches and field work aim to encourage primary school teacher students to gain a deeper understanding of scientific evidence of forest ecology and its abiotic and biotic elements. The field work course mainly focuses on developing science process skills, the biology and geography content as well as pedagogical knowledge. Collaboration took place between the teacher student groups, as well as with the teachers.

Using Google Sites and Docs

Google sites were used as a common platform. The Sites were constructed so as to present the students´ learning process from the beginning to the end of the course. From the platform's first main page, students were able to find the field work learning goals, schedules, research problems, the maps of research areas and instructions for data collection. All the important instructions were easily available to the students on the Sites.

The second of the platform pages included instructions on how to handle and analyze samples in the laboratory. These pages had their own subpages which were named according to the research topics (the soil of the research area, plants of the research area, invertebrates of the research area etc.). Students also wrote the results of their sample analysis onto these pages. For this purpose, the pages included common spreadsheets, where students filled in the results of their sample analysis. The spreadsheets were made with Google Doc's software and were connected into the Sites´ pages. The spreadsheets calculated the average values in real time which enabled the students to see how the values changed when they filled in the columns. This seemed to stimulate students´ discussions and thoughts about the sample analysis results. These pages also included links to the Google Blogger, which was used for analyzing plant data (see next paragraph).

From the third of the main pages, students and teachers found links to the students` own web pages. With the use of Google Sites' software, each group made their own web pages. Here they presented their research work and results with pictures, tables and figures, which had been made mainly by using Google Doc's software. The students´ own Sites served as a research report which, in this form, can easily be shared within the learning community. The fourth and last of the main pages included guidelines for students' self-reflection, which they wrote about on their own web pages. This gave the teachers easy access to read about the students' reflection.

Use of the Google Blogger

The Google Blogger was used in plant identification and classification. Each group took photographs during the field work and linked them into a collaboratively formulated plant blog. Each photo was labelled with the following tags: forest site type, level of forest (tree, shrub, field and ground layer) as well as the name of the species.

Teacher students used this collaboratively formulated plant blog and its tags when they analyzed the data of vegetation and reported their results on the Google Sites. With the aid of tags they estimated the tree layer structure as well as the covering shrub, field and ground layer. They used the tags when they reported which plant species and forest site types occur more frequently than others. They also reported how and why abiotic factors influenced the plant's structure and why different kinds of plants could grow in this particular area. Teacher students used blogs and tags to present their conclusions in suitable ways, as well as discussing the limitations of their inquiry.

We are discovering that Google Sites can work well as a main platform which connects three different social software tools (Google Docs, Google Blogger and the students` Google sites) together. From the Google Sites, users are able to move to the students´ Google Sites, Google Docs and Google Blogger. We think that social software provides new opportunities for learning and new ways of working for the field work course. Because our field work course is based on inquiry learning, the data collection, data analysis, graphing and reporting, play a central role. We find that different software can support students in the design of data collection, logging data in the laboratory or field, analysis of data, as well as reporting on results. Tagging helps the teacher students to draw general conclusions as it is not possible for them to examine every plot or the entire sampling area. Tagging encouraged teacher students to think about the connections between the main concepts and consider why a particular concept is being used both in the field work, as well as in the report.

The Use of Wiki Confluence in the experimental learning of chemistry and physics

The experimental nature of science learning is important; this is emphasized in primary teacher education in our department. This particular course, Basics and Pedagogy of Chemistry and Physics 4 ECTS, consists of lectures (10 in all, 2 hours each) and weekly laboratory work (12 times, each session lasting 2 or 3 hours). The challenges which result from limited time resources, the extensive content together with the social nature of learning, have led us to think about how we can re-organize laboratory practices. There are 120 first-year student teachers working in 6 laboratory groups. Each of the groups consists of 5 teams with their own weekly experimental assignments. The topics covered during the weekly laboratory work include the basic phenomena in mechanics, thermodynamics, optics, electricity and magnetism; planetary motions and eclipses; chemical compounds, solutions and dissolving, chemical reactions, acids and bases.

The use of Wikis in laboratory work documentation offered an environment in which the student groups are able to produce a collaborative package when reporting on their experimental work; this can then be made available to the other teams. Wikis is a form of multimedia that enables interaction between texts (i.e., planning, setting hypotheses, presenting data, and drawing conclusions), photos (e.g., depicting experimental settings and equipment, presenting data with drawings, etc.), videos (authentic documentation of experiments and phenomena) and links (e.g., to further information, similar experiments documented in YouTube or simulations and applets). Furthermore, Wikis enables the giving and receiving of comments and feedback amongst the student teams.

The software implemented on the course is Wiki Confluence, which is used at the University of Eastern Finland. Its advantage is that our students can use their university username and password, and the university offers technical support.

Preliminary findings from this pilot course have been positive. Putting documentation into a Wiki environment forces student teachers to discuss the whole experimental process thoroughly, before publishing it. It is also a design process, gathering things together into an environment which is then made available to others. This increases the teams’ personal interest in the product and enhances their working process. Furthermore, Wiki-based reporting increases the team’s commitment and responsibility: the teams need to be able to “trust” each other’s work, because the Wiki pages form the major part of the students’ learning material during the course. The pages are available to the students throughout their studies in teacher education, e.g. also during their teaching practice.

Concluding remarks

Primary student teachers reported that they have learned about the usage of ICT in science teaching and learning. They considered learning the use of ICT and other forms of social software in their studies, to be important because they saw them as soon becoming a reality in schools. Conversely, some student teachers saw ICT as taking the main role in science learning; they were worried that natural phenomena and conceptual learning might become marginal when having to concentrate mainly on managing computer problems.

The use of social software also appears to support common knowledge construction. Social software particularly offers easy ways for accessing and sharing information. Research also suggests that the benefits of using computers for data logging include saving time, an improved ability to interpret data, an increased focus on student-student integration and interaction with the computer that could support deep learning (see Webb, 2010).

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3.5 Science-Technology-Society (STS): Challenges and Chances

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In various countries, Science-Technology-Society (STS) is taught as a school subject. It is a so-called integrative, or interdisciplinary approach to teach biology, chemistry, earth sciences, and physics, not as separate subjects, but in ONE subject – including society and technology. What are the challenges and chances of such a subject? What are the characteristics of interdisciplinary teaching? How is STS related to inquiry-based science education? In the workshop we will discuss these and other questions on the basis of specific examples, i.e. of units like 'Petrol – and in the future?' or 'Blood pressure: relating the perspectives of medicine and physics'. Most of the examples and the underlying theory are part of the Swiss curricula. Switzerland, the home country of the presenter, has a long tradition of STS-teaching at all school levels, in particular in lower secondary school (grades 7-9). The following topics will be discussed in the workshop – always on the basis of providing concrete examples.

Arguments for a STS-approach

There are seven arguments and objectives of STS-Teaching and interdisciplinarity, respectively (Aikenhead, 1994; 2005; Bennett, Lubben & Hogarth, 2007; Labudde, 2008):

1. To integrate students' preconceptions and questions, i.e. to implement a constructivist oriented teaching style.
2. To motivate students and to increase their interest in science.
3. To prepare students for tackling complex problems, even – in the long term – key problems of mankind, like the ozone-problem, the change of gender roles, or the gap between poor and rich countries.
4. To prepare students for their professional live that has, in many cases, interdisciplinary characteristics.
5. To teach and cultivate interdisciplinary skills, like sophisticated and differentiated thinking, or tolerance of ambiguity.
6. To be able to gather and judge information in the age of ICT (information and communication technologies).
7. To teach science for both boys and girls, i.e. to reduce gender problems in particular in physics and chemistry.

Different categories of interdisciplinarity

Interdisciplinary has become a vogue word and a dazzling term. It is not a well-defined concept. The variety of words, like inter-, trans-, pluri-, multi-, and intradisciplinary leads to confusion. We try to systemize different forms of interdisciplinarity, used here as a generic term.

One can distinguish various categories of interdisciplinarity: on the one hand at the level of content and on the other hand, at the level of school subjects. The last includes two types of interdisciplinarity:

I) an integrative school subject like STS;

II) an additional subject like Problem Based Learning, or 'Interdisciplinary Themes, in addition to the separate subjects biology, chemistry, and physics.

Categories on the level of content include three types of interdisciplinary instruction (see Figure 1):

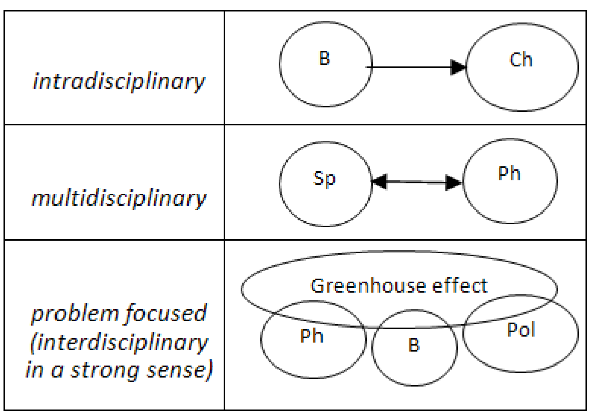

Figure 1. Three types of interdisciplinary instruction

- Intradisciplinary: Relating one subject, A to another subject, B (a one-directional link), i.e. when teaching drugs in biology, linking the topic with chemistry.
- Multidisciplinary: Linking two subjects, A and B (a bi-directional link), i.e. sports and physics within a teaching unit 'altius, citius, fortius: no limits?'
- Interdisciplinary in a strong sense: dealing with a problem like the greenhouse effect by including, among other subjects, physics, biology, and political science.

A mind-map 'interdisciplinary teaching'

Does interdisciplinarity always mean team-teaching? Is project learning the main, or even the only teaching method in STS? Is the assessment in STS mainly formative and less summative than in traditional school subjects?

The answers to all are 'no'. Of course, it is possible, that interdisciplinary approaches include team-teaching, project learning and formative assessment – but it is not a necessity.

In order to illustrate the different kinds of interdisciplinary approaches, teachers and science educators can develop a mind map (Labudde, 2008; Labudde et al., 2004). In the centre of the map are 'Me and my subject.' From the centre, several branches are drawn, each of them belonging to one of seven dimensions:

1. categories (see above);
2. content;
3. skills;
4. role of the teacher;
5. teaching methods;
6. assessment;
7. open dimension.

Figure 2 illustrates two of the branches, 'categories: level of contents' (see above) and 'co-operation of the teachers. Thus the mind-map can illustrate and classify different kinds of interdisciplinary teaching. It can show that there is

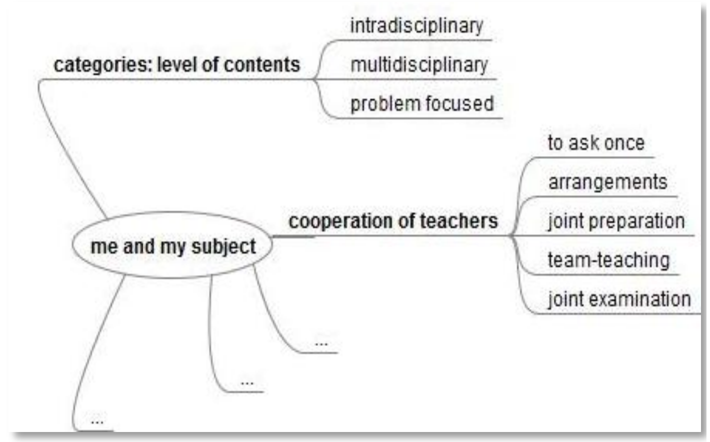

Figure 2. Two branches out of 16 of the mind-map on 'interdisciplinary teaching'

not ONE way to teach STS. Teachers find the mind-map extremely useful when preparing and analysing interdisciplinary (science) teaching units.

Inquiry-based science education and STS

Some of the main objectives of inquiry-based science education (IBSE), as promoted by PROFILES, are that the students should be able (PROFILES, 2010, p. 11):

- To ask high-level questions (especially to initiate inquiry) and hypothesize solutions for tackling unsolved experimental problems.
- To solve scientific problems (experimentally using the range of process skills and/or using suitable secondary sources).
- To interact professionally, including collaboratively sharing knowledge with their peers, community members, or experts.

These features are part of the broader 5E model of Bybee et al. (2009), which includes: engagement, exploration, explanation, elaboration, and evaluation – so-called 21st century skills. The key idea of the 5E model is 'science education through inquiry'. Typical teaching units, based on the 5E model and on the IBSE-approach in PROFILES respectively are (PARSEL 2012):

- Champagne - how much can you afford?
- Lara is pregnant.
- Can I trust my Eyes? How do scientists observe.
- Chitosan - Fat Magnet?!

Many of these and other IBSE examples show typical features of interdisciplinarity: the problem, or question can only be answered on the basis of two or more disciplines, e.g. biology, chemistry, political sciences, ethics. In order to reflect on the problem one has to gather and to combine information from different disciplines. It is necessary to put together factual and procedural knowledge from more than one discipline.

Within PROFILES, Inquiry-based Science Education (IBSE) and the STS-approach, as a paradigmatic example of an interdisciplinary science education, are strongly related. One determines and requires the other, and vice-versa.

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3.6 PROFILES Modules of Best Practice

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A major source of IBSE related PROFILES teaching modules, taking into account student relevance and hence striving towards strong student motivation, are the 54 modules developed under the PARSEL project (www.parsel.eu). However, Work Package 6 in PROFILES envisages teachers providing evidence of ownership of PROFILES ideas. The development of further PROFILES modules is one such source of evidence. This workshop is about developing modules that enable teachers to undertake innovative and motivational classroom teaching, while offering one approach to meeting the ownership intentions of PROFILES.

The workshop has 3 stages:
1. Presentation of the underlying theoretical constructs and structures.
2. Examining modules and the included components.
3. Developing a scenario and the IBSE science question(s) derived from the scenario.

Introduction – the PROFILES intentions
The intention is to promote best practice. But, of course best practice needs elaborating, because it would appear that best practice in science teaching is not universally identified in the same way. Furthermore, in the PROFILES context, best practice is not a single concept, but is seen as encompassing a range of attributes, some of which are specific to the teaching of science subjects. A preliminary list of such attributes highlight at the theoretical and practice levels:

Theoretical
1. A social constructivist approach to inquiry-based science education.
2. Interdisciplinary learning related to cognitive, person and social development and an appreciation of the nature of science.
3. The promotion of the 'Education through Science' concept.
4. Recognising the need for including Education for Sustainable Development.
5. Striving for competencies related to acting autonomously, using tools interactively and functioning in socially heterogeneous groups (OECD, 2005) and the promotion of 21st century skills.

Practice
6. The teacher acting as a professional, willing to reflect on his/her practice.
7. Stimulating and sustaining student intrinsic motivation and student centred learning environments.
8. Developing scientific problem solving and socio-scientific decision making skills.
9. Encouraging the self determination and self-efficacy of students.
10. Ensuring safe practices and developing the capability for risk assessment.

The PROFILES approach and hence PROFILES modules have the above targets in mind. This workshop examines selected modules and discusses the manner in which the above are identified and promoted. Underlying each PROFILES module, in promoting the above, is the unique PROFILES design structure, based on a 3 stage model, although the teaching is enacted as one continuum. Thus, the model is first explained as a major innovation, which drives the teaching sequence and flow from a theoretical consideration and a practical action.

In the model, stage 1 seeks to:
Theoretical construct. Evoking the intrinsic motivation of students
Motivation is seen as the key to learning via PROFILES and major steps are needed to ensure

science teaching is relevant and far from being boring, a problem identified in science teaching, especially at the junior secondary (grades 7-9) level (EC, 2007; Osborne et al., 2003). While teacher-driven (extrinsic) motivation is recognised as very important, there is often too great a reliance placed on the teacher in this respect. PROFILES modules thus strive to support the teacher by attempt to directly evoke student intrinsic motivation by:

- Putting forward a relevant, meaningful and well understood title.
- Initiating a scenario that has a local social context which has relevance for the students.
- Evoking an emotional response from students by addressing a concern, issue or interesting situation.

The modules thus begin in a familiar social context, which can be used to stimulate a science learning need on the part of students. This is not easy to achieve of course and possible reasons for this are:

- Lack of an awareness of situations which are relevant to students.
- Difficulty in putting forward a scenario which is socio-scientific (this differs from science being applications within society e.g. using paint on rusted iron railings; sound reflection via echo location by bats; rate of change of distance with time shown by the velocity of a car).
- Ensuring that the science learning, stemming from the scenario, is within the students' learning needs for the particular students involved (it is within the intended curriculum or within the students' academic capabilities).

Practical construct. Using a Scenario

Students are first exposing to a stimulating title (usually via a handout, but this could also be by showing powerpoint slides, etc) and, secondly, by a motivational situation, story, activity and so on, which, in PROFILES, are collectively labelled as the scenario. The title is carefully worded to entice the students to become involved with the scenario. The title avoids the use of unfamiliar science words so that the science learning is not, as is the usual textbook approach, made explicit at the beginning. In striving for familiarity, the title is most likely to adopt a society focus, often being expressed in the form of a question.

The scenario is not, in itself, about the learning of conceptual science, but an attempt to lead towards student appreciation of the value in learning the scientific ideas that will follow. Student identification, with the scenario and student involvement in reflecting on the scenario, is a major feature, with the scenario itself having a scientific underpinning. Students are exposed to the intended learning by means of a handout (which in PROFILES is labelled 'for the students' and includes the title, the scenario and intended student tasks).

Step 1 continued – Building on the intrinsic motivation to derive the need for science learning

Theoretical construct. Transferring intrinsic motivation to the science problem.

Motivation drives the reflection and discussions on the scenario and allows identification of the underlying constructs initially understood by students (these may be social and/or scientific). Motivation also allows further identification of unknown scientific constructs, related to the scenario, as well as allowing students to put forward known learning on which the teacher can build (social constructivism).

The value of stimulating the students' intrinsic motivation, via the scenario, is further appreciated in hypothesising that it is possible to maintain the students' intrinsic motivation beyond the scenario so that students 'want to' find out more about the underlying science ideas and 'want to' put forward the science question(s) for investigation.

Practical construct.Guiding students from socio-scientific to a focus on the scientific

If the students do not put forward science ideas (perhaps in brainstorming sessions), the teacher needs to explicitly ask students about teacher identified scientific constructs, so as to seek their reactions and determine whether they can identify the scenario link. If students are able to identify a range of scientific constructs, the teacher's role is to guide students, through divergent questioning (not yes/no questions), to identify prior science learning plus science learning, which is unknown but of major importance in understanding the underlying scenario constructs.

Identifying the science question

Theoretical construct IBSE

The science question to be investigated is the introductory stage for undertaking IBSE, which also includes 'education through science' learning, especially risk factors. The question thus drives the problem solving, student-centred approach.

Practical construct. Developing the science question to investigate

This is the initiating of IBSE, which is enacted through the use of an appropriate range of science process skills. The teacher guidance sets out to:

(a) highlight the key science ideas to be explored, and
(b) to develop the scientific question in a format which can be investigated by the students in a suitable manner.

In highlighting (a), teacher are expected to identify prior student science learning, possible misconceptions and from the feedback, identify the appropriate starting point for tackling the unknown science.

Undertaking IBSE problem solving learning of the conceptual science ideas

Theoretical construct

The problem solving is promoted through minds-on, hands-on, student-centred learning to enable problem solving to reflect on the validation of the data collection, the accuracy by which it is expressed and the interpretations that can be made leading to the solution of the problem.

Practical construct

The learning is student-led, but teacher-guided and is expected to follow one of three directions – structured (teacher guidance is very dominant); guided (teacher guidance is whenever students have a need; open (teacher guidance is minimal and mainly for reinforcement, wider reflection and evaluation). IBSE involves the teacher guiding, without 'simply telling', so as to lead to valid outcomes, which can be interpreted and a solution found. The teacher is able to follow-up by reinforcing the conceptual science, as appropriate and associate these with other scientific concepts, so that patterns in science knowledge are appreciated and the science learning is not gained in isolation. The teacher can also, for example, seek feedback through the use of concept maps to better appreciate students' learning connections.

Stage 2, in the 3 stage model, the IBSE learning, involves continuing to maintain student intrinsic motivation using student centred approaches, with the teacher establishing a conducive learning environment (teacher use of extrinsic motivation) by –

- seeking evidence to answer the scientific question;
- undertaking scientific process skills, as appropriate, for tackling the science question(s);
- interpreting the evidence in a valid and reliable manner;
- determining the appropriate solution and how this can be suitably disseminated;

- drawing a conclusion and representing this in a suitable format;
- appreciating the place of the new knowledge, in relation to previously acquired scientific knowledge and concepts (for example by creating concept maps).

Consolidating the science learning

Theoretical construct

Stage 3, in the PROFILES 3 stage model, is an important step in the consolidation of the conceptual science learning and transfers the science learning back into a socio-scientific frame (the original scenario). The purpose of learning the science was to be able to better appreciate the socio-scientific situation and to be able to put forward a meaningful decision, which, in stage 1, was not possible because of the missing science knowledge. Now, however, the acquisition of the science can be evaluated by the manner in which students can participate in the decision making process, while at the same time, argumentation skills are strengthened through participating in consensus decision making. This involves putting forward points of view, refuting the arguments by others and modifying one's own views, as appropriate, to arrive at a compromised outcome.

Practical construct

Important at this stage is for the teacher to gain adequate feedback from students on their learning gains. While this can be entertained through classroom, or homework exercises (and these are not excluded), the real test is to enable the students to transfer the science learning to a new situation – in this case, the initial scenario, where earlier the science knowledge was unknown. In placing the science in a social setting, other attributes will also impact and hence the discussions, or role playing, debates, etc will lead to making a reasoned decision by students, which can be challenged or refuted by other students. The teacher is expected to lead the groups (if undertaken through group work) to reach a consensus decision and then to take the range of group decisions to the whole class, for wider consensus decision making, in keeping with making decisions in a democratic society.

Examining a Module

Each module has at least 3 parts

- a front-page, elaborating general information;
- student part;
- teacher's guide, and,
- possibly also, an assessment guide and teacher notes.

While the 3 stage model is ever present, the 3 stages form an integrated whole within the modules and thus stages are not highlighted. Nevertheless the expectation is that stage 2 dominates the teaching time and any module occupies 4-6 lessons of mainstream, curriculum-related teaching (PROFILES is not an add-on, or revision focused).

In designing a module, the following components are important:

- *Module Title* which has a society orientation using words/situations familiar to students.
- *Learning Outcomes* are included: as cognitive, process, personal and social.
- *The Scenario* is motivational for students and will stimulate discussion.
- *IBSE:* Students are involved in seeking evidence for the Science Question.
- Modules include a *Socio-Scientific Decision-making* component.

In constructing modules, it is recognised that:

- Student ownership through participation is anticipated to be high.
- Intended scientific learning by student emphases higher order cognitive learning.
- Nature of Science is stressed as tentative (not the absolute truth); empirical (evidence-based); culturally embedded (society and personally biased); theories seen as independent of laws.
- Experimentation/modelling included, ensuring high gains in cognitive and process skills.

- Promoting learning for responsible citizenry (STL/Education through Science), as indicated by the stated specific learning outcomes/ competencies.
- Suggested formative assessment approaches can be given.

Developing a scenario leading to a problem solving scientific question

Creating a scenario

By far the most difficult aspect in developing a module is putting forward the socio-scientific scenario and with this the title of the module. Both need to be seen as relating to a meaningful situation and have relevance, as perceived by the students, for their lives. While the title can be topical and the scenario building on the situation, this is not always feasible and local situations are encouraged,, especially where they relate to health or risks, family, the environment, personal freedoms and interactions as well as issues of safety, excitement, or other emotional aspects. At first hand, the title can seem to have little in common with the learning of science, but much of the frustration by the general public is often the scientists inability to deal with science issues in society (usually because there are too many parameters to control) e.g. Is a new drug safe? Can technology make cars safer? Or is genetically modified food unacceptable?

From scenario to learning through IBSE

If stage 1 is the most difficult to conceive, then probably the most difficult aspect to teach is the step from stage 1 to stage 2. This takes the learning from the socio-scientific discussion, in which student recognition is focussed into realising the science aspect is not known and the forward process is to move into the learning of that science, through a problem solving, or inquiry-based approach. This means drawing attention to the need for a scientific question, carefully framed so that evidence can be obtained in an attempt to answer the question and solve the problem. Unfortunately, the modules can only draw attention to this in the teacher's guide rather than in the script itself.

Feedback, or assessment *(student assessment related to education through science)*

Assessment is expected to cover all aspects of learning. In PROFILES modules this relates to:

- **Cognitive or intellectual development,** especially with reference to higher order skills (analysis, synthesis, evaluation based on Bloom's taxonomy), or relational and extended abstract thinking (based on the SOLO taxonomy by Biggs & Collins, 1982), or aspects such as creative thinking, problem solving thinking, argumentation skills, or justified decision making.
- **Appreciation of the Nature of Science** (What is Science?) and an ability to use **scientific process skills** in association with cognitive thinking.
- **Development of personal skills**; these being seen as attitudinal, aptitude (e.g. perseverance, safe working, initiative, ingenuity) and the range of communication abilities (written, oral, graphical, tabular, symbolic).
- **Development of social skills**; these being seen as cooperative or collaborative learning, gaining of social values and the ability to make justifiable socio-scientific decisions.

About Assessment

In using PROFILES modules, the teaching is geared to a purposive, motivationally driven, development of a range of competencies by students, which are expected to enhance scientific literacy. The competency development is indicated by the learning outcomes, which thus relate to the width of education intended, through the teaching of science (education through science). Within any attribute, multiple learning outcomes are likely to be present and the number of outcomes indicated, in a specific module, gives an indication of the areas of emphasis in the teaching and learning. This emphasis can, of course, be enhanced by the teacher, reflecting on student's differing backgrounds.

However, it is important to note that the modules are part of the curriculum. They encompass theoretical and practical components that together make up the curriculum learning. This is very important, as 'education through science' (Holbrook & Rannikmae, 2007) is an intention in all science curricula in all countries. All school curricula are educational in intent.

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3.7 Action Research for Innovations and Continuous Professional Development (CPD) in Science Education

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Introduction

Teachers have been repeatedly identified as the key if any sustainable innovation in educational practices is expected to be successful. This is why extensive, dynamic and long-term continuous professional development (CPD) of science teachers has been demanded inside the framework of science education reforms in order to assure sustainable learning among teachers (Loucks-Horsley & Matsumoto, 1999). Working within such a framework, teachers require guidance and support in all stages of their training when it comes to implementing curriculum changes or in bettering their teaching methods and styles (Loucks-Horsley & Matsumoto, 1999). Under such circumstances teachers have generally proven themselves to be excellent learners, who are interested in trying to teach new curricula and improve and enrich their personal teaching methods (Joyce & Showers, 1983).

One set of medium to long-term strategies to connect both research and practice – including the practitioners thereof – to one another is the wide variety of methods of Action Research (e.g. Feldman, 1996; Parke & Coble, 1997; Bencze & Hodson, 1999; Eilks & Ralle, 2002; Altrichter, Feldman, Posch & Somekh, 2008). Each of these methods has a different focus and employs a different strategy, however, all of them include strong bottom-up, teacher-centered components (e.g. Mamlok-Naaman & Eilks, 2011).

Within the wide span of possibilities for teacher professional development, Action Research is seen either as a practitioner-oriented inquiry into teachers' work and their students' learning in the classroom (Feldman & Minstrel, 2000) or as the development of new educational strategies oriented on teachers' and students' deficits or personal interests (Eilks & Ralle, 2002). Within both ways, the first goal of Action Research is not to generate new knowledge - whether local or universal - but rather to improve and change classroom practices and contributing teachers CPD (Feldman, 1996). Nevertheless, this point may be viewed differently depending on the Action Research mode chosen and depending on the objectives negotiated within the group of practitioners and researchers (Eilks & Ralle, 2002). In the end, the cyclical development of individual practices and generation of results of general interest can be understood as two sides of the same coin, with both having equal importance.

This paper presents three cases of using Action Research's potential for innovation in science education, coming from Israel, Germany and Austria. The case from Israel focuses on building professional competencies in a group of teachers when it comes to reflecting upon and developing their own individual professional practices by carrying out small-scale, individual research projects. The case from Germany describes a ten-year-old cooperation of a group of teachers from different schools accompanied by an educator from the university focussing on the joint development of new curricula and lesson plans for wide dissemination. The Austrian case uses Action Research for subject oriented school development and thus integrates science education with other subjects and the development of the school as a whole. This paper links the three examples leading to a joint reflection.

Three countries – three cases

Israel

This project (e.g. Dass, Hofstein, Mamlok, Dawkins & Pennick, 2008) focused mainly on allowing teachers to develop their own individual practices by enabling them to conduct small scale Action Research studies in their schools. A workshop structure was established to build the teachers' confidence in the area of conducting Action Research as a part of their CPD. Action Research was selected as a topic within this program in order to: (1) provide teachers with a powerful tool for enhancing their professional expertise by performing small-scale research projects, (2) improve opportunities to practice the technique in the teachers' schools, and (3) create a professional community of corroborating teachers.

In planning the program, it was assumed that the teachers needed to improve their content knowledge, PCK, and leadership skills in order to become professionals. Action Research was assumed to offer potential solutions for reaching all of these goals using a joint approach. The Action Research segment of the program was structured around a series of workshops teaching the methodology and research tools necessary for data collection and evaluation. This was carried out by coupling workshop phases with Action Research activities performed directly in the teachers' school environments. In between the workshops, the teachers were asked to both discuss the content of the workshop with their school colleagues and to apply the learned strategies and methods to several aspects of their own practice.

Twenty-two teachers participated in the program. All participants were experienced secondary school teachers having at least 10 years of experience teaching high-school chemistry. They were identified as potential candidates for becoming chemistry coordinators.

The program involved weekly meetings and consisted of a total of 450 hours. The Action Research course consisted of eight meetings. The workshop syllabus encompassed making the participants familiar with backgrounds in both chemistry content and pedagogy, but also with knowledge and skills about performing educational research by qualitative research techniques in general and Action Research in particular.

The workshop was accompanied by a study about its effects (Mamlok-Naaman, Navon, Carmeli, & Hofstein, 2004; 2005). The participants' reacted very positive regarding how the Action Research workshop contributed positively to their work. Most of the teachers expressed satisfaction with the workshop. This was particularly true with respect to their personal interest in conducting Action Research in their own classrooms, and in becoming part of a community of practice. Many teachers stressed the fact that they had learned the importance of reflecting upon their work using Action Research. Some of them continued conducting Action Research with their students, stating that their pupils raised very good points which contributed to their work.

Germany

In this project a group of roughly ten secondary school teachers from different school types, accompanied by a science educator is working together for more than 13 years now (Eilks & Markic, 2011). The focus of the group's work looks at the development, testing and evaluation of alternate teaching approaches for science education based on new curricular structures, pedagogies and media.

The project is based upon Participatory Action Research (PAR) for education research as described in Eilks and Ralle (2002). PAR in this sense attempts to improve teaching practices through the close cooperation of university science education researchers and in-service teachers. It seeks to develop new curricular and methodological approaches and analyze them in authentic teaching situations, thus leading to an evidence-based understanding of the effects of newly-developed teaching approaches. The model also aims at sustainable changes in the fields touched by these innovations and seeks contributing the CPD of all participants involved. To achieve such research-based innovation, a cyclical model of brainstorming, evaluation, reflection and revision is applied. Any ideas for classroom innovation are continually compared to the evidence available from empirical research. In order to connect these two areas, relevant research evidence is presented to the teachers by the university researcher in a group discussion format. Empirical results are also compared to actual teaching experiences in the classroom and examined with respect to the needs and wishes expressed by teachers for their day-to-day situation in school.

From the accompanying research on teachers' CPD one can see that over the years a continuous shift in the teachers' attitudes and views on practice-research relations could be observed (Eilks & Markic, 2011). In the first year, the teachers viewed themselves mainly as technical supporters of innovation. The reason for this was uncertainty about the level of trustworthiness and security to be found in the newly-developed curricular and methodological approaches. Nevertheless, all of the teachers expressed a feeling after the initial year that the new approaches had proven themselves better than the old ones. At the end of the first year it was readily apparent their point-of-view had begun to change. This was even more the case in year two and three. The discussion shifted towards self-reflection among the teachers. The group started reflecting upon the meaning of the process for the individual on their own initiative. The teachers said that the long-term cooperation had led to increasing openness inside the group and a tendency to self-confidently and offensively bring their own criticisms and ideas into play. Many of the teachers described an increasing feeling of being able to competently reflect upon their own teaching. The participants expressed changes due to their own professionalization, with a focus on a totally different view towards methodological variety. Individual practitioners began to start their own initiatives for the group, with an even larger jump seen in the third project year. Finally, discussion led over to the teachers feeling more self-confident in stretching the regulations set up by circumstances when implementing student-oriented and student-active chemistry teaching practices. Some of the teachers enthusiastically accepted the offer of becoming members of a team of textbook authors to implement and widely disseminate their work and ideas.

Austria

The nation-wide project 'IMST' (Innovations Make Schools Top) aims at improving instruction in science, IT, mathematics, German language and related subjects. The focus is on students' and teachers' learning in the context of the whole school (www.imst.ac.at). Innovations are not regarded as singular events that replace an ineffective practice but as continuous processes involving teacher teams and the whole school with the aim to lead to a further development of practice. Most of the participating schools develop cross-curricular labs which foster experimental and inquiry-based learning. Teacher teams at schools have ownership of their innovations. These teacher teams research, reflect and document their experiences in a systematic way (Action Research). They are facilitated by a university team. As a support the schools are offered seminars (i.e. on Action Research methods; about experimental teaching and learning settings), writing workshops; network meetings to exchange experiences among teachers and schools; a pool of advisors, and financial gratification for the documentation of the innovations (Rauch & Kreis, 2007). The participating schools use the instrument of a school development plan. This is a framework to develop and sustain a culture of continuous quality development and self-evaluation at school and should also allow to credibly demonstrate that the school cares for quality (Posch, 2003).

A joint reflection

This paper described three examples applying Action Research to science education. All three have a completely different character. The first was an interactive course design, which successfully qualified experienced teachers to use Action Research in innovating and reflecting upon new practices in their own individual school environments. It also taught them the skills necessary to become innovative leaders with the ability to inform their school colleagues and to implement Action Research beyond their own classrooms. The second project created a network of teachers from different schools, accompanied by a university science educator. This group learned how to develop and research innovative curricula and methodological approaches in chemistry education with the goal of generating both curricular structures and teaching materials which could be widely disseminated. It also contributed to changing individual teaching practices and to promoting teachers' ongoing professional development via the Action Research process. Within the third project teams of teachers developed cross-curricular science labs. In a whole school approach these teachers negotiated with colleagues and the headteachers which changes necessary in the curriculum eventually should be accepted by other subject groups (i.e. languages, humanities) at the school (Rauch & Senger 2006). With time different models of science labs were developed, reported upon via Action Research and published on the internet, in the IMST newsletter and in books (www.imst.at). The ongoing reflection and reporting as well as the exchange among teachers from different schools turned out to be very supportive to overcome obstacles at their own schools. This was made possible by networks on a local (school district) and regional level involving not only teachers but also local school authorities, teacher education and research institutions as well as businesses (Rauch & Erlacher forthcoming). In terms of reflection and documentation so called "writing workshops" offering three days of intensive reflection, writing and sharing were seen as very helpful.

All three projects can be considered successful in their own individual ways. The advantage of the Israeli case study is the workshop structure. The necessary contact time with the accompanying researcher and the overall duration of the project are limited and can therefore be repeatedly applied to several different groups of teachers simultaneously. This allows the process to reach a relatively large number of teachers and schools. On the other hand, this approach has limited potential for constructing more wide-reaching innovation projects, which focus on multiple schools or on changes within an entire curriculum. The advantages of the second project is that it aims on long-term-cooperation and widespread dissemination. Due to the ongoing, long term cooperation there is continuous input from the research side towards the teachers. The results were also able to be widely disseminated in various arenas, up to and including school textbooks to be marketed all over the country. However, the main limitation of this model is caused by the need of the intense, long-term accompany by the university researcher. Advantages and limitations in the third project are that learning is not restricted to a certain subject lesson but involve teachers from different subjects and reflect learning as a phenomenon of the whole school. Cross-curricular activities (i.e. labs) offer the possibility to more authentic and relevant science learning for students. But it requires the internal support by a school culture which values distributed leadership, co-operation, quality development and learning in the sense of a learning organisation as well as external support (i.e. facilitation in networks). To meet the challenge of complexity of a whole school approach Action Research offers an efficient methodology as well as instruments.

All the three projects can be considered successful when it comes to aiding teachers' CPD. The participants achieved higher levels of professionalism by taking ownership of new strategies for better reflecting upon and improving their teaching practices. It can be hoped that this will make them better able to cope with their own practices and help contribute to their future development.

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3.8 IBSE Experiments

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Experiments in Science Education

Science experimentation plays a crucial role in science education. The reasons are the decisive role of experiments in science research and the cognitive importance of experiments in science education (Haury & Rillero, 1994). That is why science teachers' professional competence to use science experiments in teaching/learning science is a very important part of their pre-service and also in-service training. Teachers' experimental skills play a crucial role in the acquiring of students' scientific and educational skills (Trna et al., 2010) and thus experience in the use of science experiments is an integral part of the individual pedagogical content knowledge of every science teacher (Royer et al., 1993). Crucial aspects of science teachers' professional competence to use experiments are their motivation, experience and professional training in experimentation.

Experiments in IBSE

Inquiry-based science education (hereinafter IBSE) has proved its efficacy in increasing students' interest and at the same time stimulating teacher motivation. IBSE is effective with all types of students from the weakest to those most able and supports the improvement of the gifted.

Very importantly, students´ experimental activity is included in all four levels (identified later) of inquiry-based science education. Implementation of experiments is necessary for IBSE, although these need to be meaningfully incorporated in carefully chosen teaching/learning methods, which is the main task for the science teacher.

It is not easy to transform science content into an IBSE format. Just as students cannot immediately switch from traditional methods of learning to inquiry-based learning, so teachers must also "learn" how to implement IBSE. For this, it is important for teachers to be able to use certain experiments in all corresponding IBSE levels. In this workshop, we present characteristics of each of the four levels of IBSE and examples of implementation of experiments (Trnova & Trna, 2011; Trna, 2011).

Confirmation inquiry

The outcome of this level is confirmation of the knowledge of principles, concepts and theories. The results of experiments are usually known in advance. Confirmation inquiry is useful in beginning IBSE so as to develop students´ experimental skills. Students can gain practice in specific inquiry skills, such as collecting and recording data.

- *Oxidation-reduction 1 (chemistry):*
  In the frame of curriculum content on oxidation-reduction, students confirm the sequence of metals in the electrochemical series.They choose one of the metals and insert it into different aqueous solutions of metal ions. They observe whether there is a chemical reaction and changes to the metals. They summarize all their observations in a table and analyze their results. On this

base, students make conclusions and compare them with theory (the accepted sequence by scientists under the experimental conditions used) which is told to the students beforehand. The task for students is to determine which metal is less reactive comparing the reactivity of metals during the oxidation-reduction experiments.The goals and rationale of this inquiry is to enable constructive building of the electrochemical series.

- *Floating and diving 1 (physics):*
  Students gradually place balls made from substances of known density into water (see Figure 1). The worksheet contains a table naming the substance and a table of densities of these substances. Listed for reference is the density of water and student initially compare the density of balls with that of water. Students check their expectation by the behaviour of the ball when placed in water: floating or sinking. To simplify the experiment, the balls can have, the same volume and. On this basis, the relevant theory is confirmed experimentally.

Structured inquiry

The teacher has an influence on procedure and helps students in inquiry by asking appropriate questions. But students generate an explanation, supported by the evidence they have collected through experimentation.

- *Oxidation-reduction 2 (chemistry):*
  Students conduct the same experiments as in the first level, but in this case, electrochemical series should not be given to students beforehand.
- *Floating and diving 2 (physics):*
  Students place the balls, which are made from substances of known density in water (see Figure 2). Students enter the name of the substance and its density into the table. They record the behaviour of solids in the liquid (floating, sinking). The final analysis of the density of balls leads to the conclusion that their behaviour depends on their density in comparison with the density of liquid. The aim of this experiment is that the students, themselves, discovered the density law.

Guided Inquiry

The teacher is the “guider of the inquiry”. The teacher encourages students using the research question and provides students with guidance about their investigation plans. They design procedures to test their questions and the resulting explanations.

Figure 1. Glass of water; polystyrene, plastic and iron balls

Figure 2. Balls with different density


Figure 3. Only the differing shape of bodies


Figure 4. Only the differing volume of bodies


Figure 5. Only the differing density of bodies

Outcomes of inquiry are better when students have had a lot of opportunities to learn and practice different ways to plan experiments.

- *Oxidation-reduction 3 (chemistry):*
  To develop deeper understandings of metal oxidation-reduction reactions we ask students to predict, on the basis of experiments which metals it is possible to use for metal plating and why.
- *Floating and diving 3 (physics):*
  Teacher only gives students a research question. They are not given the solution, the procedures for the experiments. The basic research question might be: "Find the factors in the behaviour of a body when put in to a fluid," Students should seek their own experimental method and equipment (see Figures 3, 4 and 5).

Open inquiry

Students should be able to derive questions, design and carry out investigations with experimenting, record and analyze data and draw conclusions from the evidence they have collected (Hofstein et al., 2005). Because it requires a high level of scientific reasoning and cognitive demand from students, it is especially suitable for the development of gifted students.

- *Oxidation-reduction 4 (chemistry):*
  During the previous explorations, students made conclusions on the basis of experiments, which were planned by the teacher. In open inquiry, students carry out their investigations so they suggest procedures for the experiments and determine which metals and aqueous solutions of metal ions will be used. They need to include their focus question, a prediction, a detailed plan how they will carry out their investigation, and the data table (if necessary) which they intend to use.
- *Floating and diving 4 (physics):*
  Students are almost completely independent. The teacher acts as an implementing partner - consultant. Students are not explicitly given the research question and the experiments to undertake. They choose suitable experiments, which reflect a set of phenomena. These may include melting ice cubes floating in a container with hot water (see Figure 6).

Figure 6. A glass of warm water and melting ice

Conclusions

IBSE is a way which may be taken to increase knowledge and skills of the students in science. Experiments play a crucial role in IBSE because they are beneficial to promoting students´ interest and participation in science activities. The PROFILES project offers experiments within IBSE which were devised by experienced teachers and shown to be applicable in their teaching.

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3.9 WebQuest Projects: Inquiry-oriented Projects suitable for Science Education

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Introduction

We are living in an informational era, where the impact of information technology in our society is very evident, involving institutional changes, both structural and functional in all areas of economic and social life. The impressive increasing performance of computing systems, the multitude of their applications in all areas, the expansion of computer networks and Internet information explosion, has led to the globalization of the information society, this being accompanied by a real desire for acquiring knowledge. In this context, the Internet has become a very powerful tool, more and more useful in many areas and being extremely useful in promoting and implementing alternative educational technologies. Currently, the Internet can be exploited by all actors involved in the educational system, and new technologies for on-line training are constantly developed. In fact, it is suggested that the educational system feels the urgent need to integrate new strategies and technologies that maintain this field in line with the evolution of society.

Within teaching practice, a number of alternatives to traditional teaching are emerging, most of them including ICT elements. Many of those alternatives represent, at the same time, both learning and assessment methods. Teachers may require students to use such alternatives, but these are not intended to be the subject of explicit learning (upper secondary grades), or implicit learning (primary grades). As alternatives, instruments, posters, portfolios, and electronic projects can be mentioned. In addition, the Web can be used successfully in facilitating and supporting cooperative activities. The new technology-based resources are useful for students to achieve quick, easy and efficient individual tasks and group work. In this direction, WebQuest projects can be seen as alternative tools.

Model

An application of educational projects - fully exploiting ICT facilities - is the WebQuest technique (developed and implemented for the first time in 1995 in the USA by Bernie Dodge and Tom March).

Using specific Internet tools (WWW), WebQuest proposes a working method, which has as its basis the constructivist idea of making the personal effort for one's own knowledge development, as an alternative to traditional learning methods. It is based on a model of searching on the Web, this also containing elements of cooperative learning.

In fact, the WebQuest is a complex model: type / iconic / prognosis (Glava, 2009).

- Model-type models are considered benchmarks, norms, due to their repeated use, or recognition of their broad applicability. In this respect, the WebQuest project provides a design structure of teaching that use the Internet resources, guiding the design structure itself and the described teaching activity.
- Iconic models are learning models that replicate two- or three-dimensional complex realities in the form of plans, drawings, designs and reproductions. WebQuest fits into this category of models, given that it proposes a synthetic structure, outlined, which emphasizes a simplified learning activities description that has to be conducted on it.
- Prognostic models are analogies that reverse, to some extent, the model-reality shaped relationship, since, in this case, the model is based on a still non-existent reality, anticipated by it. WebQuest fits perfectly into this category of models, modelling a reality that will take place, like the planned learning activity.

A WebQuest design model curriculum was first proposed in 1995 to a secondary education school - Poway High School, California. Since 1995 until today, Bernie Dodge maintains an educational portal called WebQuest.org and the number of users of his strategy is huge (http://webquest.org/index.php).

The basic idea is the use of informational, cultural, and educational Internet resources, through clear objectives: students learn how to select and use information from various sources and then develop their ability to think critically.

Even though the Internet is not an educational resource par excellence, since we are teachers, we must try to understand the world in which our students live and the landmarks to which they relate. So, the Internet is not only useful in education in general, but, by an effective usage, it can revolutionize the students learning style.

Bernie Dodge said that a teacher who wants to develop such a learning environment organized around Internet resources, may find this intent an impossible task, taking into account the complexity and multiple opportunities that can be addressed. As a result, Dodge suggests the grouping of tasks focused on Internet use into three sections – Input, Processing, Output (Figure 1), described as follows (Dodge, 2000):

(a) Input: in this section are grouped various information, articles, images, background music, background noise, breaking news, press reports, various research, data, reports etc. All of those represent, in fact, the information that students will receive for processing, like data from the web space.

(b) Processing: involves processing the input data to obtain a final product, thus assuming: comparison, analysis, synthesis, evaluation, problem solving, decision making, critical and creative thinking.

(c) Output: initial data, further processed, are transformed into products of student learning activities. These products, published on the web, can become starting points for further learning process: oral presentations, PowerPoint presentations reports, teleconferencing, videoconferencing, projects.

Consequently, WebQuest can be broadly defined as a strategy for implementation of new technologies in education and the use of the Internet as an information resource.

Based on ideas of inquiry and constructivism, WebQuests involve cooperative learning, and students work on projects in groups. Also, it has been demonstrated that there is a strong connection between WebQuests and multimedia techniques, and thus another important opportunity for using the Internet in education (Gorghiu et al., 1995).

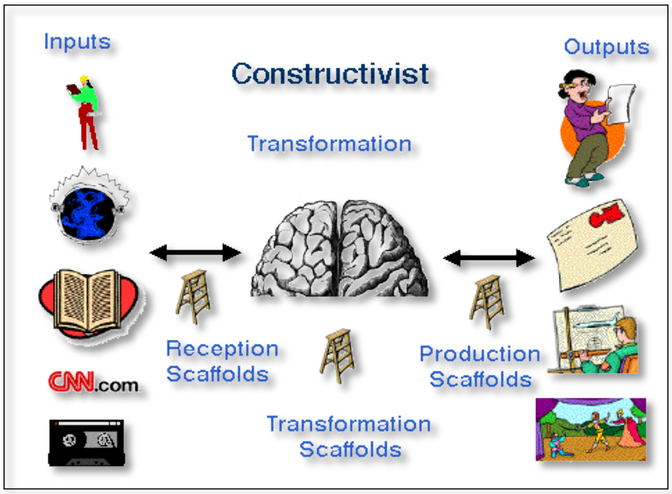

Figure 1. A visual approach of WebQuest [Dodge, 2000]

Specifying the main elements of the WebQuest educational strategy, Bernie Dodge (1997) offers a clear definition: *"WebQuest is an inquiry-centred learning activity through which students interact with information taken mainly from the Internet"*.

More recently the Web has integrated Web 2.0 social networking sites, blogs, wikis and podcasts. Therefore, the WebQuest model has also adapted to the existing trend, meaning the need to define some methodological recommendations which allow student involvement in activities appropriate to Web 2.0 technologies. These aspects bring, in turn, the increasing of students' knowledge (March, 2007).

WebQuest is an educational activity focused on investigation, due to the fact that once accessed, all the information taken from various sources of information (indicated by the teacher) are processed in order to create correlations and original learning products that come like an answer to a question, a solution to a problem, a response to a community need, etc. The process and the organization of the learning steps are described by the teacher, together with the evaluation criteria.

Summarized, WebQuest provides students with technical training situations of criticism and creativity thinking, cooperative learning skills, abilities and depth of information processing and learning. Since all those concepts are retrieved in multiple contemporary pedagogical discourses on effective learning, it can be concluded that WebQuest is a technique that uses new information and communication technologies and which provides a context for the optimal approach to teaching and learning in a modern manner, in line with contemporary theories on learning.

WebQuest is a learning project that is organized around learning tasks clearly stated by the teacher where it is the teacher who proposes the project, together with the necessary sources of information (containing the information needed to solve the formulated task). The sources are mostly Internet links, preselected by the teacher, the students being invited to access and use them. Thus, WebQuest encourages students to become familiar with the Internet, to find specific information, and at the same time, also allows the training of students' computer skills, like web browsing in a safe context, guided by the teacher. By just showing Web pages, the teacher allows students a degree of autonomy in the use of information sources and selection of relevant information.

As there is no best 'learning situation' in an absolute way, there is no 'best WebQuest'! However, valuable WebQuest projects are characterized by a series of attributes that provide quality education to a WebQuest. Generally, a WebQuest has the following features (Glava, 2009):

- A qualitative WebQuest gives students a contextualized learning situation: a specific problem to solve, an investigation into a well-defined topic, a resolution of a social or community issue, etc.
- It integrates a motivating factor: a context relevant to student learning, a form of organizational learning that support the activism and the learning autonomy - those roles involving students in a learning process beyond the traditional school pattern.
- sources of information presented to students are available according to the age and individual/group particularities.

In addition, the educational characteristics of a WebQuest are:

- contributes to the aims imposed by the national curriculum; where the WebQuest integrates the requested exigencies and included in official curricular requirements;
- includes educational challenges such as cooperative learning, interdisciplinary work tasks and the need to use transferable skills (communication, use of computer facilities, planning and monitoring of learning);
- encourages self-assessment, containing a set of detailed criteria for assessing the student work, which they can see and follow from the beginning of the process of project solving;
- supports the development of the learning process by describing the steps to be followed in order to meet learning objectives, and through the proposing of cognitive organizers and graphic information processing;
- facilitates the transfer of teaching project in another educational context, integrating a page of useful methodological suggestions for another possible teacher user.

There are two distinct levels of organization for a WebQuest (Dodge, 1997):

- short-term WebQuest – aims to acquire and integrate knowledge. At the end of implementing such a project in a short period of time, the student accumulates a significant amount of new information and carries out in-depth understanding. A short term WebQuest can be achieved in one to three hours (lessons);

- long-term WebQuest – aims to expand and structure knowledge. After a long term WebQuest, the student retains in depth the information accessed, processed and evaluated to a certain extent. Finally, he/she demonstrates knowledge of material covered by creating a product for which a reaction is expected from others (online or offline). A long term WebQuest is normally deployed with a class for a period of one week to one month.

Whatever level of organization (in the short or long term), a WebQuest must be designed in such way to organize student learning time effectively. The benefit that a student can take from the free navigation on the Internet, without the constraints of a theme or a particular purpose is questionable; in addition, many schools give students a limited time surfing. Therefore, a WebQuest needs to be effective and must clearly state the purpose for which it is created.

Content

There are six major parts included in a WebQuest (Blanco, 2003):

1. Introduction

This part provides essential information and motivational support for offering to the students roles to play. The technique gives them the way to carry out a play. Some of them could be 'an inside volcano researcher'. or 'a botanist that analyses the tropical plants'. This section also includes an overview of the learning goals to students.

One of the expectations of the introduction is to make all the activity pleasant for students. If the projects are correlated to students' interests, ideas, experiences or future goals, they become more interesting. The motivational support makes the students engaged at the beginning of the WebQuest.

2. Task

The task is a description of what students will have accomplished by the end of the WebQuest. In the beginning, the teacher has to find some resources for a specific topic on the web and then, the teacher opens the activity to the students that includes information from the several sites. As Bernie Dodge mentioned, the task should be doable and interesting.

A difficult matter is to develop the task. That's why the teacher can ask the students to publish all the information found on a website. Besides that, they can cooperate in a research effort with another website or institution, or create specific materials that define aspects of their work. The task needs to be visible, with a global importance and of course, fun for the students.

It is recommended for the teacher to show a final project, or examples from previous projects. If a project is very good, it could be used by the teacher several times.

3. Process and Resources

The process is a description of the steps that learners should go through in accomplishing the task, with links embedded in each step. All the processes should be broken out into clearly described steps. In the case of long-term projects, it is better to have a demonstration of each step. The demonstration offers a step by step process and refreshes the written resources.

In describing the learning process a list of resources (websites, printed resources) that the students will need to complete the task is usually inserted. At this moment, the WebQuests have the resources included in the Process part, in this way being accessed at the needed time. Beside the web resources, the students can use non-web resources: videos, audio cassettes, books, posters, maps, models etc.

4. Evaluation

The WebQuest needs a rubric for evaluating students' work. A rubric is a set of criteria used to evaluate the student's performance. The requirements need to be objective, related to the students' capacities, consistent and specific to the tasks. The goals have to be clear.

It is recommended to exemplify three categories of students: exemplary, acceptable and unacceptable. The difference between an exemplary and acceptable activity is designed to have a positive aspect: make the students to work more to achieve the first category. Anyway, an explanation regarding the unsatisfactory activity will establish a minimum of standards that all the students are expected to achieve. Finally, all the students need to have had a good experience in achieving the project.

5. Conclusions

This part allows the students to reflect and teachers to make a summative evaluation. This part needs also time for discussions and pointing on various applications of the lesson. In addition, the students can learn different ways to improve their work.

6. Teaching guide

The teacher's Guide is a page or component 'WebQuest for teachers' for teachers who intend to use the WebQuest project in their class, either in its original form, or modifying it and adapting it to the context in which it will be applied. Possible reuse of WebQuest products involves publication on a website, or in a virtual library. Such collections can be created on the website of the educational institution, or can be published like web pages and included in different collections of WebQuest projects.

Activity

(a) Split in groups of 4 members.

(b) Start to consult some Science WebQuest examples from the *QuestGarden* website (http://questgarden.com/search/webquest_results.php?curr=currscience&grade=grade912&Submit=Search), or see some examples presented in the *BestWebQuest.com* matrix, proposed by Tom March, available at: http://bestwebquests.com/.

(c) Try to develop, in a group. a model using the WebQuest template file, called *WebQuest.doc* available in the working e-platform. The chosen theme should be linked to the specific national curriculum subjects. The *WebQuest.doc* template file contains a specific format developed for this activity. Necessarily, all parts of such a project will need to be developed: introduction, task, process and sources of information, evaluation, conclusions and teaching guide. These sections should be provided in separate pages.

(d) Since this is devised as team work each participant assumes one role of the team and tries to first solve the individual tasks. In performing the assumed role, it is necessary to search and select the needed resources from the Internet, suitable for the age and level of knowledge of students.

(e) Start to design the steps of the teaching/learning process and insert all the needed information resources inside this section.

(f) Design, with colleagues, the individual and group evaluation criteria.

(g) Emphasize one or few conclusions that contain a summary of activities and knowledge / skills / abilities acquired by students during the project. Being designed for students, the findings need to be motivational for students and emphasize the students' success. Also the launching of other possible topics for future investigation or some questions for reflection can be addressed to the students. Findings may include rhetorical questions, or additional links that may suggest that students are able to extend or transfer their knowledge to other content than those provided in the project.

(h) At the end of the project, start to develop a teaching guide for other teachers who will try to use the WebQuest project in their classes, either in its original form, or modifying it and adapting it to another context.

(i) Using the model presented in the template file, *WebQuest.doc* - save and load the created file as *Proiect_WebQuest_GroupX.doc*, and upload it in the working e-platform.

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3.10 Teachers Ownership: What Is it and How Is it Developed?

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(See Chapter 1.4.4)

CHAPTER 4: REFLECTIONS ON INQUIRY-BASED SCIENCE EDUCATION IN EUROPE AND OUTLOOK

4.1 PROFILES: Some Ideas and Comments

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In 2009 a small group of enthusiasts worked hard on preparing a proposal of how to improve science education in Europe and used this together with nearly 20 partners from different European nations in January 2010 to answer a call of the European Commission in the 7th Framework Programme section "Science and Society". The Commission's experts emphasized: *"the impressive geographical coverage with an elaborate consortium on 22 experienced universities, with sound knowledge of IBSE and European projects, situated in 20 countries. Cultural diversity and language issues are handled with professionalism."*

They liked the consortium's ideas, accepted the proposal and thus the Commission granted an acceptable funding.

The call and hence of course the proposal based mainly on expert reports like "Europe needs more Scientists", "Science Education in Europe" or the "Rocard Report": "Science Education now". The main findings of the Rocard group (2007, p.2) are here, because these are also the three pillars on which the PROFILES project is built (Introduction of IBSE, inclusion of a wide range of stakeholders, a strong focus on teacher professional development):

- A reversal of school science- teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science.
- Renewed school-science teaching pedagogy based on IBSE provides increased opportunities for cooperation between actors in the formal and informal arenas.
- Teachers are key players in the renewal of science education. Among other methods, being part of a network allows them to improve the quality of their teaching and supports their motivation.

Allow me to elaborate on these three aspects.

Scientific Literacy and Inquiry-based Science Education

There is a worldwide consensus accepting scientific literacy as the common goal for school science for all students. Scientific literacy is not only understood as a utilitarian concept with systematic knowledge of science facts, concepts and procedures, but as an educational concept helping young people orient to an unknown world to develop their whole personality. Jack Holbrook is talking about "education through science" and not "science through education"; this goes along with the German/Scandinavian tradition of education ('Bildung'), where school science is seen as a contribution to the individual's general education. Summarizing, Cory Buxton (2006) has reviewed the arguments for promoting scientific literacy for all:

Economic: for a more competitive economy; *Humanistic*: for a more well-rounded education; *Civic*: for a better informed voting public on issues involving science and technology; *Political*: For the importance of logical inquiry skills in supporting democracy; *Social justice*: for equitable educational opportunities for all students; *Critical*: scientific literacy that can help to empower marginalized students and their teachers in contesting their social reproduction.

It‘s easy to understand that these goals are not achievable by teaching science in a traditional way, only focusing on facts and concepts and just transferring the pure academic discipline at a lower level from university to school. During the last 30 years, several approaches and strategies have been created to support the development of these goals. Keywords are Science/ Technology/ Society (STS), Context-based teaching, Socio-scientific issues, Self-directed learning, Inquiry-based Science Education (IBSE), among others. Students’ own inquiry processes motivate them to become and stay active, physically as well as mentally, and help them learn science and its significance in everyday and vocational life, as well as learn about science and develop personal and social competencies.

There are many definitions of inquiry and inquiry-based science education. As an example, the suggestion by Marcia Linn and her colleagues will be mentioned here:

“Inquiry is the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments.” (Linn, Davis, & Bell, 2004).

Very often the process of inquiry is illustrated as a cycle; one of them was created by Llewellyn (2002, p. 16):

Inquisition: Stating a question to be investigated.

Acquisition: Brainstorming possible solutions.

Supposition: Selecting a statement to test.

Implementation: Designing and carrying out a plan.

Summation: Collecting evidence and drawing conclusions.

Exhibition: Sharing and communicating results.

I think most IBSE teaching units follow this cycle, where the reflection and discussion of the results can generate new questions. The actual PROFILES internal IBSE philosophy is not explicitly specified, but the teaching and learning process is described within the classroom modules and in the three stage model, adapted from the predecessor project - PARSEL. This three stage model includes the Llewellyn steps, but goes beyond pure science and extends the teaching to real life and decision making. Thus, the first stage aims for motivating students and introduces a socio- scientific issue; in this, a research question will be stated, possible solutions brainstormed and a statement to test will be selected. Then, the deliberately designed collecting of evidence leads to justified conclusions during the second stage, while the third stage gives room for reflection, discussion and personal decision-making. Within PROFILES, there is a rich pool of modules which not only come from PARSEL, but also from other sources such as developments by partners or from former projects. I look forward to seeing all the chosen modules, adapted to the PROFILES philosophy, plus the manner in which they are used and the results of their implementation.

Renewed school science pedagogy through involvement of stakeholders

It is not only the huge number of intelligently designed and creatively developed modules and the three stage model which constitute the uniqueness of PROFILES linked to three fundamental pillars I mentioned earlier. There is also the creatively planned participation of stakeholders from different science education relevant areas. The PROFILES Delphi Study, by consulting not only science education researchers, teachers and students, but also teacher trainers, scientists, politicians and journalists about their views on contemporary science education, is helpful for defining the content, context and strategies of teaching and learning. Furthermore, the outcomes will help to define a specific philosophy for PROFILES on IBSE, the development and adaptation of teaching and learning modules, as well as for teacher training strategies and materials.

In fact, the inclusion of a broad range of stakeholders will not only help in development, it will also support the implementation and dissemination of the new ideas. Since the PROFILES approach is not developed by a small isolated group of researchers from an ivory tower, but with the participation of a wider public, the chance of acceptance will be much higher. The stakeholders, situated in influential positions, can help to implement “their” ideas in classroom practices. And since the stakeholders are included from the beginning, they, of course, can be expected to identify themselves with the project and thus act as nuclei for networking and dissemination. First results from the starting point made with the Delphi study are to be seen at this conference, a conference where we can see a rich diversity of stakeholders as PROFILES supporters, or even ambassadors.

Continuous Professional Development (CPD) for Teacher Ownership

We have learned from John Hattie’s (2009) study, who re-analyzed more than 800 meta-analyses, based on more than 50000 single studies on what influences student learning, that the teacher is the key variable. Also the most important points for successful teachers are that they are willing to reflect on their own teaching and learn from their own errors or successes.

“It is critical that teachers learn about the success or otherwise of their interventions: those teachers who are students of their own effects are the teachers who are the most influential in raising students’ achievement.” (Hattie, 2009, p. 24)

“If the teacher’s lens can be changed to seeing learning through the eyes of students, this would be an excellent beginning. This involves teachers seeking countering evidence as to the effectiveness of their teaching, looking for errors in their thinking and knowledge, seeing how students build on their prior knowledge and conceptions of learning, asking whether there is enough challenge and engagement in the learning, and understanding the strategies the students are using when learning and confronting difficulties.” (Hattie, 2009, pp. 252, 253)

Based on the above, reflective teachers can assess learning processes and give adequate feedback. ‘Providing formative evaluation’ and ‘feedback’, with high effect sizes (.90 and .73), emphasize a well elaborated scaffolding of the students’ learning process. Meanwhile, ‘Inquiry-based teaching; is found only with an effect size of .31, with problem-solving teaching with .51, teacher clarity (.75), meta-cognitive strategies (.69) and goal challenging (.56). Nevertheless, all these variables can be seen as being included in IBSE, so it is very important to clearly define the specific IBSE philosophy and train teachers to use it competently.

With the emphasis on Continuous Professional Development (CPD), PROFILES has chosen a very important focus. On the one hand, we see the importance of the teachers’ role; on the other, only a small percentage of teachers are adequately prepared to teach according to these new standards. Research has shown that single training events are not sufficient; PROFILES with its one year lasting seminars recognises this requirement. In many countries, particularly in those where CPD is not mandatory (Germany is one of those), teachers are isolated when preparing their lessons and have no chance to develop new ideas in cooperation with colleagues or to improve their qualifications. PROFILES is trying to counterbalance this; they offer a motivating CPD, classroom modules and networking. The CPD structure, from teacher as learner, teacher as teacher and teacher as reflective practitioner, up to forming teacher ownership is completely in accordance with the current status of research, and I look forward to seeing the next stage in the project involving a network of experienced and motivated teachers. According to Hattie, we have to try to develop a supportive learning environment where error is welcomed and fostered, for teachers as well as for students.

"To facilitate such an environment, to command a range of learning strategies, and to be cognitively aware of the pedagogical means to enable the student to learn requires dedicated, passionate people." (Hattie, 2009, p. 23)

At the start I talked about a small group of enthusiasts who prepared a proposal. I think you now have a greater group of PROFILES enthusiasts, researchers, teachers and more stakeholders who all together work on a successful project.

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