

PROFILES



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

Bolte, C., Holbrook, J., Mamlok-Naaman, R., Rauch, F. (Eds.):

Science Teachers' Continuous Professional Development in Europe

Case Studies from the
PROFILES Project



SCIENCE TEACHERS' CONTINUOUS PROFESSIONAL DEVELOPMENT IN EUROPE

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Supporting and coordinating actions on innovative methods in science education:
teacher training on inquiry based teaching methods on a large scale in Europe

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<i>Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria</i>	

Preface

PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) is currently one of the largest European FP7 funded project in the field of “Science in Society.” The consortium currently consists of 22 partner institutions located in 21 different countries (status quo: January 2013; see Figure 3 of the Introduction). The PROFILES partners come from the following countries and belong to the listed institutions (the names of the PROFILES steering committee group members are mentioned in brackets):

- Germany: Freie Universität Berlin (Coordination: Claus Bolte & Sabine Streller)
- Austria: Alpen-Adria-Universität Klagenfurt (Franz Rauch)
- Cyprus: Cyprus University of Technology (Eleni Kyza)
- Czech Republic: Masaryk University Brno (Josef Trna)
- Denmark: University of Copenhagen (Jan Nielson)
- Estonia: University of Tartu (Mii Rannikmäe)
- Finland: University of Eastern Finland (Tuula Keinonen)
- Georgia: Ilia State University Tbilisi (Marika Kapanadze)
- Germany: University of Bremen (Ingo Eilks)
- Ireland: University College Cork (Declan Kennedy)
- Israel: Weizmann Institute of Science (Avi Hofstein & Rachel Mamlok-Naaman)
- Italy: Università Politecnica delle Marche (Liberato Cardellini)
- Latvia: University of Latvia (Dace Namsonē)
- Poland: University of Maria Curie-Skłodowska (Ryszard Maciek Janiuk)
- Portugal: University of Porto (João Paiva);
- Romania: Valahia University Targoviste (Gabriel Gorghiu)
- Slovenia: University of Ljubljana (Iztok Devetak);
- Spain: University of Valladolid (Angela Gómez-Niño);
- Sweden: Karlstad University (Shu-Nu Chang-Rundgren)
- Switzerland: University of Applied Sciences Northwest Switzerland (Peter Labudde)

- Turkey: Dokuz Eylül University (Bülent Cavas)
- ICASE, UK: International Council of Associations for Science Education (Jack Holbrook)

This book – the 2nd PROFILES Book on “*Science Education and Teachers Continuous Professional Development in Europe: Case Studies from the PROFILES Project*” includes 53 different contributions by PROFILES teachers and partners in which they offer insights into, and overviews of, their activities within the PROFILES project through case study approaches and field reports.

Case Studies within PROFILES

These case studies examine the actual teaching/ learning situation by soliciting and processing as much data as possible from different sources, agreeing with Creswell (2007, p. 95) that “*the researcher needs to have a wide array of information about the case to provide an in-depth picture of it.*” The goal of the authors is to include as much in-depth data and analysis as possible.

Case studies were chosen as the focus of this book so as to better illustrate and disseminate good practice within PROFILES. The intention in forming this collection of case studies was that these contributions offered lively and informative insights into the coordination actions within the PROFILES project. Each partner was free to choose their own case study focus, but the target was to obtain empirical investigations of a phenomenon, taking into account its context, through using different data sources (Hancock & Algozzine, 2006). The case studies in this book were created as descriptions and analyses of cases and systems focussing on persons, groups, events, processes or institutions in the respective countries, covering at least two or more PROFILES work packages (the sections are described below). To better reflect the teaching or teaching approach taking place, partners focused in their case studies on a range of facets promoted within the project, especially related to teacher professional needs teaching support materials and reflections on teaching the PROFILES way.

In this book, the various contributions have been grouped into 4 sections:

1. Case studies on Stakeholders' Involvement and Interaction,
2. Case studies on PROFILES teaching modules (learning environments),
3. Case studies on CPD and Ownership,
4. Case studies on Networking and Dissemination.

Many of the case studies are descriptive, offering a description of the phenomenon and its context. However, others are more illustrative, going one step further and looking for causal links: "*their primary purpose (of the case study) is to determine how events occur and which ones may influence particular outcomes*" (Hancock & Algozzine, 2006, p. 33). The examples in this book follow these criteria, although, in a few cases more general narrative case stories are included.

This 2nd Book of PROFILES can be downloaded via the PROFILES International Website (www.profiles-project.eu) and via: <http://ius.uni-klu.ac.at/misc/profiles/articles/view/31>.

If you would like to know more about the PROFILES project, you can also take a look at the 1st PROFILES Book on „*Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*“ (Bolte, Holbrook, & Rauch, 2012). This book contains 69 contributions focusing on the engagement of the PROFILES partners in the first project period and their presentations at the 1st PROFILES International Conference on Stakeholders Views on Science Education. Furthermore, this book offers more detailed insights in the theoretical background – the “philosophy” – of the PROFILES project and the approach the consortium agreed on and follows (Bolte, et al., 2011; Bolte, Holbrook & Rauch, 2012). Beside this one can find a detailed description of four (from eight) central working fields – in the terminology of the European Commission these working field are named as “work packages”. The work packages described in the PROFILES Book #1 are related to the “European Stakeholders Views on Inquiry-based Science Education as well as the Method of and Results

from the International PROFILES Curricular Delphi Study on Science Education Round 1” (Schulte & Bolte, 2012), on “Innovative Inquiry-based Science Learning Environments in the Framework of PROFILES” (Holbrook & Rannikmäe, 2012), on “Teachers’ Ownership and the question: What is it and How is it Developed?” (Hofstein, Mamlok-Naamam, Rauch & Namsome, 2012) and on “How to Involve Stakeholders in IBSE Networks” (Rauch & Dulle, 2012). Last but not least, in the 1st Book of PROFILES interested colleagues find the conference keynotes focusing on “Inquiry-based Science Education in Europe”, on “Effective Continuous Professional Development in Science Education” and statements on Students’ (Intrinsic)Motivation, Learning Outcomes and Gains”. This book – the 1st PROFILES Book – can also be downloaded via the PROFILES International Website (www.profiles-project.eu) and via: <http://ius.uni-klu.ac.at/misc/profiles/articles/view/31>).

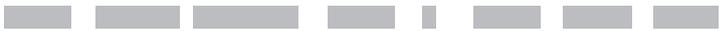
We hope you will enjoy the reading and gain valuable and interesting information about the PROFILES project.

Yours,

Claus Bolte, Jack Holbrook, Rachel Mamlok-Naaman and Franz Rauch

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Introduction: about PROFILES

Claus Bolte & Sabine Streller – Freie Universität Berlin, Germany

Miia Rannikmäe – University of Tartu, Estonia

Avi Hofstein & Rachel Mamlok-Naaman – Weizmann Institute of Science, Israel

Franz Rauch & Mira Dulle – Alpen-Adria-Universität Klagenfurt, Austria

The PROFILES project (PROFILES, 2010; Bolte, Holbrook, & Rauch, 2012) promotes science teacher professionalism through a continuous professional development programme to support teacher self-reflection on the innovative ideas in the project linked to stakeholder views, inquiry-based learning, student-centered approaches and a thrust for science education that enhances students' learning in knowledge, skills, attitudes and values.

Why such a project?

PROFILES has its foundation in a report published by the European Commission called "Science Education Now: a renewed pedagogy for the future of Europe" (EC, 2007). This report examines a cross-section of innovative on-going initiatives and set out to draw from them elements of 'know-how' and 'good practice' that could bring about a proper and reasonable change in young people's interest in science studies – and to identify the necessary pre-conditions for aiming at these objectives. This is in response to the awareness that:

"In recent years, many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics. Despite numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. Unless more effective action is taken, Europe's longer term capacity to innovate, and the quality of its research will also decline. Furthermore, among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat." (EC, 2007, p. 2)

Such comments are related to concerns of students at adolescent level or above, rather than primary

(pre-grade 6) where students generally had a favorable attitude towards science (Osborne, Simon & Collins, 2003). PROFILES is a response to the need to take more effective action.

The PROFILES project (PROFILES, 2010) builds on three of the four major findings indicated in the European Commission report (the 4th refers to other projects) (EC, 2007), vis:

1. A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science.
2. Renewed school's science-teaching pedagogy, based on inquiry-based science education (IBSE), provides increased opportunities for cooperation between actors in the formal and informal arenas.
3. 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.

About PROFILES

PROFILES (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science) is currently one of the largest European FP7 funded project in the field of "Science in Society" (FP7-science in society-call, 2009). The project promotes inquiry-based science education (IBSE) through enhancing the self-efficacy of science teachers to take ownership of more effective ways of teaching students.

PROFILES is a project seeking to guide and support teachers to enhance students' scientific literacy (Gräber & Bolte, 1997) or the 21st century and thus firmly encompassing 21st century skills as pointed

out for example in the PROFILES (Inter-)National Curricular Delphi Study (Schulte & Bolte, 2012; see also Section 1 in this book). While the focus of the project is student centred learning, within an inquiry-based approach to science education (IBSE), it also recognises issues in the teaching and learning of science subjects which need to be clearly addressed. The PROFILES project is grounded on the following key components (PROFILES, 2010; Bolte, Streller, Holbrook, Rannikmäe, Hofstein, Mamlok Naaman & Rauch, 2012):

- PROFILES promotes learning which is ‘student-motivationally’ driven (Ryan & Deci, 2000; PROFILES, 2010). 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 (Bolte, Streller & Hofstein, 2013). 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 (Bolte, Holbrook & Rauch, 2012).
- PROFILES supports the relevance of building the learning from students’ prior experiences in a *constructivist manner* (Yore, 2005), 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). PROFILES additionally provides a ‘motive’ for students to want to satisfy a recognised ‘need’. In this, PROFILES strives to move away from positivist teaching. Instead, PROFILES takes on a more ‘constructivist’ viewpoint (Piaget, 1950; Prawat & Flowden, 1994; v. Glaserfeld, 1989), whereby student findings (under the conditions they find these) are taken as real, have inherent value and are worthy of their effort when put into a meaningful context.
- Through PROFILES, students are encouraged that

the science learning component 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 – as the PROFILES consortium would term it – an ‘Education through Science’ approach, which recognises that science education, to enhance students’ scientific literacy, is much wider than science content and skills and that attitudes, aptitudes (individual and social developments) and values are also important learning components (Bolte et al., 2012).

Work packages and activities in the PROFILES project

The PROFILES partners follow the project’s aims and try to reach the objectives through their engagement in eight working areas – the so called “work packages” (PROFILES, 2010). The eight work packages (WP) of PROFILES are interdependently connected (see Figure 1).

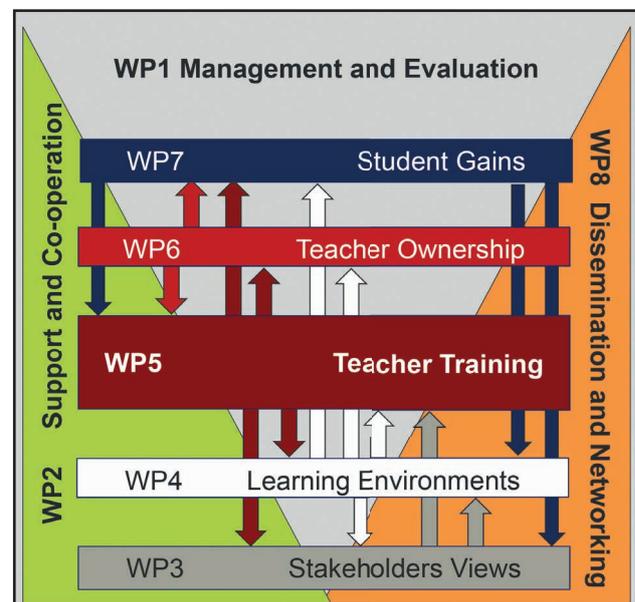


Figure 1. The eight PROFILES work packages and their interdependencies

Two work packages are more related to administrative tasks and issues (e.g. WP1: Management and Evaluation) and to supporting the partners regarding their project activities and in fostering the cooperation among the partners

(WP2: Cooperation and Support). The other six work packages cover the more operative activities of the project: Within WP3 (Stakeholders' Involvement and Interaction) PROFILES tries to involve stakeholders in order to enhance the project activities and the implementation of its outcomes (Schulte & Bolte, 2012). In WP4 (Learning Environment) innovative materials and modules – so called “PROFILES type Modules” – are adapted and created both for the use in teaching and learning settings in schools (Holbrook & Rannikmäe, 2012) and for the “long term Teacher Training” programmes which build the core of WP5 (Hofstein, Katevich, Mamlok-Naaman, Rauch & Namsone, 2012). The PROFILES continuous professional development (CPD) programmes for pre-service and in-service science teachers should finally lead to specific professional attitudes of the participants involved in the PROFILES CPD programmes of the partners; these attitudes and concerns of the teachers the PROFILES consortium would term as “Teacher Ownership” (WP6; see Hofstein, Mamlok-Naaman, Rauch & Namsone, 2012; Schneider & Bolte, 2012). All PROFILES activities should finally reach the students in schools in a positive manner via their science instruction – as described above). The investigation of how the students benefit from the PROFILES type learning environments and the approaches combined with these are the central issue of WP7 (Students Gains; Albertus, Bolte & Bertels, 2012; Bolte & Streller, 2011; 2012). All work package activities should be and are disseminated in a broad manner and via different channels. In WP8 (Dissemination and Networking) – a work package strongly connected to all the other PROFILES work packages – the partners take care of this (Rauch & Dulle, 2012; Bolte, et al., 2011).

In this book – the “2nd Book of PROFILES” (the 1st Book of PROFILES was published in 2012 (see Bolte, Holbrook & Rauch, 2012) – the partners focus mainly on four of the eight work packages; namely on the involvement of stakeholders (WP3), on the development of PROFILES type materials (WP4), on the PROFILES CPD programmes in order to collect first insights into the effect of these programmes on “teacher ownership”, and last but not least on PROFILES network activities (WP8).

Stakeholders' Involvement and Interactions

As mentioned above, an important aspect within PROFILES is the involvement of stakeholders and their interactions between each other (Bolte, Holbrook & Rauch, 2012). In particular, PROFILES seeks to build a bridge between different groups of stakeholders that are involved with science and science education (such as science education researchers, teachers, students or scientists) and local actors by supporting networking and co-operation among them (Schulte & Bolte, 2012). Therefore, the PROFILES partners have decided to involve stakeholders in at least two different ways:

On the one hand, stakeholders are engaged through international and national meetings and conferences during which the different actors come together and exchange views on issues of modern science education. The first of these international meetings took place in September 2012 in Berlin. During this meeting, experiences and first results of the PROFILES project were shared and discussed with stakeholders from more than 25 different countries (Bolte, Holbrook & Rauch, 2012). The next meeting – the 2nd PROFILES International Conference – will take place in Berlin, 25–27 August 2014; interested colleagues are kindly invited to attend this conference (see www.profiles-project.eu).

On the other hand, PROFILES tries to bring into contact as many stakeholders as possible so that they can discuss aspects and facets of desirable science education in a systematic way. This intention, which enables both a national and international exchange of ideas, is carried out on the basis of the “(Inter-)National Curricular Delphi Study on Science Education” (Häußler, Frey, Hoffmann, Rost & Spada, 1980; Bolte, 2008; Schulte & Bolte, 2012).

A first step towards this intention has been realised by collecting the views from different stakeholders regarding desirable science education within the partners' countries' school systems. For this, the PROFILES partners have collected views from more than 2.700 different stakeholders and involved them in discussions regarding aspects and opinions

about a desirable science education and IBSE by means of the ‘International PROFILES Curricular Delphi Study on Science Education’ (Schulte & Bolte, 2012). By means of the PROFILES Curricular Delphi Study on Science Education stakeholder’s views and opinion are analysed through three consecutive rounds. In the frame of the second and third round the PROFILES partners provide the participating stakeholders with feedback on the outcomes from each round by means of qualitatively and statistically analysed stakeholder statements, which are then commented on, assessed and/or added to by the stakeholders involved in the study (Linstone & Turoff, 1975; Häußler et al., 1980; Bolte, 2008; Schulte & Bolte 2012).

More information on the involvement of stakeholders in the PROFILES project through the “(Inter-) National PROFILES Curricular Delphi Study on Science Education” and on different consortium partners’ perspectives on their involvement of stakeholders, related to other work packages in the PROFILES project, are addressed in Section 1 of this book (see Schulte & Bolte, this book, and the contribution of the other partners focusing on this topic in Section 1). After a brief introduction on the method and design of the (Inter-)National Curricular Delphi Study on Science Education one can find five case study articles in which partners present their national Delphi Studies, the results they have analysed so far and how these findings have supported their activities within the PROFILES project.

PROFILES Learning Environment

In initiating PROFILES in the classroom, teachers are guided by PROFILES type teaching modules (PROFILES, 2010; Bolte et al. 2011; 2012). The structure of such modules follow developments in a previous FP6 project, named “PARSEL” (PARSEL, 2006) and are firmly based on a 3-stage model (Holbrook, Kask & Rannikmäe, 2008; Holbrook & Rannikmäe, 2010), in which the title of each module and its initial elaboration via a scenario is context-based and relates to an area perceived to be of relevance and motivational to students. This is seen as extremely important, as the focus of PROFILES is in most of the cases adolescent students and

beyond, where the declining interests in science learning are well documented in the literature and where strong considerations of future careers are being undertaken (Osborne, Simon & Collins, 2003).

While the 3-stage model promotes a motivational, context-based introduction, capturing students’ prior learning and setting the scene for further motivated student learning, the second and major stage are the gaining of ‘new’ science concepts through a student-centred, inquiry-based approach. In this stage, modules use a variety of approaches, but all promoting student learning through one of three characteristics – structured inquiry (where the stress is on interpretation of outcomes), guided inquiry (with a stress on the approach, or process as well as the interpretation of findings), or open inquiry (where students are capable of solving self-identified scientific problems without strong teacher guidance).

But the intention within PROFILES was that modules also encompassed a 3rd stage, where the science gained was utilized in making decisions for example about a socio-scientific context identified by the module title and/or initial scenario. The communication, social and personal competences taught at this stage drew attention to the wide range of competences expected within science education and were thus a crucial component in meeting the intellectual, person and social developments and learning associated with the nature of science (Holbrook & Rannikmäe, 2007) expected of an ‘education through science’ philosophy PROFILES, 2010; Bolte et al. 2012; Holbrook & Rannikmäe, 2010).

With the above in mind, PROFILES type modules are associated with the following characteristics (PROFILES, 2010; Holbrook & Rannikmäe, 2012):

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/competences covering education through science expectations – conceptual science learning, skills development, personal developments and social issues, plus the intended number of lessons.

A *student script*, including a motivational scenario for the module and student activities, or tasks. These tasks relate to all three PROFILES stages without sub-division; 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.

Beside this, some PROFILES type modules adapted for, or created within, the partners' CPD programmes include suggested *Assessment strategies* to assist the teacher in handling formative assessment feedback during the teaching, especially in the areas of non-cognitive learning. A further and 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 in implementing PROFILES as effective as possible into practice.

The PROFILES Teacher Continuous Professional Development (CPD) Initiatives

Throughout the last 3 years of the PROFILES project almost all the partners finished at least two rounds of CPD programmes in which about 50 science teachers were involved. The minimum duration of each CPD cycle was (is) 40 hours. In many of the partners' countries, these interventions were carried out as face to face (F2F). However, some partners used additionally on-line CPD activities. Feedback data about the nature of the PROFILES partners' CPD activities was gathered through on-line questionnaires administered by the leaders of PROFILES' WP5 (the Weizmann Institute of Science), in which the partners were asked to report about the models which were implemented, difficulties that occurred, and about the implementation of the modules that were developed in most of

the cases by the partners and their participating teachers during the CPD activities. The modules were implemented in the science classrooms and teachers had ample opportunities to reflect on their experiences either orally or in a written form. In general, the partners and their related teachers developed new (original) modules based on the PROFILES goals and pedagogical approach. Few decided to adopt modules that already existed and that were already developed during the previous FP6 project – namely the PARSEL project (PARSEL, 2006). The fact that most partners choose to develop original modules is a sign for originality and positive attitude towards the PROFILES project. In the CPD, teachers, in groups opted to develop modules that were declared to be relevant to their students, to the participating teachers, to the learning environment, and to the country (education system) in which the CPD took place.

Regarding the feedback (based on the teachers' written and oral reflections) received from the partners it is reasonable to suggest that the two most prominent strategies developed/adopted for the CPD were: *The "teachers as curriculum developers" and teachers as "action researchers"* (Loucks-Horsley, Hewson, Love & Stiles, 1998; Mamlok-Naaman & Eilks, 2012). These two models enabled high involvement of teachers in the professional development procedures and enhancement. The CPD initiatives were aimed at the development of the teachers through four stages of development (see Figure 2; the Four-Stage-CPD Model based on: Hofstein, Mamlok-Naaman, Rauch & Namsone, 2012, p. 57), namely: The teacher as learner, the teacher as teacher, the teacher as professional practitioner and, for some, the teachers as leader (Bolte et al., 2011; 2012).

The CPD was planned so that teachers are able to develop significant self-efficacy in teaching, based on the PROFILES philosophy and approach and its related pedagogical interventions and skills used. This includes, as a major component, IBSE (Inquiry-based Science Education), experiencing decision-making procedures and within this practice the idea of education through science as the thrust of science education. While the 1st CPD round enabled the strengths and weaknesses of the CPD

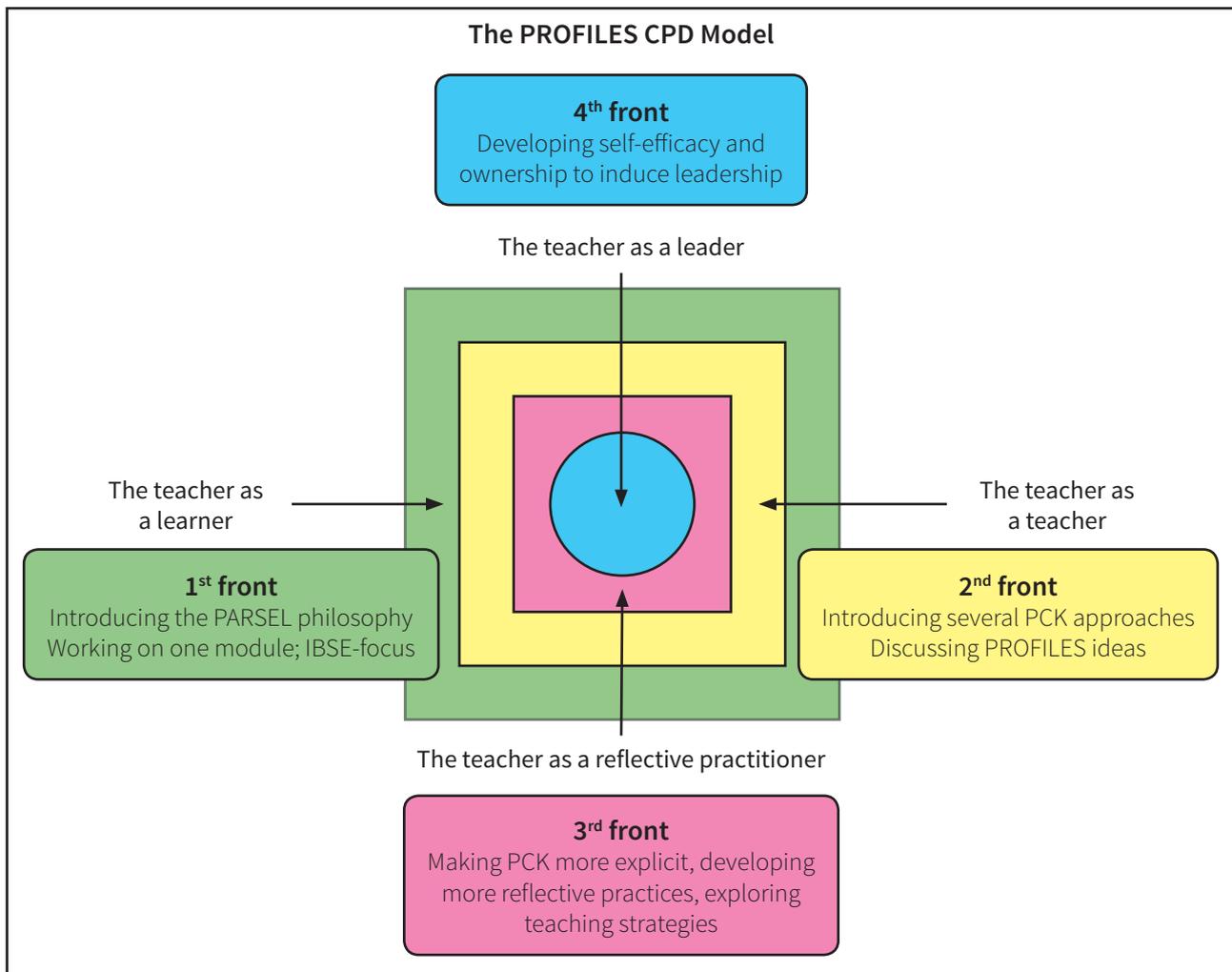


Figure 2. The PROFILES Four-Stage-CPD Model (based on: Hofstein, A., Mamlok-Naaman, R., Katchevitch, D., Rauch, F. & Namsone, D. (2012), p. 57. (PCK means pedagogical content knowledge)

procedures to be realised by the CPD providers, the 2nd round built on the prior experiences (the first CPD cycle teachers from the 1st round who strove to achieve ownership in operationalizing the PROFILES (and its related skills e.g. IBSE) ideas. In addition, during the 2nd CPD cycle partners collected (and submitted examples highlighting teachers' reflections based on case-studies, portfolios, and/or e-portfolios. These enabled PROFILES CPD providers to obtain in-depth information about teachers' developments throughout the various stages of the PROFILES CPD.

The development of teacher ownership through the PROFILES project

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 as it would be appreciated as a step forward for science teaching (see also Section 3 in this book).

The term teacher ownership and the issues related to this are rather new to most science educators in general and to science teachers in particular. Osborne (2002) suggested that teachers who are involved extensively in the process of development of learning materials will develop a sense of ownership of these. It is suggested that development of a high level sense of ownership will effect significantly on teachers' professional attitudes and their behaviour as pioneers and, for some, development of leadership (see the Four-Stage-CPD-Model in Figure 2).

The highest level of PROFILES operational goals is to enhance their teachers' ownership regarding the PROFILES goals, philosophy, and pedagogy. This target, on the one hand, sees teachers being sufficiently appreciative and skilled in applying PROFILES ideas so as to be willing and able to guide other teachers to implement PROFILES type modules to involve in the dissemination activities (e.g. in their schools with other teachers or in the region), workshops or presentation for others (such as for pre-service or in-service teachers). This is the PROFILES concept of "teacher as leader" (see Hofstein et al., 2012; Hofstein, Carmi & Ben-Zvi, 2003). Beside this, a guide, written for PROFILES partners and their professional development providers, was developed on ownership (see: <http://stwww.weizmann.ac.il/g-chem/profiles/ownership.html>).

However, the success of PROFILES can be considered from a number of perspectives. One perspective chosen by the PROFILES consortium is focusing on the teachers, for example by determining the self-efficacy of science teachers involved in PROFILES (see Section 3) or by re-constructing how PROFILES teachers change profession oriented attitudes by analysing the development of their "stages of concerns" (Schneider & Bolte, 2012; Bolte & Schneider, in this book; see Section 3).

Another perspective the PROFILES consortium decided to focus on is the perspective of the students involved in the PROFILES project and to evaluate PROFILES impact on enhancing students' scientific literacy, for example by analysing attitudinal aspects of students towards their science learning. This is undertaken within the PROFILES project by investigating students' (intrinsic) motivation to learn, the development of their interest in learning science and/or by looking at their concerns about choosing a career in the fields of the natural sciences (Albertus, Bolte & Bertels, 2012).

Analysing Student Gains

Before the PROFILES project started, different instruments had been created and adapted by the PROFILES team at the Freie Universität Berlin (FUB). Some of those were introduced to

the PROFILES partners at consortium meetings and workshops (Albertus, Bolte & Bertels, 2012). Finally, the PROFILES steering committee agreed to concentrate on one specific instrument for analyzing the students' assessment of the 'Motivational Learning Environment (MoLE)' (Bolte, 1995; 2006; Bolte & Streller, 2011) in the PROFILES classes and to compare these assessments with those collected from students in non-PROFILES classes. For this purpose the partners translated the MoLE instrument into their national languages and started their data collection within the frame of a pre-post and/or in a treatment-intervention design.

In the context of the pre-post test and treatment-control group studies the MoLE-questionnaires were administered to students before and after PROFILES lessons (see Bolte & Streller in this book – chapter 3.7; Bolte & Streller, 2012). Some partners decided to administer the MoLE questionnaires to non-PROFILES classes in order to compare the findings of non-PROFILES lessons with lessons following the PROFILES teaching and learning philosophy. In this case, the non-PROFILES classes (classes of the same grade than the PROFILES classes but which were not taught with PROFILE modules) serve as the control group (Bolte & Streller, 2011; 2012).

Up to now, more than 18.000 students and more than 900 teachers have been involved PROFILES-wide in this investigation. The MoLE analyses reports – which we have received so far – point to a significant increase in students' motivation to learn science in the treatment (the PROFILES) sample (see Bolte & Streller in this book – chapter 3.7; Bolte, Keinonen, Mühlenhoff & Sormunen, 2013). The increase of students' motivation to learn science can be shown with respect to the students of the PROFILES treatment groups' assessments regarding the MoLE scales in general (REAL assessments) and by analyzing "Wish-to-Reality Differences" (WRD), as many WRD values decrease in a statistically significant manner from the beginning (pre-test) to the end (post-test) of the PROFILES intervention (Bolte, 1995; 2006; Bolte & Streller, 2011; 2012). Besides this, it can be stated that the MoLE Instrument provides questionnaires for data collection and analyses that, by employing

only two items per scale, are an exceptionally efficient and nevertheless scientifically reliable and valid instrument (Bolte, 1995; 2006) to obtain insights into the learning atmosphere of (one's own) science classes as assessed by the students. Therefore, using the MoLE instrument can highly be recommended if teachers, CPD providers and/or science education researchers want to get insights into students' assessment of how they wish and perceive the learning and motivation climate in their classes.

As mentioned above the two work packages which are more oriented towards evaluation and evidence (WP6 "Teacher Ownership" and WP7 "Students Gains") are only briefly touched upon and in this book – the '2nd Book of PROFILES'. However, reports on the partners' activities within these two work packages (WP6 and WP7) and insights in the PROFILES treatments and their evaluative findings of the PROFILES CPD programmes and the PROFILES classroom intervention will be the main focus and emphasis of the next – the '3rd Book of PROFILES', which will be published and available via the PROFILES homepage (www.profiles-project.eu) in 2014.

PROFILES Networks and Dissemination

As an important component of PROFILES, partners set up **teacher networks** (and interacting with other networks) to both maximise the dissemination and to make teachers more aware of the PROFILES project and its goals. Within PROFILES, networks are 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 contribute to improve the regional structures best (Altrichter, Rauch & Rieß 2010). The PROFILES project itself is a good example for an international network, consisting of 22 partner institutions located in 21 different countries (see preface). Some partners are involved in other EU projects both offering opportunities for synergies as well as support for the international impact of the PROFILES philosophy. Figure 3 shows the diversity

of PROFILES member countries.

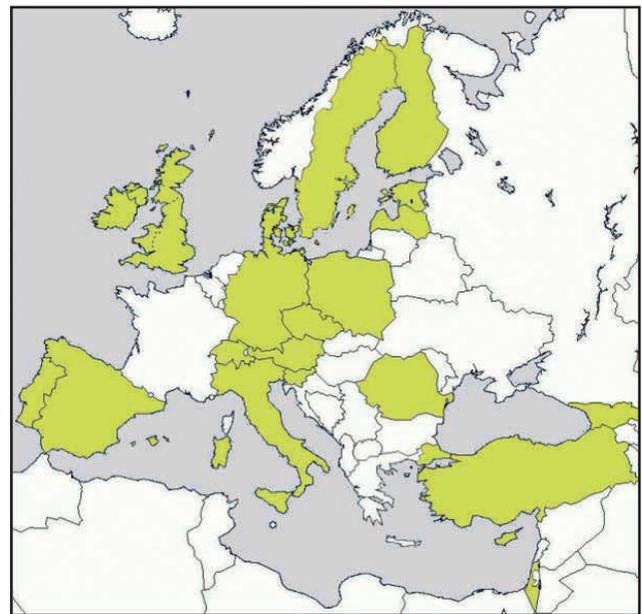


Figure 3. Distribution of the PROFILES partner countries

Although the initial situation differs in every partner country, partners can build on already existing structures (Rauch & Dulle, 2012). Questionnaire results show that PROFILES Networks are mainly supported by six factors:

- Information and Communication Technology (ICT)
- The interest and motivation of teachers and
- Institutional support and that from other networks
- EU projects (like PROFILES)
- A clear network concept
- A change of educational framework conditions (curriculum reform)

Barriers to the networking process are mainly seen in the fields of resources (e.g. a lack of time and finance) and a lack of motivation of teachers or CPD participants. Furthermore, it was (often) stated that networking requires an additional need for administration.

The dissemination of the PROFILES approach 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 becoming 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 (PROFILES, 2010; Bolte, Holbrook & Rauch, 2012). To reach these goals, the project partners:

- support the PROFILES International Homepage (see: www.profiles-project.eu),
- maintain their local PROFILES webpages which are regularly updated and reached via a) www.profiles-project.eu or b) <http://ius.uni-klu.ac.at/misc/profiles/articles/view/15>,
- distributed within the first two years of the PROFILES project, approx. 6.000 printed and 10.000 digital PROFILES booklets (flyers),
- published five PROFILES Newsletters in English and German languages and translated at least parts of these newsletters into their national languages and disseminated these among teachers and stakeholders in their respective country (Volume #6 of the PROFILES Newsletter will be published and disseminated in Summer 2014),
- adapted and developed a broad number of innovative PROFILES learning and teaching materials, which can be accessed on the PROFILES partners' local websites via www.profiles-project.eu and http://www.profiles-project.eu/PROFILES_Modules/index.html,
- presented workshops and papers at national and international conferences or at their PROFILES National Stakeholder Meetings and/or published articles in teacher and science education journals articles on local, European and international levels. A list of these PROFILES presentations and publications, periodically updated, can be found via: <http://www.profiles-project.eu/Dissemination/PROFILES-Publications/index.html>.

Another dissemination activity was the first International PROFILES Conference on 'Stakeholders Views regarding Inquiry-based Science Education' that took place from the 24th to 26th of September 2012 in Berlin, Germany. Among the more than 100 participants not only project partners from 20 different PROFILES countries

could be found but also colleagues from schools, school-administration and universities that were interested in Inquiry-based Science Education (IBSE).

The second (and final) PROFILES International Conference on 'How to enhance IBSE and Scientific Literacy' in Europe' will take place from 25th to 27th August 2014 in Berlin (see www.profiles-project.eu). Project results will be presented to stakeholders, other invited guests from schools and other educational practices, as well as colleagues from other EU projects related to the Conference's topic. Furthermore and as mentioned before, a '1st Book of PROFILES' titled "*Inquiry-based Science Education in Europe: Reflections from the PROFILES Project*" was published in 2012 (see Bolte, Holbrook & Rauch, 2012), including presentations by invited speakers from the 1st International PROFILES Conference on Stakeholders Views (held in Berlin, 24–29 September 2012). This book also includes a more detailed introduction of the PROFILES project aims and framework provided by the initiators of the project with a special emphasis on four selected work packages; namely WP3 (Stakeholders' Involvement and Interaction), WP4 (Learning Environments), WP5/6 (Teacher Training and Ownership) and WP8 (Dissemination and Networking). The '1st Book of PROFILES' can be downloaded via: www.profiles-project.eu and http://ius.uni-klu.ac.at/misc/profiles/files/Profiles%20Book%202012_10.pdf.

By 2013, PROFILES networks (in connection with other science education networks) include approx. 3.400 teachers and 1.313 educational institutions across all partner countries. Within 2014, all partners plan to expand their networks, include new members and interlink with other networks and associations. In this context most PROFILES partners plan to conduct further regional and/or national seminars and workshops and attend national and international conferences (see Section 4, *Case Studies on Networking and Dissemination*).

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**SECTION 1:
CASE STUDIES ON SCIENCE EDUCATION
BASED ON STAKEHOLDERS' VIEWS
OBTAINED BY MEANS OF A NATIONAL/
INTERNATIONAL PROFILES
CURRICULAR DELPHI STUDY**



Case Studies on Science Education based on Stakeholders' Views Obtained by Means of a National/International PROFILES Curricular Delphi Study

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Introduction

With respect to the objectives of PROFILES (2010) – such as 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 – the involvement, support and interaction of different stakeholders and to take into account their views and opinions is an essential part of the PROFILES project (Bolte et al., 2011, 2012). This aspect has mainly been recognized within Work Package 3 “Stakeholder Involvement”, one of the eight different work packages (WP) embedded in PROFILES and contributing to the goals of PROFILES (PROFILES, 2010). All of the eight different work packages are connected through interdependencies and benefit in this way from each other in various ways. The particular value and thrust of involving different stakeholders within WP3 is in bridging “the gap between the science education research community, science teachers and local actors” (PROFILES, 2010), allowing cooperation and enhancing other project activities through processing and disseminating the different stakeholders' views. Stakeholder involvement has in WP3 in particular been realized by applying the Delphi method (Linstone & Turoff, 1975) through the “*International PROFILES International Curricular Delphi Study on Science Education*”. This study currently includes most of the different PROFILES partners implementing a curricular Delphi study in their respective countries, collecting and analysing systematically in a three-stage procedure the different stakeholders' views on desirable science education.

The method of a curricular Delphi study (Bolte, 2008; Häußler, Frey, Hoffmann, Rost & Spada, 1988; Mayer, 1992; Osborne, Ratcliffe, Collins, Millar & Dusch, 2003) was chosen as a systematic approach to involving a wide range of stakeholders in order to bring together their views and opinions. The aim of the “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 identifying desirable aspects and approaches of modern science education with regard to scientific literacy.

The overarching question that is particular focused on in the course of the “International PROFILES Curricular Delphi Study on Science Education” is *what aspects of science education do you consider advisable and pedagogically desirable for the individual in the society of today and in the near future?* Relevant stakeholders included in this study are groups that are involved with science and science education. In the sample, these are in particular students, pre- and in-service science teachers, science education researchers and scientists (Schulte & Bolte, 2012). The structure of the International PROFILES Curricular Delphi Study on Science Education allows not only individual analyses of each of the PROFILES partners' stakeholder views, but enables comparisons on an project-wide international level as well (Schulte & Bolte, 2012; Schulte et al., 2013).

The main purpose 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 meaningful way (Linstone & Turoff, 1975). The results of Delphi studies serve to gain specific insights about aspects of a particular field or topic that are difficult to determine and to predict (Häder, 2000). In this way, the results derived from these predictions provide guidance and support for the accomplishment of tasks and the realization of goals.

The Delphi method is characterized by several characteristic features. In general, a Delphi study involves a fixed group of participants ('experts') who engage with a certain topic in several consecutive steps (rounds). After every round, empirically

determined group answers of the respective preceding round are fed back to the participants. In this manner, 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. Thus, gradual processing of the general question is reached. Another methodical feature of the Delphi technique is that the participants interact and cooperate anonymously among each other throughout the study. This is to avoid participants being influenced or affected by each other at a too early stage, e.g.

by the opinions of well-known and renowned individual participants. The data collection, the analyses and the reciprocal information flow are carried out by a central working group (Häder, 2000; Linstone & Turoff, 1975). As for the curricular aspects, the working group develops specific criteria for selecting the participants dealing with curricular matters in the course of the study. Moreover, the general question is specified with a formal question and answer format (Häußler, Frey, Hoffmann, Rost & Spada, 1980).

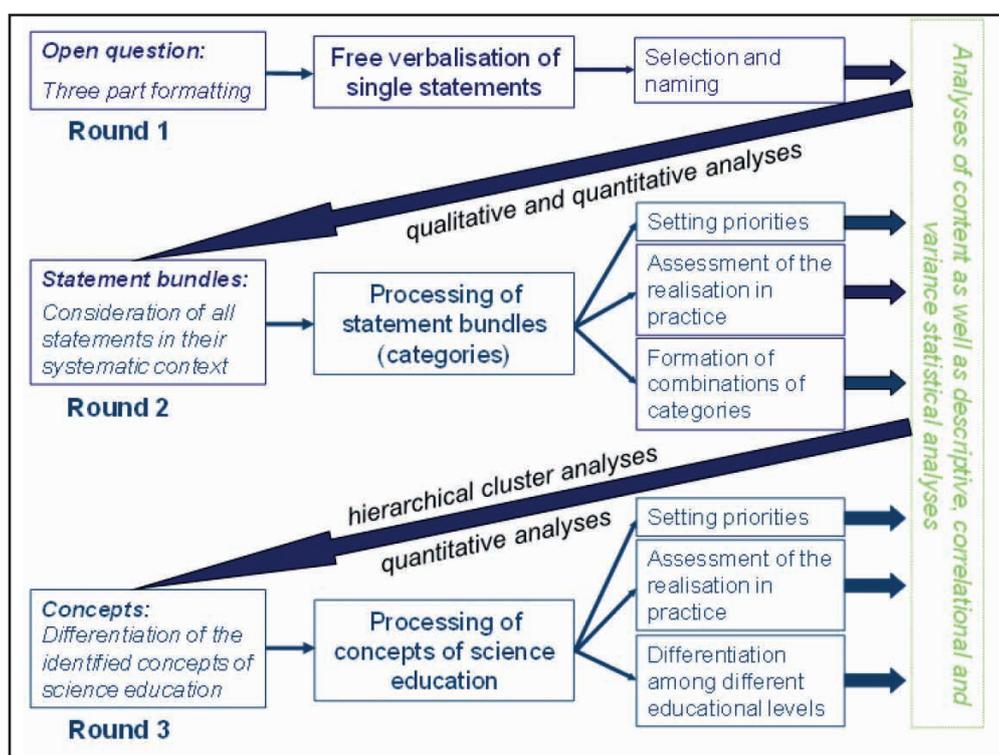


Figure 1. Method of data collection and data analysis in the Curricular Delphi Study on Science Education (Bolte, 2008)

Brief Overview of the International PROFILES Curricular Delphi Study on Science Education

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 questions refer to

motives, situations and contexts that could initiate science related educational processes, to topics and fields that should be addressed in science lessons and to qualifications and attitudes that should be developed and enhanced to support students in becoming scientifically literate. 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 evaluated statistically (Bolte, 2003b, 2008; Schulte & Bolte, 2012).

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. These assessments are made on a 6-tier rating scale, ranging from 1 (“very low priority” / “to a very low extent”) to 6 (“very high priority” / “to a very high extent”). Furthermore, in order to identify concepts of science education and to reduce and condense the high amount of different aspects that are considered important regarding desirable 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 and translated into concepts of meaningful science education (Bolte, 2003a, 2008; Schulte & Bolte, 2012, 2013).

In the *third round*, the identified concepts are fed back to the participants for further assessment from two different perspectives analogously to the first part of second round. In a further step, the participants are also asked to differentiate their assessment among different educational levels (Schulte & Bolte, 2012).

The PROFILES Steering Committee agreed on aiming at a sample size of about 100 stakeholders per partner, encompassing the following four sample groups: Students ($n \approx 25$), science teachers ($n \approx 25$), science education researchers ($n \approx 25$) and scientists ($n \approx 25$). By now, more than 2.700 stakeholders from 19 different countries have been involved, providing valuable insights about their views on desirable science education (Schulte & Bolte, 2012). Insights from five different national curricular Delphi studies are offered in the following contributions.

How Findings of the (Inter-)National Curricular Delphi Studies have an Impact on the Work in the PROFILES Project

In the following five articles, different consortium partners present in five case studies their most recent findings in the field of stakeholder views.

In particular, they underline specific aspects of the outcomes of their national “Curricular Delphi Studies on Science Education” and discuss them in view of other project activities and topics from different perspectives.

The first contribution, written by the team of the Ilia State University in Georgia, focuses on the results of the first and second round of their Delphi study in Georgia and describes how the outcomes especially of the second round of their Delphi study enhanced the CPD workshops in Georgia and the adaption and development of PROFILES type modules they conducted within their PROFILES CPD courses.

The second contribution, prepared by the team of the University of Valladolid in Spain, addresses key points for motivating contexts in science education, which they identified throughout their Delphi study, bridging in this way the results of their Delphi study and the development of appropriate IBSE modules which were used for the CPD course in their PROFILES long term teacher training programme.

The third contribution, composed by the team of Karlstad University in Sweden, compares different Swedish stakeholders’ views on science education determined in the first two rounds of their Delphi study and against the current Swedish curriculum for the science subjects in grade 7–9. The article then shows exemplarily how to embed the findings of this comparison in developing a PROFILES 3-stage teaching module to promote inquiry-based science teaching and learning in Sweden.

The fourth contribution, presented by the team of the FHNW in Switzerland, elaborates on how the results of the Swiss Delphi Study can be interpreted and used for the future development of science education programs and curricula in Switzerland by drawing a connection between their empirically determined findings and aspects present in the current science curriculum.

The fifth contribution, provided by the team of the Dokuz Eylül University in Turkey, addresses the realization of IBSE within their PROFILES activities, highlighting how outcomes of their Delphi study were used for enhancing their PROFILES CPD

courses. In particular, their article aims at showing how the diversity and discrepancy in the teachers' perceptions regarding science education in Turkey relates to the views of the other included stakeholders and what attempts were undertaken to meet these discrepancies through the PROFILES continuous professional development programs in Turkey.

In all the five cases it is shown that the implementation and realisation of the "International PROFILES Curricular Delphi Study on Science Education" has been valuable and that its results turned out to be helpful in enhancing the work on the PROFILES CPD programs or other PROFILES work packages. Currently, we are further working on elaborating common features and differences regarding comparisons on an international level. On the findings with respect to the international perspective and common sense concerning the term of "Scientific Literacy" we will certainly soon report; supposedly in the 3rd PROFILES Book.

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1.1 Stakeholders' Views on Science Education in Georgia – Curricular Delphi Study

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Abstract

This article indicates the views of stakeholders in science education in Georgia through a three round Delphi study. Outcomes from the study were used to guide the direction of a continuous professional development (CPD) programme under PROFILES promoting motivational inquiry-based science education. Details of the way the Delphi study outcomes impacted on the CPD programme are given. Revised curricula are anticipated in 2016 and related to this the differing views of stakeholders about science education in a future Georgia can be expected to have a significant impact.

Introduction

National educational reforms in Georgia began in 2004. During these years, several versions of new national curricula for both elementary and secondary schools were first piloted and then implemented. One focus in these processes was the current situation related to science education and the importance of a scientifically literate society. Much attention was paid to the development of new science curricula which acknowledged a more inquiry-based and student-oriented approach. In view of these developments, an important but belated consideration was to establish modern and contemporary understanding of the desirable science education in schools offering general education.

For an inclusive approach, taking into account the views and opinions of a wide section of those related to aspects of modern and desirable science education. It is necessary to bridge the gap between the differing view of diverse groups within the society, involved or having an interest in the science education offered in schools (termed here as “stakeholders”). This article relates to an approach seeking views and opinions using a Delphi study. The aim of the “Curricular Delphi Study on Science Education” – which the Ilia State University (ISU) conducted in accordance with (Bolte, 2008; Schulte & Bolte, 2012) is to engage different stakeholders in reflecting on the focus, content and aims of science education, as well as outlining aspects and approaches of their considerations on modern science education. In this regard, the Curricular

Delphi Study on Science Education in PROFILES partner countries (PROFILES Consortium, 2010) is intended to offer comprehensive insights into opinions of different stakeholders in the society who have a concern or interest in the sciences and science education taught in schools, such as students, science teachers, science educators/researchers and scientists. This article does not relate to other sectors of society, most notable employers who engage young people in a variety of employment arenas.

The specific Georgian study involved participants in providing feedback in three rounds. The first round offers participants the possibility to express their ideas about aspects of contemporary and pedagogically desired science education through three open-ended questions regarding “motives, situations and contexts”, “fields and methods” and “qualifications” (Bolte & Schulte, 2011).

In this article we present the results of the first and second round of the Curricula Delphi study on Science Education in Georgia. Also we provide an overview about the third round, as well as a short overview about the first round of the PROFILES continuous professional development (CPD) programme for science teachers.

Results from 1st and 2nd round of the Delphi Study in Georgia

In total, 186 potential participants (‘experts’) in Georgia were asked, via e-mail, to fill out the 1st

Group		Number of questionnaires sent	Number of responses	Response rate
Students		46	34	76%
Science teachers	Science education students at university	8	6	61%
	Trainee science teachers	2	2	
	Science teachers	29	14	
	Trainee science teacher educators	10	8	
Science educators		40	13	33%
Scientists		35	27	77%
Others *		16	6	38%
Total		186	110	59%

*Note 'Others' in the table refers to the people, who worked in science (physics, chemistry, biology), but they left their profession for different reasons.

Table 1. Structure of the sample, participatory groups and participation rates for round 1

round Delphi questionnaire. As shown in Table 1, 110 stakeholders responded in the different groups. The range of participants' statements from the first round were processed using qualitative and quantitative analyses and a final classification system was developed and established on the basis of the PROFILES system recommended by FUB. The classification system consists of 100(+9) (9 categories are for the additional Methodological aspects); the categories are listed in Table 2. In most cases, the categories agree with categories established in previous Delphi studies in sciences (Bolte, 2008) and refer to guidelines and aspects of modern science education stated in educational literature (Bybee, McCrae & Laurie, 2009; Fensham, 2009). The category system developed in the Freie Universität Berlin was taken as the basis for the Georgian system as shown in Table 2 (Bolte et al., 2011). Table 2 presents an overview of the categories after the 1st round, where the additional categories of ISU are indicated in italics. From quantitative analyses, the frequencies of how often

the categories were mentioned by the participants were determined.

Delphi – 2nd round

The second round of the Curricular Delphi Study is based on the questions which results from the areas of emphasis in the first round (Bolte, 2003; 2008; Häußler, Frey, Hoffman, Rost & Spada, 1980; Listone & Turoff, 1975; Mayer, 1992). Following the Delphi Method, the second round consisted of a two-part questionnaire which was sent to all participants responding to the first round questionnaire. As shown in Table 3, 83 of the 110 stakeholders who participated in the first round responded also to the second round questionnaire. There was an increase in the numbers of in-service teachers and science educators in the second round responses. It was predicted that this was because some participants changed groups – for example scientists, or trainee teachers became in-service teachers, etc.

I: Situations, contexts, motives	II: field		III: Qualification	IV (Addition): Methodical aspects
	IIa: (Basic) concepts and topics	IIb: Scientific fields and perspectives		
N = 19	N = 21	N = 35	N = 25	N = 9
<ul style="list-style-type: none"> • Education / general development • Emotional / personality development • Intellectual / personality development • Students' interests • Curriculum framework • Nature / natural phenomena • Everyday life • Medicine / health • Technology • Society / public concerns • Global references • Occupation • Science – biology • Science – chemistry • Science – physics • Science – inter-disciplinary • Out-of-school Learning • Science development perspectives • Experiments, practical work 	<ul style="list-style-type: none"> • Matter/particle concept • Structure /function / properties • Chemical reactions • Energy • Scientific inquiry • Cycle of matter • Food / nutrition • Health / medicine • Matter in everyday life • Technical devices • Environment • Safety and risks • Occupations / occupational fields • <i>New Technology and its application / industrial processes</i> • <i>Modern scientific achievements/scientific investigations</i> • <i>Agriculture</i> • <i>Universal science laws</i> • <i>Life processes</i> • <i>Physical Phenomena</i> • <i>Chemical phenomena</i> • <i>Connections between phenomena</i> 	<ul style="list-style-type: none"> • Botany • Zoology • Human biology • Genetics / molecular biology • Microbiology • Evolutionary biology • Ecology • Inorganic chemistry • Organic chemistry • Biochemistry • Mechanics • Thermodynamics • Atomic / nuclear physics • Astronomy / space system • Earth sciences • Mathematics • Inter-disciplinary • Consequences of technological development • History of the sciences • Ethics / values • <i>General chemistry</i> • <i>Applied Chemistry</i> • <i>Cell biology</i> • <i>Life science</i> • <i>General biology</i> • <i>Relativistic theory</i> • <i>Electricity</i> • <i>Optics</i> • <i>Molecular physics</i> • <i>General Physics</i> • <i>Quantum mechanics</i> • <i>Biophysics</i> • <i>Biochemistry</i> • <i>Cosmetology</i> • <i>Pharmacology</i> 	<ul style="list-style-type: none"> • (Specialized) knowledge • Applying knowledge / thinking abstractly • Judgment / opinion-forming / reflection • Formulating scientific questions / hypotheses • Being able to experiment • Rational thinking / analyzing / drawing conclusions • Working self-dependently/ structurally / precisely • Reading comprehension • Communication skills • Social skills / teamwork • Motivation / interest / curiosity • Critical questioning • Acting reflectively and responsibly • <i>Inquiry skills</i> • <i>Civic</i> • <i>Environmental awareness</i> • <i>Observation, perception</i> • <i>Classification</i> • <i>Finding information</i> • <i>Creativity</i> • <i>Safety skills</i> • <i>Life skills/ first-aid</i> • <i>Problem-solving</i> • <i>Numeracy</i> • <i>Metacognition</i> 	<ul style="list-style-type: none"> • Interdisciplinary learning • Inquiry-based science learning • Using new media • <i>Learning based on previous knowledge</i> • <i>Project learning</i> • <i>Learning in small groups</i> • <i>Individual work</i> • <i>Using visual resources</i> • <i>Student based learning</i>

Table 2. Overview of the categories for the analysis of the experts' statements

Group		Number of questionnaires sent out	Number of responses	Response rate
Students		34	20	59%
Science teachers	Science education students at the university	6	6	87%
	Trainee science teachers	2	0	
	Teachers (in-service)	14	15	
	Trainee science teacher educators	8	5	
Science educators		13	14	100%
Scientists		27	19	70%
Others		6	4	67%
Total		110	83	75%

Table 3. Structure of the sample in the 2nd round Delphi study and participation rates

The first part of the questionnaire asked participants to assess the categories developed in the first round analyses in two different ways:

1. they were asked to rate the priority to the given categories, and
2. they were asked to evaluate how they think these categories are implemented in science education practice.
3. For both cases (priority and praxis) the participants used a six-tier rating scale.

In the second part of the second round study, the participants were asked to combine these categories to form a set of category bundles that seem to be especially important to their combination.

Table 3 shows ISU sample structure and

participation rate for the second round. It is visible, that total number of participants 83 (75% of the participants from the first round) took part in the second round.

An increased number of in-service teachers and science educators were included in the second round. The reason for this is an exchange between the groups – for example scientists or trainee teachers became in-service teachers, etc.

The results from the second round were analyzed statistically. Categories chosen by the participants were clustered by means of cluster analyses and were interpreted as “conceptions for contemporary science education.” Three such clusters were identified as:

Concept A: Awareness of the sciences in social and scientific contexts in both educational and out-of-

school settings.

Concept B: Intellectual education in contexts of scientific inquiry, development of general skills and occupation.

Concept C: General science-related education and facilitation of student's interest in contexts of everyday life using modern and various methods of education.

The labeling of these three clusters are based on the FUB concept (Bolte & Schulte, 2012) because of similarities and overlap in terms of content.

After the first and second rounds of the Delphi Study, it was clear, that Georgian stakeholders stress the importance of scientific context, as well as connections with everyday life in both educational and out-of-school settings. It is also worth mentioning the priority given of scientific inquiry and the development of general educational skills.

Delphi – 3rd Round

All 83 stakeholders who had participated in the 2nd round took part in the 3rd round of the study. The questionnaire for the 3rd round consisted of two parts:

1. Stakeholders were asked to assess the results of the Georgian responses from round 2, and
2. Stakeholders were asked to estimate the concepts, developed by the FUB PROFILES team on the basis of their clusters (Bolte & Schulte, 2013)

The analysis of this data is ongoing.

PROFILES CPD programme

Based on the outcomes of the 1st and 2nd rounds of the Delphi study, in which the Georgian stakeholders stressed the importance of scientific context connected with everyday life, both for in-school settings and for out-of-school activities, it was considered feasible to use the results of this Delphi study to guide the PROFILES CPD programme and to plan activities based on these, especially with

respect to the differences between the priority and praxis. The aim of the CPD training and the classroom intervention using PROFILES modules was to encourage in-service teachers to implement motivational IBSE in their schools and integrate the PROFILES approach into their teaching practice.

In total, 19 science teachers from different regions of Georgia participated in the 1st PROFILES CPD programme (7 biology, 6 chemistry, and 6 physics teachers) and 5 inquiry-based modules were suitably adapted from PARSEL (www.parsel.eu), or other sources and implemented in Georgian schools:

1. "Stumbling over Biodiversity" (Pany, 2011)
2. "Preventing Holes in Teeth" (Lindh, Nilsson, & Kennedy, 2009)
3. "Brushing up on Chemistry" (Tsaparlis & Papaphotis, 2009)
4. "Traffic Accident: Who is to blame" (Holbrook, 2009)
5. "Cola and Diet Cola" (Streller, Hoffmann, & Bolte, 2011; Streller, 2012)

The relevance of these modules to society and the everyday life increased students' interest in the subject.

Findings from implementation of the PROFILES modules in schools.

The following feedback indicate Georgian teachers' impressions regarding their experience when implementing inquiry-based learning using PROFILES modules and teaching approaches after the PROFILES CPD programme: a biology teacher (N1) mentioned:

"Students were involved with great interest. One boy, who was never active during the lessons, was seen as the best in all PROFILES activities";

a physics teacher (N2) stated:

"Students became very active; they undertook measurements in the school corridor and involved students from other classes";

a biology teacher (N3) said:

“All students were very active. They created a video in the dental clinic on their own initiative and brought their own resources to the classroom for investigation”;

a biology teacher (N4) said:

“After implementing PROFILES modules I was able to find my own way of teaching”; and

a chemistry teacher (N5) answered:

“Students asked me to have similar lessons at least once a week and, during the lessons, they considered themselves ‘great researchers’”.

This initial feedback shows the very positive attitudes of Georgian science teachers to the project and to the CPD. Further we observe changes in the teaching praxis of teachers after the CPD courses and implementation of PROFILES modules.

It is planned to implement a 2nd PROFILES programme along similar lines. During the programme the results of the Georgian Delphi study will be discussed in relation to the PROFILES philosophy and approach.

Conclusion

For many years in Georgia, the main approach to teaching has been to promote content-based learning. The system of education has been highly centralized, stemming from an imposition of unified methodological approaches implemented in the Soviet Union countries.

Interest in the Delphi study is caused by the National Educational Reform undertaken in Georgia, beginning in 2004. Although several versions of the new curricula were piloted and implemented during 2004–2010, another revised version of the national curricula for the elementary level was implemented in the 2011–2012 school year and in 2012–2013 this was extended to the basic and secondary school level for all public schools. These ongoing reforms

radically change the educational system and new requirements are being suggested for science teaching as well. Inquiry-based learning and problem-based learning approaches were the main methods suggested from Ministry of Education and Sciences, although the PROFILES approach based on a wider philosophy incorporating education through science learning outcomes was also encouraged.

Nevertheless, new revised curricula are anticipated in 2016. And related to this, it is very important to capture the different views of stakeholders about science education in Georgia. The outcomes of the full three rounds of this study will be used to guide the CPD further and seek to enthuse teachers in improve science teaching in the country.

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1.2 Using the Delphi Technique to Improve Science Education in Spain

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Abstract

This article identifies key points in the various fields of science that can improve the scientific culture in today's society. While numerous authors have agreed on the importance of improving and intensifying the scientific culture in society in general, and more particularly among pre-university students, it is difficult to unravel what fails in educational practice, as well as what are the topics of a good culture and science education. Through the use of the Delphi technique we collect the views of more than one hundred individuals from different groups related to the field of science and education. From a cluster analysis of data from the second round, a set of five concepts were identified. And, from a third round, one concept seemed very important for all four groups of stakeholders; that is Concept E: Science related with the interest to preserve the Earth and human health. Taking into account these results, the Spanish PROFILES partner decided to focus on these concepts and new IBSE modules were developed by some stakeholders participating in the Delphi study. Two new modules proposed and implemented in the classroom: "The alcohol we could drink for driving safely" and "Will our coastal areas be submerged because of Global Warming?" were developed. We discuss this development.

Introduction

The results from 15 year old Spanish students in the PISA tests (Programme for International Student Assessment) in science are very poor (OECD 2003; 2007; 2009; 2011). Several studies have shown the value of approaching science teaching from an inquiry-based method, because it increases students' interest and attainments levels and stimulates both, students' and teachers' motivation (Rocard et al., 2007). This change in science teaching, from mainly deductive to inquiry-based methods, impacts directly on teachers, key players in the science teaching renewal. 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).

Because of the need and importance of quality training, one area susceptible to use these inquiry-based methods is higher education. Furthermore, the formation of future primary teachers is, specifically, an ideal space for this (Kenny, 2010). Vilches and Gil-Pérez (2007) consider that the changes in teaching must be extended to University teachers in the training of 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."

Under this scenario, the Delphi technique (Bolte, 2008) has been used in order to seek evidence on the keys to improve science education. The statistical analysis of the data collected from several questionnaires administered to various stakeholders (more than one hundred from students, high school teachers, university faculty and teacher educators, scientists and researchers) are shown in this study. The first results from the third and last round of the Delphi study are also shown and discussed.

From this, we illustrate how new PROFILES Modules have been developed using the results from the Delphi study. New IBSE modules have been developed by some stakeholders participating in the Delphi study, which involve inquiry strategies in the health education and environmental fields.

The UVa PROFILES Curricular Delphi Study on Science Education

The Delphi method is based on asking a fixed number of groups of stakeholders throughout the different rounds (Linstone & Turoff, 1975). In

this study, four groups of stakeholders have been selected. Initially, 160 stakeholders (70 students, 30 teachers, 30 educators and 30 scientists) were invited to participate, with a total of 126 actually participating in the first round. Participants were asked in written and electronic form to fill out the PROFILES Delphi questionnaires (Bolte & Schulte, 2011).

The first round of the UVa PROFILES Curricular Delphi Study on Science Education started by presenting to the participants a set of 80 aspects (categories), based on the FUB (Freie Universität Berlin) category system and asking them to mark those, which in their view, were the most important categories. Following in terms of content the FUB category system, the items were grouped into 5 categories (Motives, Topics, Science fields, ability/skills and learning strategies) (Bolte & Schulte, 2011).

UVa sample structure and % of participation in the total sample.

The second round took place in two parts. In the first part of round 2, the participants were asked to assess the categories established in the course of the first round analyses from two different perspectives. On the one hand they were asked to prioritize the given categories and, on the other hand, to assess to what extent the aspects expressed by the categories are realized in practice in science education. In the second part, the participants were asked to combine the given set of 80 categories into those categories that seemed especially important to them (Bolte & Schulte, 2012). The number (N) changed for the different rounds given that some of the participants did not send the questionnaires, or the questionnaires received were not useful.

Group	Round 1		Round 2. – 1 st Part		Round 2. – 2 nd Part		Round 3	
	N	%	N	%	N	%	N	%
Students	61	48	27	32	18	19	54	45
Science Teachers	22	17	20	24	24	26	23	19
Science Educators	22	17	18	21	25	27	21	18
Scientists	21	17	19	23	27	29	21	18
Total	126	100	84	100	94	100	119	100

Table 1. Sample structure of the UVa PROFILES Curricular Delphi Study on Science Education, N being the number of questionnaires and % the percentage of participation of each group in the total sample.

In the second round, we sent the questionnaire to the same 160 participants who were contacted in the first round. In this way, the UVa PROFILES Curricular Delphi Study on Science Education modified the general Delphi methodology in such a way that in each round, the same initial group of stakeholders was contacted. The participants were presented with the same set of categories and were asked to assess these categories according to their priority and to their realization in practice. The number of valid questionnaires received in each group were as shown in Table 1. Table 1 shows the

Results of Round I

For every category we have selected the three items more voted by the stakeholders. As for motivation (first category group) in the study of science, it seems that the greatest motive for the groups of science educators and scientists is Education. With respect to concepts (second category group) this includes: Energy and Environment, very generally referred to by teachers and scientists. In scientific fields (third category group) highlight the Human Biology and Earth Sciences, as voted by teachers

of both groups. Furthermore, the skills (fourth category) most valued by students and teachers are the training in secondary school critical thinking, reasoning and ability to analyze and drawing conclusions along with compression, and in terms of teaching and learning strategies (fifth category group) highlights the most votes in the group of scientists, science learning by inquiry.

Results of Round II

In order to identify concepts related to science education that were considered important, the participants in part II of round 2 were asked to combine, from the given set of 88 categories, those categories that seem especially important to them. The results of the hierarchical cluster analyses were based on the form sheets which the participants were asked to fill out in the second part of the questionnaire (Bolte & Schulte, 2012; Schulte & Bolte, 2012). Every participant filled out one form sheet. The identification and content-related profiling of conceptions about desirable science education was conducted by the FUB team. This was based on hierarchical cluster analyses of the data of the total sample collected in the second part of round and took place in several consecutive steps (Pérez, 2004).

From the cluster analysis from the second round, a set of five concepts were identified:

- Concept A: *Knowledge of science in the relevant basic concepts, properties, processes.*
- Concept B: *Science related education and facilitation of interest in the context of safety-risks, emotional and social concerns.*
- Concept C: *Science related to everyday life and occupational fields, promoting student interest.*
- Concept D: *Development of the intellectual personality through interdisciplinary science knowledge.*
- Concept E: *Science related with an interest to preserve the Earth and human health.*

Results of round III

In the third round of the PROFILES Curricular Delphi Study on Science Education, the stakeholders were asked, using a Likert scale, about the importance which each concept has in real (practice) science education at the secondary school level and their actual importance (priority) (Bolte & Schulte, 2013). In general the five concepts were, from the participants' point of view, not realized in science education in accordance with their priority, as shown by Figure 1. Concept A is the only concept that showed, for all participant groups, practice in classrooms related to the priority given by the stakeholders.

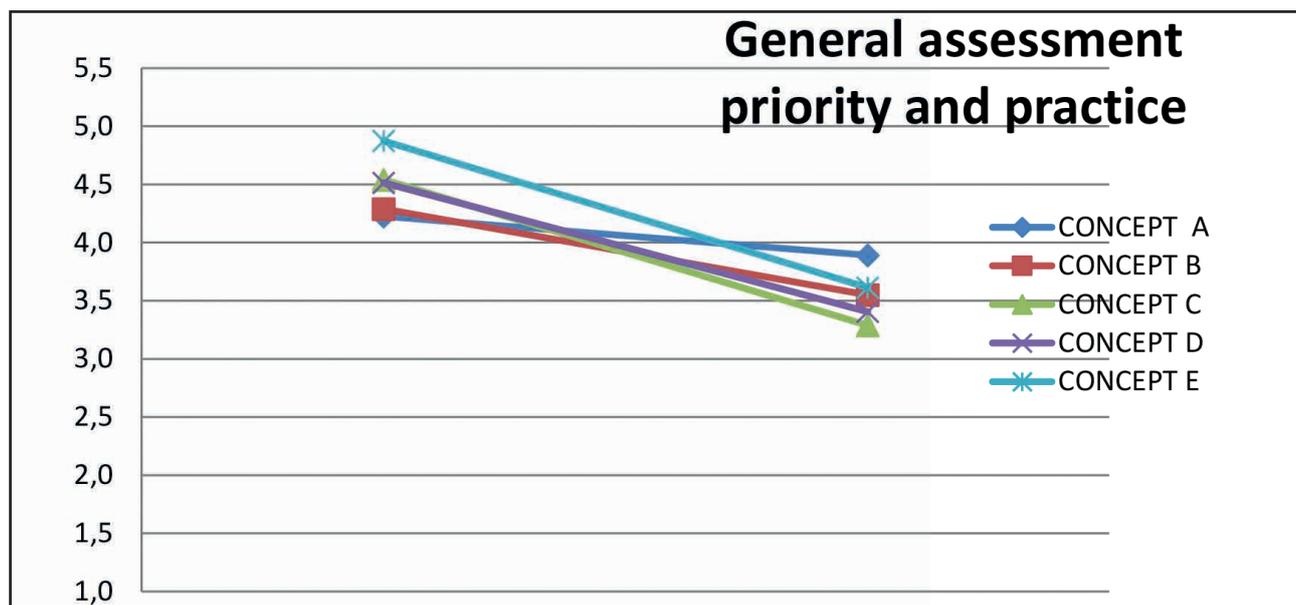


Figure 1. The priority and practice results from the third round.

Sample	Concept A		Concept B		Concept C		Concept D		Concept E	
	Mean	St.Dev.								
Students	0,130	1,8536	0,019	1,3939	-0,648	1,6952	-0,519	1,5751	-1,241	1,6361
Teachers	-1,000	1,2060	-1,304	1,1455	-1,783	1,2777	-1,783	1,7827	-1,304	2,0546
Educators	-0,952	1,9359	-1,238	1,0911	-1,095	2,0471	-1,333	1,8797	-0,571	1,5991
Scientist	-0,762	1,6705	-1,667	1,0165	-2,238	1,0911	-2,095	1,3381	-1,810	1,5690

Table 2. Results of priority-practice differences for every concept and every group from the third round.

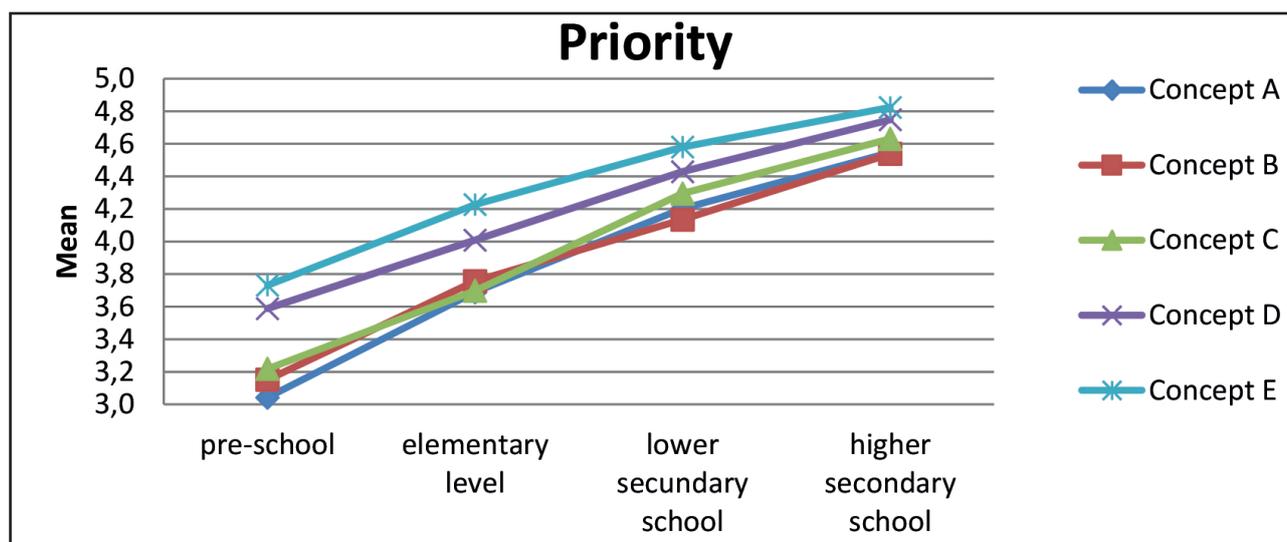


Figure 2. The results of how the priority of every concept is evaluated by the participants for each educational level.

The priority-practice differences were evaluated, and analyses of the data undertaken for each group of stakeholders. Table 2 indicates the differences for every concept.

The largest difference corresponded to concepts C and D, particularly in the opinion of the scientist group. This means that these two concepts differed in practice from the priority given by the group of scientists.

Additionally, in the same questionnaire and using, for the same concepts and priority and practice the same scale, the participants were asked about their opinion regarding each educational level (pre-school, elementary school, lower secondary level and higher secondary level). The results for the priority assessment were as showed in Figure 2.

The Delphi method identified consensus among the participants. The four groups of the stakeholders

agreed about the importance of the five concepts in desirable science education and their respective realization in educational practice, but they also agreed that the practice of these was not at the same level. This feature meant that the preparation of PROFILES continuous teacher training courses, focusing on innovative science teaching, was an important need.

Looking for the appropriate IBSE Modules

“PROFILES promotes IBSE through raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students, supported by stakeholders.” (PROFILES, 2010).

“The proposed innovation is that, 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.” (Bolte et al., 2011).

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 (Healey, 2005).

Building an IBSE Module in the environmental context

Starting with the idea that one of the clues for student motivation could be the environmental context, we decide to develop a scenario for a new IBSE module in the training of teachers. The new module, developed by students of the Master of Secondary Teacher Education and supported by the PROFILES Spanish group was 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 for Global warming. The competences involved were determined as: investigative, manipulative and cooperative-working skills, conceptual understanding, theory development and its application, experimental-error analysis and communication skills. The curriculum content was related to Chemistry, and in particular to the study of water properties in the solid state, density, hydrogen bonding and others. The module followed the PROFILES three-stage model. This module began with a scenario (Stage 1), where the teacher described, in a few words, global warming and presented the students with the problem of

how to determine the probability of losing the existing coastline if the sea level increased. In Stage 2, students undertook an inquiry-based problem-solving activity. This activity consisted of searching pertinent information that supported student’s knowledge and implementing an experimental plan, in order to know more about water-ice mixing properties. Last, in Stage 3 (Socio-scientific decision-making, Bolte et al., 2012; Fortus et al., 2005; PROFILES, 2010), students related data collected from their search and investigation (observations in the laboratory and undertaking several calculations) to formulate an informed opinion to the question (Bond-Robinson, 2005).

These training courses 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 (Ketelhut, 2007).

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 had studied and tried out in the pre-service training course could and would 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 with the PROFILES IBSE-modules through informal and/or formal teacher forums. This could be both 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., 2011).

Building an IBS Module in the human health context

The novel experiences of applying PROFILES teaching-learning materials with students for the degree (in Primary Teacher Education) of the School of Education in the University of Valladolid (Spain)

have been presented. A new PROFILES module entitled “*The alcohol we could drink for driving safely*” has been used to promote students’ responsibility. Students were asked to plan an investigation to identify alcoholic drinks with the highest alcohol concentration, to discover how much alcohol could be drunk and the time it was necessary to wait to avoid driving with a BAC level upper the legal limit. The competences involved were: investigative skills, cooperative-working skills, conceptual understanding and communication skills. The curriculum content was related with Biology, Chemistry, and in particular with Mathematics. The students worked on modeling alcohol metabolism/ degradation and their capacity to predict how much alcohol they can drink and for how long they have to wait before being able to drive responsibly.

We carried out participant observation, and a questionnaire was also directed to the students. In advanced, they were given the criteria that would be later used to assess their performance in such competences, which included: correct concept use, STS-E association, comprehension, information selection, critical analysis, conclusions quality, presentation skills and discussion of the conclusions. The application of the module 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 ethical and moral consequences of the scientific and technological development was the competence evaluated overall most poorly. Finally, students related data collected from their search and investigation (picking up information in the supermarkets and carrying out several calculations) in order to give an informed opinion in socio-scientific decision-making (Fortus et al., 2005; Bond-Robinson, 2005).

Conclusions and future work

The UVa PROFILES Curricular Delphi Study on Science Education has been the tool to identify the main motivational contexts for Spanish students. This supported the need for developing modules based on scenarios. Within this intended outcome,

and by means of the training and intervention linked to stakeholder support, a key target was to convince teachers that the methods they had studied and tried out could and would strongly improve the quality of their own science teaching (Michelsen & Lindner, 2007). The course was carried out with pre-service teacher trainers, where the teacher training course (CPD in PROFILES) gave the conceptual understanding of PROFILES operations and module development and finally, as a personal task, the trainees designed a module following the three-stage model and their opinions were sought about their impressions and reflections about the concepts found in the Delphi study.. We were able to conclude that they were very satisfied with the results and their experiences. We, as science educators at the university, intend to further promote IBSE strategies and the PROFILES approach among University students in the future.

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1.3 Comparing Different Stakeholders' View on Science Education with the Science Curriculum in Sweden: Reflecting on the PROFILES 3-Stage Module

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Abstract

To obtain a consensus of different stakeholders' view and contribute to the development of science education, a Delphi study was conducted in Sweden during 2012–2013. The purpose of this chapter was to compare different stakeholders' view on science education in the first two rounds of the Swedish Delphi study with the current Swedish curriculum (Lgr 11) for the science subjects in grade 7–9 and to see what aspects might need to be developed further in the science curriculum. A total of 212 stakeholders from groups of scientists, science teachers, science educators and students were invited to provide their ideas concerning science education in the first round of the Swedish Delphi study. A total of 100 responses from the first round and 76 from a second round were analyzed and presented in this article. From the results, 75 categories were identified in the first round of the Swedish Delphi study while, in the second round, the categories were narrowed down to 57 according to a mean score above 4. We found that science-technology-society (STS) was an emerging view from the stakeholders' responses, not only highlighted in our Delphi study, but also addressed in the Swedish curriculum for science subjects in grade 7–9 (Lgr 11). Some aspects revealed in our Delphi study, were not addressed in the curriculum. Based on our results, we have argued that the PROFILES 3-stage model was a suitable way of teaching sciences for grade 7–9, since the aspects analyzed from the results of the Swedish Delphi study and the Swedish curriculum could be embedded.

Introduction

The international ROSE study has shown that 15-year-old students in developed countries found many of the themes and questions of science interesting and important (Jidesjö et al., 2009), but at the same time, students failed to see school science as meaningful and rejected science and technology as possible future careers (Oscarsson et al., 2009). Similar to the above-mentioned findings, the declining interest in pursuing science studies in the majority of developed countries has been disclosed during recent years (George, 2006), which has made it necessary for science educators to reconsider how science was taught at school and what picture of science was conveyed to students. It was important to recognize that the goal of science education in school was *not only* to educate and recruit the next generation of scientists and engineers, *but also* to enhance the scientific literacy of all citizens, even though, so far, there were still differing opinions on what abilities a scientifically literate person should possess and how to achieve the learning of those abilities (Shamos, 1995).

During the past decade, the problems of relevance of the current science education in many countries necessitated a discussion about how to achieve a relevant and meaningful science education which could facilitate the enhancement of scientific literacy *for all*. To make school science more relevant for young people for the society of today and tomorrow, some suggestions have been put forward, such as increasing contextualization of the scientific content in order to make students interested in the sciences (Nentwig & Waddington, 2005), connecting more to societal issues and the link between science and modern technology (e.g. Aikenhead, 1994), connecting to interdisciplinary socio-scientific issues (e.g. Chang & Chiu, 2008, Chang Rundgren & Rundgren, 2010) and with ethical discussions (e.g. Zeidler et al., 2005), and conducting inquiry-based science education (e.g. EC, 2007; Gyllenpalm et al., 2010). The above-mentioned ideas (of making science education relevant and inquiry-based) were all embedded in the philosophy of the EU FP7 project, PROFILES, which served as the base for this article.

A central aspect of the PROFILES project is to establish an exchange among science teachers, science education researchers and other local actors (PROFILES Consortium, 2010). Thus, the PROFILES project aims at involving a wide range of stakeholders and taking into account their opinions. Stakeholder viewpoints are recognized as contributing to the development of education. For example, Rauch and Steiner (2013) point out that making a contribution to education for sustainable development needs to include efforts among stakeholders related to global learning, citizenship education, health education, peace education and so on. Further, the development of risk education, not only needs the engagement of educators, but also involvement by different stakeholders from policy, science and society (Bründl et al., 2009).

The Delphi technique has been used to identify experts' opinions, such as those by stakeholders, aiming at consensus (Bolte, 2008; Edgren, 2006; Murry & Hammons, 1995; Osborne et al., 2003). Osborne and colleagues (2003) conducted a Delphi study on experts' views on what ideas about the nature of science should be taught in school. Bolte (2008) conducted a curricular study, using the Delphi method, to probe different groups of stakeholders' (students, teachers, educators, and scientists) views on how chemistry education can be made more relevant. The latter study provides the frame for this PROFILES Delphi study. The aim of the PROFILES Curricular Delphi Study on Science Education (CDSSE) is to engage different stakeholders in reflecting on the content and aims

of science education, as well as in outlining aspects and approaches of modern science education (Bolte & Schulte, 2011).

In 2011, a new curriculum reform was introduced in Sweden, replacing an earlier curriculum from 1994. At the lower secondary school level, grade 7–9, science is divided into lessons of physics, chemistry and biology. All students receive separate grades in the three subjects, even though it is possible for schools to teach integrated science. The aim of this study is to analyze different stakeholders' view on science education in a Swedish curricular Delphi study, embedded in the PROFILES project, and compare the results with the current Swedish curriculum for the science subjects in grade 7–9. Matches and mismatches between results from the Delphi study and the Swedish curriculum are identified. Based on the results, we reflect on the appropriateness and feasibility of using the PROFILES 3-stage teaching model for enhancing inquiry-based science teaching and learning.

Method

The design of the Delphi study and stakeholder response rate

The design and method of the first and second rounds of a 3 round Swedish Delphi study mainly follows the description presented by Schulte and Bolte (2012).

Groups	Number of questionnaires sent out	Number of responses	Response rate
Students (Grade 9)	35	26	74%
Science teachers	76	30	39%
Science educators	46	24	52%
Scientists	55	20	36%
Total	212	100	47%

Table 1. Sample structure of the first round of the Swedish CDSSE

Groups	Number of questionnaires sent out	Number of responses	Response rate
Students (Grade 9)	26	21	81%
Science teachers	30	21	70%
Science educators	24	23	96%
Scientists	20	11	55%
Total	100	76	76%

Table 2. Sample structure of the second round of the Swedish CDSSE

In the first round, the PROFILES questionnaire was translated into Swedish and distributed to stakeholders (9th graders, science teachers, science educators and scientists). The main and general question of the PROFILES CDSSE focused on aspects that were considered relevant and pedagogically desirable for the individual in the society of today and in the near future (Bolte & Schulte, 2011).

A total of 212 stakeholders were invited to formulate written answers to three questions, but only 100 stakeholders replied (Table 1).

In the second round, a web questionnaire, based on the categories obtained in the first round, was developed. For each category, the stakeholders were asked to rate the priority that should be given in school science for each category (using a 6-point Likert scale) and to which degree this has been implemented in school. The second round questionnaire was sent out to the 100 participants who participated in the first round and 76 participants replied (Table 2).

Data acquisition in the first and second round of the PROFILES CDSSE conducted in Sweden

The statements received from the 100 participants (Table 1) in the first round of the CDSSE were analyzed step-by-step following the general outline developed by Bolte & Schulte (2011). After examining the statements with the list of established categories, a set of 10 questionnaires

was randomly chosen and examined by two independent coders in order to achieve a consensus regarding the categories and coding procedures. The number of statements made by participants was found to be 806 and grouped into categories, with, on average, 9.60 categories (repeated category entries not calculated) identified per participant. Categories were only formed when the category was mentioned by two or more participants. In other words, statements coming from only one participant were not developed into categories.

An analysis of the results from the second round, narrowed down the stakeholders' views on science education by selecting only those categories where the mean scores was above 4. These categories were matched with the Swedish curriculum (Lgr 11) for grade 7–9 science subjects. When the designated categories were present in the Swedish Science Curriculum, they were considered a match. In addition, a qualitative content comparison was conducted.

Results and discussions

The qualitative analysis of the first round of the Delphi study

From the 100 stakeholders who responded in the first round of the Swedish CDSSE, the final classification system consists of a total of 75 categories (Table 3), 68 of which were common to the classification system by Schulte and Bolte

(2012). Table 3 shows two new categories in part I, *learning for democracy and science as a culture*. The stress in the Swedish syllabus (e.g. National Agency of Education, 2011), on the general aim of school education to develop democratic attitudes among all students, makes it relevant to refer to this as an

important motive and aim for science education. The other category, *science as a culture*, is possibly connected to the relative popularity of socio-cultural perspectives on science education in Sweden (e.g. Säljö, 2004).

I: Situations, contexts, motives	II: field		III: Qualification	IV (Addition): Methodical aspects
	IIa: (Basic) concepts and topics	IIb: Scientific fields and perspectives		
N = 16	N = 20	N = 11	N = 17	N = 11
<ul style="list-style-type: none"> • Intellectual personality development • Emotional personality development • Students' interests • Curriculum framework • Media / current issues • Nature / natural phenomena • Everyday life • Medicine / health • Society / public concerns • Global issues • Science – biology • Science – chemistry • Science – physics • Learning related to interdisciplinarity • Learning for democracy • Science as a culture 	<ul style="list-style-type: none"> • Scientific models • Terminology • Scientific Inquiry • Limits of scientific knowledge • Chemical reactions • Matter / particle concept • Structure /function / properties • Energy and energy conversions • Biological systems • Development / growth • Cycles of matter • Raw materials / resources • Food / nutrition • Health / medicine • Technical devices • Environment • Industrial processes • Science in everyday life • Safety and risks • Occupations / occupational fields 	<ul style="list-style-type: none"> • Ecology • Astronomy / space • Earth sciences • Evolution • Sexuality • Gene technology/ genetics • Current scientific research • Consequences of technological development • History of the sciences • Ethics / values • Nature of science 	<ul style="list-style-type: none"> • Applying knowledge /thinking abstractly • Problem-solving / critical questioning • Making decisions / opinion-forming / reflection • Rational thinking / analyzing /drawing conclusions • Comprehension / understanding • Formulating scientific questions / hypotheses • Experimenting • Finding /evaluating information • Explaining / interpreting • Developing motivation and interest • Acting reflectedly and responsibly • Knowledge about science-related occupations • Communication skills • Social skills / teamwork • Working independently / structurally • Ability to conduct field studies • Developing self-confidence in science 	<ul style="list-style-type: none"> • Subject content focused learning • Interdisciplinary learning • Inquiry-based science learning • Collaborative learning • Context-based learning • Knowledge and skills focus • Predictive/creative focus • Analytical/evaluative learning • Using ICT • Discussion /debate / argumentation • Self-learning /self determination

Table 3. Overview of the categories for the analysis of the stakeholders' statements

In part II, three new categories were identified: *sexuality*, *gene technology* and *nature of science*. Teaching about sexuality might be connected to the fact that teaching and learning about sexuality was a requirement in the Swedish curriculum. Gene technology was also mandatory in the Swedish science curriculum, as was the nature of science.

In part III, two new categories, *ability to conduct field studies* and *developing self-confidence in science*, emerged. The stress on the ability to conduct field studies could perhaps be connected to the long-lived Linnean tradition (Dietz, 2012) in Sweden with a stress on out-door education and field studies. The importance of developing self-confidence in science has also been an important topic in Swedish schools. Several of the categories of the FUB system (Schulte & Bolte, 2012), relating to scientific fields and perspectives, were not represented in the Swedish data. And the majority of categories relating to specific fields of science were mentioned too rarely to be included as specific categories.

The quantitative analysis of the second round of the Delphi study

In the second round, a total of 76 stakeholders responded (Table 2). Since the stakeholders in the second round were asked to rank the priority of the same set of categories generated in the first round of Delphi, this provided a better estimate of how stakeholders viewed the importance of different categories, compared to the first round. A total of 57 categories were ranked with mean scores over 4, although no category was scored above 5. For expediency only the 12 categories given the highest weight by stakeholders (mean scores over 4.55) were identified (Figure 1), and among these, ten corresponded to those in the FUB categories (Schulte & Bolte, 2012). The other two categories (sexuality and developing self-confidence in science) were specific to the Swedish Delphi study.

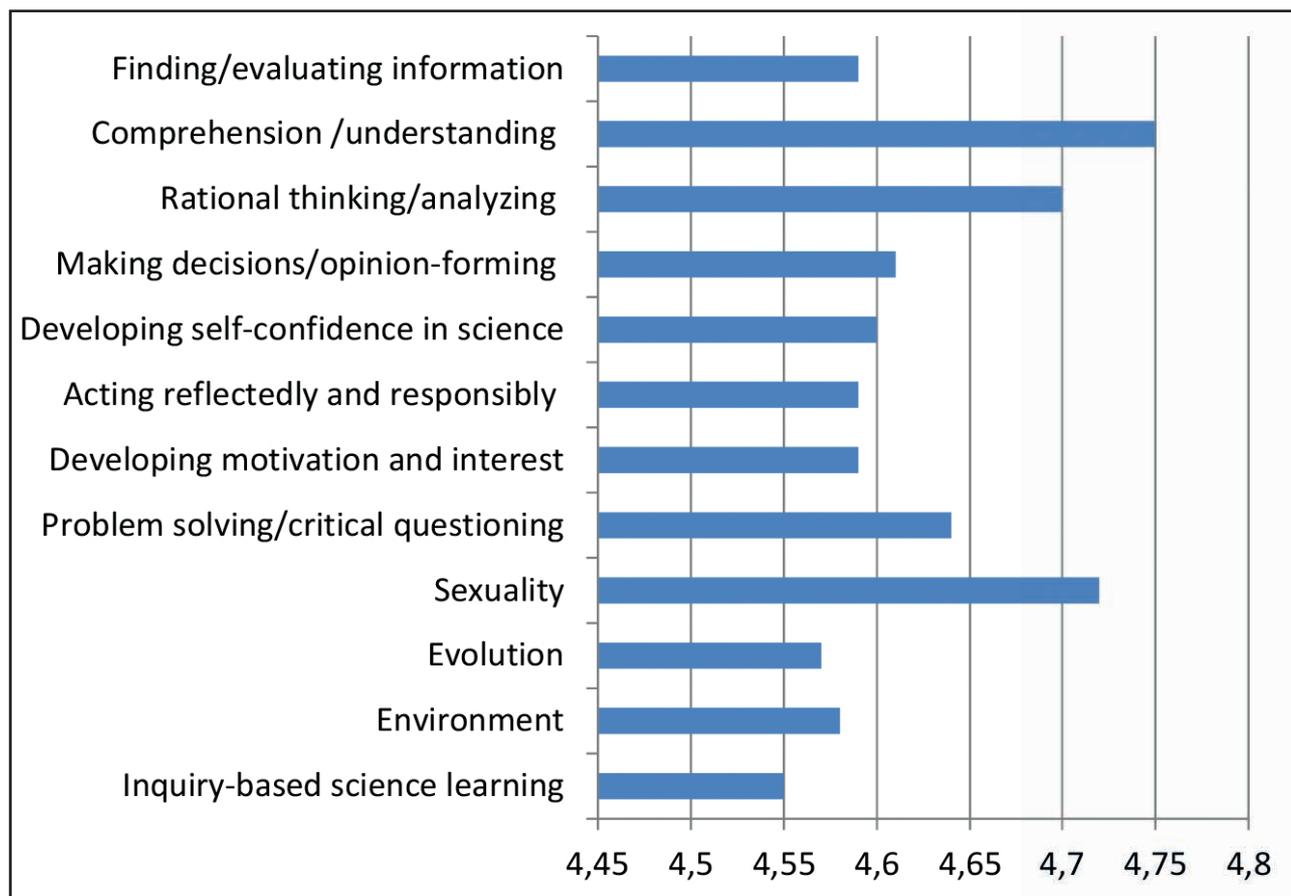


Figure 1. Overview of the 12 most highly ranked categories (priority mean ≥ 4.55) from all groups of stakeholders in the second round of the Swedish CDSSE

The qualitative comparison between the categories obtained in the Swedish Delphi study and the Swedish curriculum

The results show that science-technology-society (STS) is an emerging view by stakeholders. Within STS, aspects highly presented in the Delphi study (Table 3), as well as addressed in the Swedish curriculum for science subjects in grade 7–9 (Lgr11) are, for example: sustainability, nature of science, argumentation and decision-making, in addition to numerous related science concepts (e.g. energy, biological systems and evolution).

The focus on sustainability is salient in the new curriculum of 2011 (Lgr 11). The agreement of the importance of education for sustainability is also revealed in the stakeholders' view, as presented in the Swedish Delphi study. Environmental issues are mentioned as an important content in school science by one third of the participants in the first round and *environment* was one of the top 12 categories in the second round in the Delphi study.

The notion of nature of science (Lederman, 1992) includes characteristics of science relating to the search for knowledge using systematic investigations, formulating and testing hypotheses, creating models in order to represent natural phenomena, etc. The importance of giving students an opportunity to learn about the nature of science is firmly written into the new 2011 curriculum. The views presented by the stakeholders endorsed this component, giving a mean priority of 4.21 in the second round of the Swedish Delphi study. The highest priority, given to the categories *inquiry-based learning* (mean priority 4.55) and *problem-solving/critical questioning* (mean priority 4.64) by the participants in the Delphi study, may also be related to this.

In addition, another match between the present Swedish science curriculum and the results of the Delphi study is the focus of students being given the opportunity to form opinions on science-related societal issues and being trained in argumentation and decision-making (e.g. Chang & Chiu, 2008; Zeidler et al., 2005). The importance given to learning about issues related to sexuality by the

participants in the Delphi study also align well with the knowledge goals related to this in the Swedish curriculum.

Mismatches between the results of the Delphi study and the Swedish curriculum for science education

From a qualitative analysis of Delphi categories and the Swedish curriculum (Lgr11), aspects were identified and seen as important from different stakeholders' viewpoints, but not addressed in the curriculum for all science subjects in grades 7–9. These were geography/geology, science language, interdisciplinary, creativity and citizenship.

Geography/geology

In the Swedish curriculum, geology and physical geography is part of the geography subject, which is categorized among the social sciences in the Swedish school system. An effect of this is that earth science is taught by teachers who have their main training in the social sciences. The fact that earth science content is not taught in the natural science subjects in Sweden might result in a weaker education for earth science as a science. The current global development with common challenges such as climate change and overcoming natural hazards and catastrophes make knowledge about earth science content increasingly important and even potentially life-saving.

Global issues were given a mean priority of 4.47 in the second round of the Delphi study, but lacked explicit mention in the science curriculum. This could result in teachers not highlighting the interconnectedness of natural systems and human society, but rather highlighting the local aspects of global phenomena. This could be especially problematic when evaluating risks relating to global challenges. Risk education (i.e. educating for the ability to perceive, evaluate and prioritize personal and societal risks) has been mentioned as an important area in science education (Levinson et al., 2011). In the curriculum, risk was barely mentioned; only in the curriculum of the physics subject in the context of forces, where traffic was suggested as an example of risk. In future revisions

of the curriculum, risk education could be a good candidate for an area which could be stressed more in science education.

Language: scientific terminology

The importance of taking the language aspect of learning science into account has been stressed in the science education literature for at least two decades (Lemke, 1990; Yore et al., 2003). Lemke (1990) stated that language was much more than a passive media for transferring information about science content; it should rather be regarded as a tool that actively shapes our understanding and awareness of science. This stress on language as an integral part of science learning of science within the science education research community was, so far, not made explicit in the Swedish science curriculum. The development and training of language in the context of science and scientific terminology in the science subjects was given a mean priority of 3.97 in the second round of the CDSSE.

Interdisciplinarity

Addressing interdisciplinarity and the need for science content to be related to real issues in society were given a mean priority by the stakeholders in the Delphi study of 4.26, which seemed to contradict the separation of the science subjects in the new Swedish curriculum (Lgr 11). While the pedagogical pendulum in international science education research showed the direction of interdisciplinarity and science in society, for example, using socio-scientific issues in promoting science teaching and learning (e.g. Chang Rundgren & Rundgren, 2010; Zeidler et al., 2005), educational policy in Sweden currently seemed to point in the opposite direction.

Creativity

A problem of school science often mentioned by scientist was the lack of one of the core qualities of research, namely creativity. School science too often gave students a picture of science as described by a set of true, objective and value-independent 'facts' which needed to be learned, which could not be questioned or discussed and which had little or

no relation to the everyday world of the student. This misconception of science and the scientific endeavor has formed a major obstacle for many students. The development of creativity in the science subjects was given a mean priority of 4.06 by the participants in the Delphi study.

Citizenship

Finally, an interesting discrepancy, which was noted between the suggestions from the participants in the Delphi study and the science curriculum, related to the aim of the science subjects to develop citizens who could act reflectively and responsibly. School science was seen as having a two-sided mission – on the one hand, to provide a meaningful science education both for students who will pursue science- and technology-related studies and careers as well as for those students, on the other hand, who would not continue to study science above secondary level (who constituted the majority of students) (Fensham, 2000). It was possible to interpret an underlying intention in the curriculum to develop scientifically literate citizens (since scientific literacy was stated as a goal for the science subjects), who could also act reflectively and in responsible ways (National Agency of Education, 2011). However, the goal to educate citizens who could act reflectively and responsibly (which were one of the categories given the highest priority in the CDSSE) was not mentioned explicitly in the curriculum of the science subjects.

Reflecting on the PROFILE 3-stage model

In the PROFILES project, a 3-stage model has been developed to promote motivational inquiry-based science teaching and learning related to an education through science (Bolte et al., 2012). The three-stage model was composed, related to the idea of contextualization as the first stage, followed by de-contextualization and finally re-contextualization (Holbrook & Rannikmäe, 2010). In the contextualization stage, a familiar question-driven social context was needed to promote students' intrinsic motivation and induce students' learning interests. The stage of de-contextualization was to acquire the conceptual science learning,



allowing students the opportunity to develop a method to experience an inquiry process and try to find the answers for the questions they had asked from the first stage. At the end, the third stage concerning re-contextualization, students reflected on the social issue and argued their viewpoint by incorporating the newly found science evidence, conceptualised in the second stage, and linked the evidence to their decision-making response to the initial social issue.

Based on our findings through a comparison of the Swedish CDSSE (for both first and second rounds) and the Swedish curriculum (including both matches and mismatches aspects), the PROFILES 3-stage model showed its feasibility in

guiding the teaching of school science today (Table 4). This has been used to guide the development of PROFILES modules in Sweden. For example, a Swedish teacher has developed a teaching module entitled 'Toxic fish in the Baltic sea?' (<https://www.itslearning.com/kau/profiles/modules/>). At a later stage, the experiences from teachers' interventions in the classroom, guided by PROFILES continuous professional development (CPD) programmes, encouraged the sharing of PROFILES modules. Beyond the CPD, evaluating the teaching and learning outcomes as a PROFILES component of providing evidence of teacher ownership, could be investigated and shared.

3-stage model	The Swedish stakeholders' and curriculum aspects embedded
Contextualization	Achieving sustainability, interdisciplinarity and globalisation through the link to socio=scientific and environmental issues to stimulate motivational inquiry. Citizenship education can be embedded in the issues discussed. Interdisciplinarity Risk education
De-contextualization	Natural of science/Inquiry process Field studies The use of ICT Creativity Natural of science The use of language: scientific terminologies Other education through science attributes such as teamwork, leadership, showing initiative, cooperation, safe working
Re-contextualization	Consolidation of the conceptual science Through undertaking arguments and making justified decisions based on the socio-scientific issue , students can develop argumentation (reasoning) skills, communication skills, ethical and risk considerations, interrelate environmental values, economic values, social values, political values, with science and technology values in reaching a consensus, democratically developed decision Promote education through science learning such as communication skill (listening to others, putting forward a point of view, presentation skills), cooperative skills, exhibiting a willingness to, respect for others

Table 4. Important aspects of science education according to the first round of the Swedish Delphi study related to the PROFILES 3-step model. (Consider the appropriateness of the additions made)



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1.4 Swiss PROFILES Delphi Study: Implication for Future Developments in Science Education in Switzerland

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Abstract

Choosing science content that is relevant and at the same time appealing to students is an important goal in science education (Bolte et al., 2012). It is crucial when students are guided to learn by inquiry as intended within FP7, Science in Society projects such as PROFILES (PROFILES, 2010). However, what is a relevant and appealing context In the curricular Delphi-study on science education this question was posed to different stakeholders, such as 7th to 9th grade students, trainee science teachers, science teachers and science educators in all PROFILES-countries (Schulte & Bolte, 2012). In the Swiss Curricula Delphi study results from the first round are presented and discussed in a national science education context.

The Design of the study

Participants were asked to respond to the open-ended question, which aspects regarding science education they would consider advisable and pedagogically desirable for the individual in the society of today and in the near future. It was indicated that they should think of adolescents at the end of compulsory education and answer the question from three perspectives:

- I) Situation contexts and motives of the example in mind,
- II) the field the participant considered as relevant and
- III) Qualifications that should be developed in becoming scientifically educated (Schulte & Bolte, 2012).

The open-text answers were analyzed using a category system developed by Schulte and Bolte (2012), although in this article the results are restricted to the categories and its subcategories “Qualifications” and “Methodical aspects” (Tables 1 and 2), since those are most relevant in respect to the present introduction of the Swiss science education standards. The sample consisted of 42 students, 29 trainee science teachers, 9 teachers and 23 science educators and as it was drawn based on personal contacts, the sample is purposeful rather than representative sampling. Furthermore, because of its low sample size, the group of teachers is not considered in the analysis.

The category “Qualification” includes competences¹ that could be identified in the stakeholder responses, such as “Thinking in concepts,” “Content knowledge,” “Acting reflectively and responsibly,” “Being able to experiment.” Some responses implied methodical aspects, such as “Cooperative learning,” “Interdisciplinary learning,” or “Learning by example.”

The open-text responses were analyzed from two different perspectives. First, frequencies of sub-categories were analyzed and classified as rarely, sometimes, often and very often, coded. For example, a sub-category that was coded less than or equal to 5% of the responses of a group was classified as “rarely coded.” Frequencies starting from 5 to 20% were labeled as “sometimes coded,” from 20 to 40% as “often coded” and from 40 to 100% as “very often coded.” Second, examples of the responses of the participants were recorded and discussed for each group. The results from both perspectives were summarized and discussed against the background of science education in Switzerland.

Results I: Desired “Qualifications” and “Methodical aspects”

Table 1 indicates the results for the category “Qualifications,” with sub-categories starting from high to low importance. Subcategories coded as

¹ The definition of the term “competence” differs from country to country. The EU sees it covering knowledge, skills, attitudes and values (Eurydice 2002; 2012).

often(+)⁺ or very often(++)⁺ for each group (students, trainee science teachers and science educators) are indicated in boldface. Sometimes coded (0) or rarely coded (0.5) are recorded in a lighter grey colour. Although there is some agreement between the different groups, differences are also observed. Science educators' responses covered the widest range of different subcategories, whereas student responses addressed the lowest range.

Correspondingly, the length of the open-text answers differed substantially between groups. The following figures indicate the Median of characters, and in brackets, the Minimum and the Maximum number of characters – Students 45 (7, 355), Trainee science teachers 106 (14, 410) and Science educators 267 (32, 1505) characters.

Qualifications	Students	Trainee Science Teachers	Science Educators
Thinking in concepts	++	++	++
Content knowledge	++	+	++
Acting reflectively and responsibly	++	+	++
Judgement / opinion-forming	+	+	++
Application / transfer of knowledge	++	+	+
Awareness of the environment	++	+	+
Thinking abstractly	0	+	++
Being able to experiment	+	0	++
Motivation and interest	+	0	+
Critical questioning	0	+	+
Formulating scientific questions and hypotheses	0	0	+
Communication Skills	-	0	+
Social skills / teamwork	0	0	0
Knowledge about scientific occupations	-	0	0
Researching / investigating	-	-	0
Reading competency	-	-	-

Table 1. Frequency of coded categories in part III, "Qualifications" for the groups students, trainee science teachers and science educators. Levels: -= [0, 5]% (rarely coded), 0=[5, 20]% (sometimes coded), += [20, 40]% (often coded) and ++=[40, 100]% (very often coded).

Methodical aspects	Students	Trainee Science Teachers	Science educators
Cooperative learning	+	+	++
Interdisciplinary learning	+	+	++
Inquiry-based science learning	+	+	++
Learning by examples	0	0	+
Researching / investigating	0	-	+
Problem solving	0	-	+
Discussion / debate	-	0	0
Learning in mixed aged classes	-	-	-
Using new media	-	-	-

Table 2. Frequency of coded categories in part IV, "Methodical aspects" for the groups - students, trainee science teachers and science educators. Levels: -= [0, 5]% (rarely coded), 0=[5, 20]% (sometimes coded), += [20, 40]% (often coded) and ++=[40, 100]% (very often coded).

In the category “Methodical aspects” respectively, the subcategories “Cooperative learning”, “Interdisciplinary learning” and “Inquiry-based science learning” were coded as often or very often within all groups (Table 2, boldface). Only rarely or sometimes coded were the subcategories “Using new media”, “Learning in mixed aged classes” and “Discussion / debate” (grey).

Results II: An inside look at stakeholder responses

The results so far were complemented by several examples of open-text responses for each group. As already mentioned, the student responses were mainly very short, consisting of keywords or even a single word. Hence an interpretation of the responses was difficult and sometimes impossible. However, some responses were illuminating and provided important information about the view of this group. Neither “Qualifications” nor “Methodical aspects” were mentioned explicitly by the students. Students regarded aspects as relevant for science education that had a strong relation to their personality or to their biography. In several cases, students mentioned a disease of a friend, or a member of the family aligned with the aim to help the person or to understand the disease.

“Why do some humans have asthma? And how could one help them, when they have fits of asthma.” Student: 1–27

A second remarkable characteristic of the longer student responses was the interdisciplinarity of the suggested content.

“To look at how the psyche is in connection with functions of the human body; how much they depend on each other.” Student: 1–19

“To learn, which elements / molecules lead to life; how our world and space consist of the smallest substances.” Student: 1–10

Both excerpts show that students easily connect different areas of science. They express an interest for the fundamental questions of life. In the subtext

of these excerpts, a rather naive picture about knowledge, i.e. the acquisition of knowledge is important – tell me what it is all about! In some responses, a kind of learning by doing, or scientific inquiry approach is proposed, as the following excerpt shows:

“I prefer to learn by experience. Thus I am of the opinion that it is appropriate to have science instruction at least to some extent outside (the school).” Student: 1–38

The student did not further elaborate; what actually should be done outside and why practice is something that can be experienced outside is not given. Overall, being close to nature seems to reflect the need of the student regarding science education.

Student responses had a strong relation to their personal life, they were interdisciplinary and exhibited a somehow naive understanding of scientific knowledge and methods.

Responses from science educators showed different characteristics. As already denoted, the responses were longer. Most of the time, they did not include examples as it was intended by the study, but theoretical explanations about science education.

“Qualifications: Here I go along with the skills and accordingly domains of the Swiss competence-model: [...] to work autonomous, dialogic and co-constructive, the change of perspective and “empathy” a. o.” Science educator: 4–33

Science educator 4–33 expresses his agreement with science education standards of compulsory schools. The agreement is paradigmatic for several responses from science educators that have obviously adopted the standards to their personal vision about science education. Another characteristic that reflects the present discussion in science education research could be paraphrased as “science and society.”

“As part of a community we are obliged to shape the environment and the society forward-

looking, solidary and responsibly in the sense of sustainable development.” Science educator: 4–35

In this and other excerpts from science educators, the responsibility of the society for the environment is stressed. Some science educators express their concerns about the exploitation of resources in the present and hence suggest that sustainability should play a more prominent role in future science education. Sustainability as an important goal in science education goes with the interdisciplinary characteristic of the suggested contents.

“To understand and explain relations in the context of power supply and based on the understanding, being able to draw conclusions for one’s own life-style.” Science educator: 4–06

“Insight, that science research questions – and with them also the answers – rely partly on the business, cultural and political environment.” Science educator: 4–31

Furthermore it is pronounced that doing science is an analytical and complex enterprise and therefore the corresponding competences, such as reflecting, being analytical and undertaking complex thinking or researching should be pronounced in science instruction. One science educator even noticed that learning science *“is not only fun, but hard work”* (Science educator: 4-21), what shows that the stereotype of science as a particularly difficult discipline is persistent. Less often, responses referred to motivation or curiosity. The promotion of students’ creativity is mentioned only once.

Science educator responses were often aligned to science education standards, pronounced sustainability as an important goal of education and stressed the analytical and complex nature of science.

Responses of the group of trainee science teachers were similar to the latter group, but consisted more often of examples.

Implementation of PROFILES and the development of Science Education in Switzerland

The results of the Delphi Study yield interesting hints which can and will be used for the future development of science education in our country. The results of the Delphi Study come at a convenient moment: a new curriculum and – as a consequence – new textbooks and instructional materials are just on their way to being developed or will be prominent in the next ten years. In the discussion for this article, the focus is placed on four different perspectives:

- 1) science as an interdisciplinary endeavor;
- 2) skills for a broad scientific literacy;
- 3) the contents as a balance between students’ everyday world and the systematic of science;
- 4) inquiry-based learning (IBL) as a method and a means;

All these perspectives are very relevant to the PROFILES philosophy and approach (Bolte et al., 2012).

Science as an interdisciplinary endeavor

Science educators and – to a lesser extend – students and trainee science teachers underline the importance of interdisciplinary learning. Students are interested in content that are relevant for their lives (PROFILES refers to this as context, Bolte et al., 2012); their examples show interdisciplinary relations to biology, chemistry, physics, technology, and other disciplines. These results are surprising, because Switzerland has a long tradition of an interdisciplinary science education. For example, in lower secondary school (grades 7–9), in almost all cantons and school tracks, science is taught as one single subject; very often named, depending of the cantonal curriculum², “science and technology,” or “nature–human–society” (Labudde, 2003; Labudde et al., 2005). These subjects, their objectives and content, are similar to the STS-approach and -subject in Anglo-Saxon countries (Aikenhead,

² Until now, Switzerland has not one centralized school system, but each of the 26 cantons has its own system.

2005; Bennet et al., 2007). In Switzerland, also in upper secondary school, the so called *Gymnasium* (grades 10–13), the curriculum includes – besides the three classical subjects: biology, chemistry, and physics – interdisciplinary approaches and claims the integration of biological, chemical, and physical knowledge and skills.

We interpret the results of the Delphi Study, in particular the statements of students and science educators, in such a way that the integration of different disciplines can be strengthened and extended. As mentioned above, this is not a question of the curriculum; they focus on interdisciplinarity and underline its importance. Possible levers to support interdisciplinary approaches in science education are:

- The study programmes for trainee science teachers: many teachers of the lower secondary schools have studied only one science or two, e.g. biology and chemistry, and not science as a whole, i.e. as one discipline. They are socialized in one or two disciplines; they are not sufficiently familiar with interdisciplinary themes, content, skills and approaches. Some universities and teacher colleges have changed already, or are on the way to changing their programmes for the professional development of science teachers. The results of our Delphi Study support this change.
- The development of interdisciplinary teaching units and materials: Very often teachers ask for “good”, interdisciplinary examples, i.e. ideas for interdisciplinary instruction. As described elsewhere, there are different types of interdisciplinary instruction: intradisciplinary, multidisciplinary, and problem focused (Labudde, 2003; 2008). It is a challenge for science educators and teachers to develop more teaching units by which students learn interdisciplinary thinking, i.e. learn to take different perspectives and to integrate the contents and skills of various subjects, including the ideas of sustainable development.

This need is very much taken up by PROFILES where modules are guided by the PROFILES 3-stage approach. In this approach (Holbrook & Rannikmäe, 2010), the teaching begins from a familiar, motivational setting, which inevitably, of course, is in the context of the society. It is purposely chosen to be socio-scientific and in this sense, as learning is related to the society, it takes on an interdisciplinary focus, not only in seeing biology, chemistry and physics as interrelated, but also the natural and social sciences are both considered. The context, especially when taking on the focus of an issue, or concern, gains its relevance from the students' recognition that it is part of their world. The issue or concern strives to instill a sense of intrinsic motivation in the students from which the prior science learning can be distilled through interactive teaching methods, this background providing the platform for the conceptual science learning recognised by students as appropriate for better comprehension of the socio-scientific issue. This leads to the second stage of the learning process, driven by the intrinsic motivation stimulated in stage 1.

The second stage, the student-centred, inquiry-based or problem-solving phase is more specific and depending on its width of study is less interdisciplinary and more conceptually focused. However the 3rd PROFILES stage sees the need to consolidate this science learning and to further address the socio-scientific issue, drawing on the science in an interdisciplinary sense (but specifically included the newly gained science) to further tackle the issue interrelating to the economic, environmental, ethical, moral, social or other aspects so that the issue leads to a decision-making situation, strongly promoting reasoned or justified argumentation and communication skills and leading to a consensus decision-making in an interdisciplinary sense. PROFILES strives to promote all this and the associated assessment of the ‘education through science’ (Holbrook & Rannikmäe, 2007) learning outcomes by means of carefully developed teaching modules.

Skills for a broad scientific literacy

It is noteworthy that in a survey with open questions like a Delphi Study, so many persons ask for “qualifications” and “methodological aspects” that are normally not in the mainstream of science education, e.g. they expect more “acting reflectively and responsibly,” “judgment / opinion-forming,” and “cooperative learning.” These qualifications and methodological aspects complement more traditional ones like “thinking in concepts,” “content knowledge,” “application of knowledge,” or “learning by examples.”

These results confirm strongly the skills and national standards in science education which have been published only two years ago by the cantonal ministers of education (EDK, 2011; Labudde et al., 2012). To a certain extent the results of the Delphi Study validate the skills. In order to explain this statement, one has to describe the skills and standards briefly. They are based on a three-dimensional competence model which includes three axes: skills, domains and levels (see Figure 1). These outcomes from the Delphi study also point to a strongly supportive stance for the PROFILES approach included in the education through science focus (Holbrook & Rannikmäe,

2007; 2012) whereby science education is seen as much broader than science and the education in all subjects encompasses generic skills such as acting as responsible citizens through the development of reasoning skills in decision-making socio-scientific situations, cooperative learning and leadership skills and personal attributes such as ingenuity, initiative and safe working.

The first axis comprises six skills:

- 1) to ask questions and investigate;
- 2) to exploit information sources;
- 3) to organize, structure, and model;
- 4) to assess and judge;
- 5) to develop and realize;
- 6) to communicate and exchange views (For the axis of the domains see the next sub-section).

Each of the skills is described in detail and consists of several sub-skills. For each sub-skill a “can-do-description”, i.e. a standard, has been formulated (EDK, 2011). The selection of the skills and the description of standards are based both on an empirical evaluation and on normative decisions (Ramseier et al., 2011). The normative choices and judgments are worth discussing and sometimes controversial.

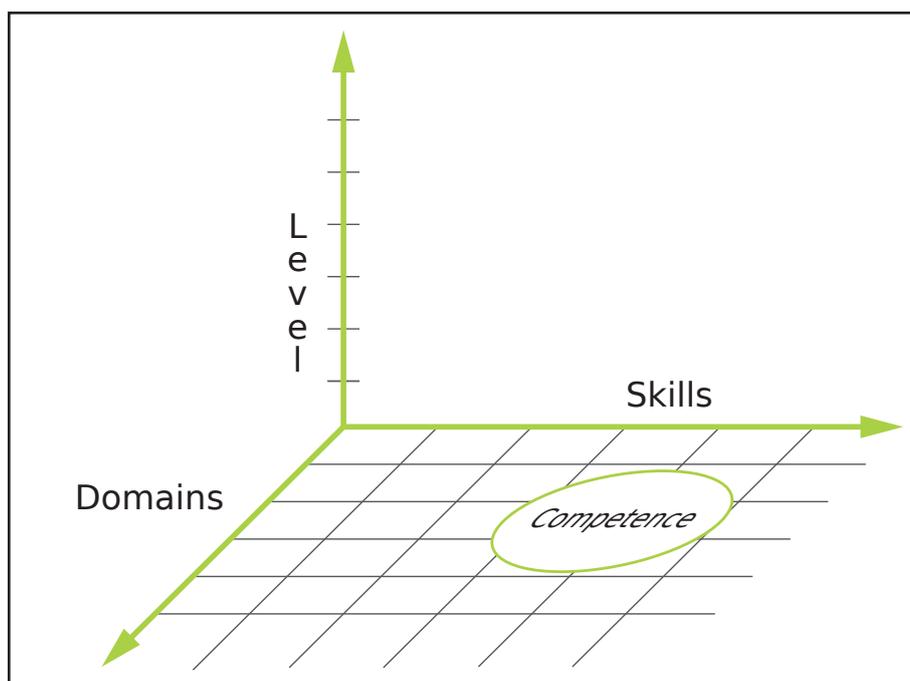


Figure 1. The three-dimensional competence model for science: A competence at the intersection of a skill and a domain.

It is one of the remarkable results of the Delphi Study that they confirm these choices and judgments that underlie the Swiss standards. The confirmation concerns two points:

- 1) the spectrum of skills in general, i.e. the six skills mentioned above and with them a broad spectrum of scientific literacy,
- 2) the skills 4 and 5 with their focus on judgment and development including acting reflectively and responsibly, i.e. skills that are – at least until now – not in the mainstream of daily science instruction. The opinion of students, trainee teacher students and science educators is in line with the national standards in science education.

It is noteworthy the directions and philosophy of PROFILES directly relates to the opinions derived from the Delphi study and the directions advocated in the Swiss curriculum reforms. While the need is being identified and the curriculum is being put in place, the PROFILES unique approach to inquiry-based science education with its stress on students' intrinsic motivation provides both the continuous professional development model (geared to providing the science where the teachers are insufficiently interdisciplinary), provide the PCK where the teachers are shown to be deficient (based on a teacher needs approach), provide the reflective practitioner guidance from intervention using modules in the classroom situation and above all the development as a leader guidance so that the teacher can progress from a self-efficacy level of meeting indicated needs within the CPD to a level of teacher ownership and the supportive implementation teaching modules, assuming of course that the philosophy and 3-stage model is being meaningful interpreted.

A balance between students' everyday world and the systematic teaching of science

Many of the answers coded as “qualifications” are related to the content, e.g. “thinking in concepts,” “content knowledge,” “application/transfer of knowledge,” and “awareness of the environment.”

An in-depth-look at the students' answers shows their wish to relate science with their personal life. This wish is not new; it is well-known from similar surveys all over the world, including PROFILES (PROFILES, 2010).

How do these answers correspond to the future curriculum that is under development and called “Curriculum 21”? (See Lehrplan 21, 2013. It is called “Curriculum 21” because of the 21 German speaking cantons that developed the curriculum together). The competence-model mentioned above (Figure 1) gives the frame for the future curriculum. Beside the skills, the competence-model lists seven domains: 1) motion, force, energy, 2) perception and regulation, 3) structures and changes of matter, 4) organisms, 5) ecosystems, 6) human body, health and well-being, 7) perspectives in nature, society and technology. This frame sets a broad spectrum of content. It has the potential to include most of the students' wishes with regard to the cognitive content of science.

In fact, if one compares the wishes of the students in the Delphi Study with the can-do-formulations in Curriculum 21, many of the wishes can be found – mostly implicitly – in the science curriculum (N&T, 2013). For example, the wish of student 1–10 (see above) to learn which molecules lead to life is related to: “*Students can use simple models in order to describe the characteristics of substances.*” (ibid. p. 6). And, “*students can explain why the build and function of cells and parts of cells influence and correspond to each other.*” (Ibid. p. 22). This example shows in a paradigmatic manner, that a student's wish or a student's question does not correspond one-to-one with a specific formulation in the curriculum. It is up to the teacher to relate and reconcile both, a daily challenge which demands much pedagogical content knowledge (PCK).

The results of the Delphi study show a familiar problem, a well-known dilemma: on the one hand the students' wish for content related to their everyday world and giving answers to the general question “how does the world function?”, and on the other, students' and science educators' awareness of “content knowledge” and “thinking in concepts,” i.e. the awareness of the abstractness

and systematic of science and scientific concepts.

As PROFILES is not curriculum related, it naturally relates to the intended curriculum. However while PROFILES does not specify content, it recognises the importance of PCK and the recognition that content is not the only education aspect in science education. If the conceptual science provides the intellectual input, then the education through science focus ensures the everyday life link and especially the need to develop skills, attitudes and values. It is the latter that competence-based curriculum strive to develop and it is this that forms the bridge, as PROFILES advocates between everyday life and the conceptual scientific thinking. It is not a question of either-or. It is an awareness of interlinking, not from science to society, but perceiving the direction as a motivational approach from society to the needed science learning. Where the emphasis lies in terms of society or conceptual science will obviously depend on the interests, needs and wishes of the students. PROFILES caters for all of these.

Inquiry-based learning as a method and a means

In the category “methodological aspects,” science educators strongly demand “inquiry-based learning” (IBSE) and “cooperative learning.” In the category “qualifications,” they underline the objectives as being able to formulate scientific questions and hypotheses and being able to experiment. Analyzing students’ answers, one is able to remark on the somehow naive understanding of scientific knowledge.

These wishes correspond completely to the national standards (EDK, 2011) and to the future science curriculum (N&T, 2013). The standards include a chapter “Working Self-reliantly and Reflecting” with a focus on inquiry-based learning. Given that the standards are the frame for the future curriculum, its emphasis on inquiry-based learning in science education (IBSE) does not surprise; in several sections, the can-do-formulations demand this. For example: *“In regard situations and phenomenon, students can ask questions, formulate hypotheses, and determine variables in order to*

examine questions and hypotheses.” (Ibid. p. 3) *“The students can plan and implement observations and experiments on their own”* (Ibid. p. 3). In the introduction to the science curriculum, it is stated: *“Examining authentic problems enable the students to make experiences and to explore the world on their own”* (NMG, 2013, p. 4). These and other objectives are in complete alignment with the utterances of the science educators: a good base for the future implementation of the new curriculum.

The science curriculum includes two chapters on the nature, importance and methods of science titled: “Understanding and reflecting the nature and influence of science” and “Applying scientific methods and technological solutions” (N&T, 2013, p. 1–5). These chapters are not only related to inquiry-based learning, but also to the objective of a differentiated understanding of scientific knowledge and methods. The new curriculum could be a base in order to overcome students’ somewhat naive understanding of science.

Not surprising, PROFILES advocates inquiry-based learning in science education. The IL in its name indicates this (Bolte et al., 2012). Inquiry-based science education is seen in terms of structured inquiry, guided inquiry and open inquiry, the latter being the target where students identify the science question, put forward hypotheses, plan the investigation and interpret outcomes (Trna & Trnova, 2012). Alas, how can students put forward the science question unless the learning starts in their world, they recognise the situation and they see the need for the science learning putting them in the position to ask the scientific questions that leads to the IBSE approach. In many circles, not surprisingly, open inquiry is associated with the student project. The PROFILES approach attempt to build up the open inquiry level by giving students experiences in the direct aspects of inquiry learning and striving towards the open inquiry approach based on a student centred learning. The PROFILES 3-stage approach is a unique approach to IBSE specifically striving for student involvement in all facets of science learning and seeing open inquiry as an important target. As such, content is not the driving force; it is the developing of competences which are the hallmark of enhancing meaningful

scientific literacy that are the real tenets of science education. Science curricula need to recognise this.

Summary

In this article, results on the first round of the curricular Delphi study in Switzerland were presented. Participants were asked which aspects regarding science education they would consider advisable and pedagogically desirable for the individual in the society of today and in the near future. The open-text answers were structured into three parts, I) Situation contexts and motives of an example in mind, II) the field the participant considered as relevant and III) Qualifications that should be developed in becoming scientifically educated.

Open-text answers were categorized with a system developed by Schulte and Bolte (2012) and analyzed in terms of the frequency of the occurring subcategories.

An analysis of the open-text answers reveals that student responses were driven by a strong personal involvement of the suggested content. Several responses referred to a disease of a member of the family or a friend. In general, the suggested content of science education was interdisciplinary and touched fundamental questions of life, such as the connection between nature and mind or atoms and life. Science educator responses could be characterized by the alignment to the science education standards in Switzerland, the emphasis on sustainability as an important context and the analytical and complex nature of science.

When discussing the results of the Delphi Study focus was on four perspectives:

- 1) science as an interdisciplinary endeavor;
- 2) skills for a broad scientific literacy;
- 3) the contents as a balance between students' everyday world and the systematic of science;
- 4) inquiry-based learning (IBL) as a method and a means.

The discussion yields confirmation, chances, and challenges. These perspectives are directly related to PROFILES either in terms of the CPD, or the classroom intervention using modules based on a uniquely designed motivational 3-stage approach.

Confirmation: In many cases, the answers of students', trainee science teachers, and science educators in the Swiss Delphi Study correspond to objectives of the Swiss science standards and of the future curriculum, for example, the consensus on "interdisciplinary learning," on the broad spectrum of skills in regard of scientific literacy, and on the demand for IBL.

Changes: The new curriculum is a base for changes, e.g. to overcome the naive understanding of scientific knowledge that students exhibit in their answers in the Delphi study or to foster the qualifications "acting reflectively and responsibility" and "judgment" that are qualified important by the science educators.

Challenges: Although science educators underline interdisciplinary learning and although national standards and the curriculum refer to science as one (interdisciplinary) subject, students wish more integration of biological, chemical and physical knowledge. This very much matches the PROFILES approach and philosophy.

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1.5 The Realization of Inquiry-based Science Education in PROFILES: Using a Delphi Study to Guide Continuous Professional Development

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Abstract

Stakeholders' involvement and interaction in the PROFILES project is seen as essential in order to bridge the gap between communities who are involved and/or affected by the quality of school science education. To fulfil this need, the PROFILES project initiated a study on collecting stakeholder views and opinions on the content and aims of science education. In total, 125 participants, representing the science education research community, science teachers and local actors were involved in the PROFILES Curricular Delphi Study on Science Education in Turkey in order to facilitate the uptake of inquiry-based teaching and learning. In this article, we aimed to describe and remark on the diversity and discrepancy in the teachers' perceptions regarding science education in Turkey, in comparison to other stakeholders and how we took steps to resolve these discrepancies through teacher's continuous professional development programmes. The outcomes illustrated that the stakeholders value science education and complain about the inadequacy of current standards, yet their desired science education did not point to a different picture of science education to that currently in place. With this in mind, continuous professional development programmes for teachers under the PROFILES project were designed and implemented to enhance teachers' understanding about science education, both in terms of the inquiry-based teaching and learning as well as the need for 'education through science.'

Introduction

Stakeholder involvement and interaction in PROFILES project

The PROFILES project calls for stakeholder involvement and interaction to fulfil the need to "bridge the gap between the science education research community, science teachers and local actors in order to facilitate the uptake of inquiry-based teaching" (FP7 – science in society – call, 2009, 21). A Delphi study (Bolte, 2008; Häußler, Frey, Hoffmann, Rost & Spada, 1980; Mayer, 1992), undertaken within the PROFILES project, is a consequence of this effort. The overall objective of the PROFILES Curricular Delphi Study on Science Education is to engage as many and as diverse stakeholders as possible, first in order to collect their views on aims of science education in general and second in delineating aspects and approaches of desirable science education, specifically Inquiry-based Science Education (IBSE). Hence, the study aims at illustrating desirable science education in the opinions of selected communities from society (Schulte & Bolte, 2012). The general and methodological aspects of the study are covered in the introductory article (Schulte & Bolte, this book).

The study has been carried out in collaboration with other partners, who adapted the same approach to the needs of their country. The outcomes from the study are intended to enable an awareness of stakeholders points of view in a continuous professional development programme, designed to promote

"the implementation and dissemination of PROFILES ideas, intentions and objectives and to facilitate the uptake of innovative science teaching enhancing scientific literacy of students" (PROFILES, 2010).

PROFILES Curricular Delphi Study

The PROFILES Curricular Delphi Study on Science Education was undertaken in three rounds. In the first round, stakeholders were made aware of the framework, aims, structure, concepts and methods of the study and were asked, via an open-ended questionnaire, to reflect on the desired content and aims of science education.

The second round of the PROFILES Curricular Delphi Study on Science Education was about critically considering and reflecting on the findings,

which resulted from an analysis of the individually formulated participant responses in the first round. For this purpose, in accordance with the Delphi method, the categorisation resulting at the end of the comparisons of the first round was fed back to the participants, guided by specific tasks and questions.

The objectives of the third round of the PROFILES Curricular Delphi Study on Science Education were to:

- identify specifically priorities and realities the participants assigned to the concepts of desirable science education, derived from the hierarchical cluster analyses in round 2;
- find out where priority and actual realization in science education practice drift apart, in the opinions of the participants (Schulte & Bolte, this book).

Continuous professional development in PROFILES

Continuous professional development (CPD) is a crucial component of the PROFILES project. By means of teacher development, PROFILES:

1. Aims 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. This recognises the importance of science education as more than content and skills and the need for an 'education through science' perception (Holbrook & Rannikmäe, 2007).
2. 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.

Turkey, as one of the project partners, held workshops, in conjunction with ICASE, with 40

science and technology teachers, who teach at the grades 6–8 school level. In total, 4 CPD workshops were held during the first year of the project, stressing the need to build up a common understanding and to focus on the same target. The details of these workshops have been presented in an article on reflections from the PROFILES project (Özdem & Cavas, 2012).

Purpose of the study

In this study, we aimed to describe and comment on the diversity and discrepancy in an arbitrary sample of teachers' perceptions regarding science education in Turkey, in comparison to an arbitrary sample of other stakeholders. The study also explored how we resolved these discrepancies through continuous professional development programmes. Stakeholder views, which were evaluated in this study, were taken from the first and second rounds of the PROFILES Curricular Delphi Study. The inclusion of the third round and the overall implications are anticipated to be published later.

The main and sub-questions guiding this article were:

- Which characteristics of a desirable science education do teachers consider as being important in comparison to other stakeholders?
 - Which priorities regarding aspects of desirable science education can be derived from the responses obtained from the teachers and other participants involved?
 - To what extent are the respective aspects in the participants' opinions realized in science education practice?
 - What kind of priority-practice differences can be identified based on the views of the arbitrary collection of a group of diverse participants?
- How are the discrepancies in an arbitrary sample of teachers' responses, with regard to the first question, resolved through continuous professional development?
 - Which characteristics of desirable science

education, which teachers consider to be important, are included in the CPD?

- To what extent are the identified priority-practice differences addressed in the CPD?

Framework and data acquisition

Selection of participants

The Delphi method is based on a fixed group of participants throughout the different rounds (Linstone & Turoff, 1975). Therefore, the stakeholders who took part in the first round were called on to answer the second round of the PROFILES Curricular Delphi Study. To ensure the accessibility of the sample, a convenient sampling method was used.

Participants involved in the Delphi study included students studying at grade 8 and 10; pre-service teachers studying at different science departments in faculties of education; in-service teachers, both in their first year of teaching and those experienced; teacher educators employed in different science education university departments in Turkey; scientists employed in science departments at different universities in Turkey; employers in large – and small-scale industries; and politicians with an interest in education.

Out of 134 participants from the first round, a total number of 125 participants (93% of the participants from the first round) took part in the second round. The students (29) represented 23% of the total, of which 9 were also involved in the PROFILES CPD programme for teachers, representing 22.5% of the total of the 40 teachers.

Instruments

The questionnaire used in the first round of this Delphi study is an open-ended questionnaire addressing the following areas:

- Preferred topics/themes and methods for teaching and learning science
- Skills and attitudes that should be encouraged in school science

- Suggestions for improving science education/scientific literacy of individuals

In the second round, the categories that were identified in the first round of the PROFILES Curricular Delphi Study in Science Education were presented to the participants for their evaluation from two points of view (“priority” and “practice”) using a six-tier scale. The two points of view were specified by the following questions:

- (1) Which priority should the respective aspects have in science education (priority)?
- (2) To what extent are the respective aspects realized in current science education (practice)?

Data collection procedure

In both rounds, the questionnaires developed for this Delphi study were administered to all participants via e-mail; by means of document share in Google-docs (online questionnaire), which participants completed online; and by face-to-face interviews, which were audio recorded, depending on the availability of the participants. All data gathered through questionnaire formed a data pool on excel files enabling further analyse to be carried out.

Procedure and method of the data analysis

The statements received from the 135 participants in the first round of the Curricular Delphi Study in Science Education were analysed step-by-step as indicated in the model prepared by Bolte (2003). Weft QDA software was used in order to find out:

- (1) how many times keywords in each category were repeated,
- (2) how many of the participants used the keywords in each category, and
- (3) which group of participants used the keywords.

Consequently, the results of the data-gathering involved codes and categories, drawn in an interpretive nature by the researchers involved in the study.

Delphi round	Topics, themes, concepts and methods of Science	Students	Teachers	Science educators	Scientists
2 (priority)	Scientific inquiry/ investigations	4.45	5.41	5.71	5.64
2 (PPD)	Scientific inquiry/ investigations	.10	1.83	2.21	2.50
2 (priority)	Inquiry-based science learning	4.86	5.39	5.07	5.45
2 (PPD)	Inquiry-based science learning	.55	1.96	2.57	2.30

* PPD means priority-practice difference calculated by the formula mean for priority – mean for practice

Table 1. Results regarding inquiry-based learning from the Delphi study for means related to the priority given to the topic and also means for the difference between priority and practice

In the second round, the data regarding the first part of the questionnaire were analysed by means of descriptive and variance analytical methods. Statistically significant differences between the assessments of the different sub-sample groups were identified through the Mann-Whitney-U test.

Where does the CPD aspect come in?

Results

The statements in the answer sheets of the respondents were analysed by a qualitative content analysis approach. By reading throughout all statements made on the questionnaires, key words were sought, which summarize the statement. The resulting keywords and categories were examined under three headings:

- Preferred topics/themes/concepts and methods for teaching and learning science.
- Competences and qualifications that should be enhanced in school science.
- Contexts, motives and situations that should be encouraged in school science.

The results were interpreted with regard to:

- (a) the diversity in teachers' and other

- participants' responses, and
(b) how the discrepancies were addressed through continuous professional development programmes.

Topics, themes, concepts and methods

In the first round of the Delphi study, there was a variety of answers regarding the preferred topics/themes/concepts and methods for teaching and learning science. However, in the second round, the responses were more specific and focused on scientific inquiry. The teachers, as well as the other stakeholders, stated that scientific inquiry and inquiry-based science learning have a high priority in science education (Table 1). Here, the groups of participants were collapsed into four categories; students, including elementary and high school; teachers, including pre- and in-service teachers; science educators; scientists including; educational administrators.

There were significant differences in priority assessments and priority-practice differences (PPD) assessments about scientific inquiry between students and teachers ($p < 0.05$), students and science educators ($p < 0.05$), as well as students and scientists ($p < 0.05$).

The only significant difference in priority assessments about inquiry-based science learning

was between students and teachers ($p < .000$). However, in PPD assessment, students and teachers ($p < .000$), students and science educators ($p < .002$), as well as students and scientists ($p < .003$) significantly differ in their views.

Yet, the priority-practice difference showed that all stakeholders, except students, observed a considerable gap between the priority associated with scientific inquiry and inquiry-based science learning and the realization of this priority in current science lessons (Table 1).

How it was addressed

Scientific inquiry and inquiry-based science learning are keywords for the PROFILES project, which aims at disseminating Inquiry-based Science Education (IBSE).

Therefore, the CPD programmes were planned and implemented around these concepts and methods. For example, in the second CPD session, an aim was to agree on a definition of inquiry in order to have a common understanding of the concept by all teachers. Therefore, inquiry methods, such as open inquiry, guided inquiry, and structured scientific inquiry were introduced, and the teachers experienced all types and methods of inquiry. The teachers were asked to think about the pros and cons of all scientific inquiry methods. At the end, *teachers as teacher learners* experienced an open-inquiry on a real life topic. Moreover, in cooperation with other partners of the PROFILES project,

teachers had a chance to see examples of scientific inquiry and inquiry-based science learning in a number of PROFILES modules (Photo 1).



Photo 1. CPD workshop examples to meet the need for scientific inquiry and inquiry-based science learning

Competences and qualifications

In terms of the competences and qualifications, all stakeholders put emphasis on critical thinking skills in the first round of the Delphi study (Table 2). Also in the first round, more than half the teachers (59%) underlined the role of science education in enhancing critical thinking skills.

Delphi round	Competences and qualifications	Students	Teachers	Science educators	Scientists
1	Critical thinking skills (percentages)	30%	59%	31%	29%
2 (priority)	Formulating scientific questions/hypotheses (mean)	4.45	5.48	4.86	5.27
2 (PPD)	Formulating scientific questions/hypotheses	0.38	2.15	1.93	2.30

* PPD means priority-practice difference calculated by the formula mean for priority – mean for practice

Table 2. The results regarding formulating scientific questions/hypotheses, based on the Delphi study

Critical thinking is a comprehensive concept, which refers to the use of cognitive skills or strategies in a purposeful, reasoned, and goal-directed manner in solving problems, formulating inferences, calculating likelihoods, and making decisions (Halpern, 1999). The results, gathered in the second round of the Delphi study, specify the concept into formulating scientific questions/ hypotheses, which is prioritized by all stakeholders.

In priority assessments, the only significant difference in formulating scientific questions/ hypotheses was between students and teachers ($p < .000$). In terms of priority-practice difference, for the same category, there were significant differences between students and teachers ($p < .000$), students and science educators ($p < .004$), as well as students and scientists ($p < .000$).

Nevertheless, stakeholders, excluding students, thought that the ability to formulate scientific questions/hypotheses was not fully realized in current science classrooms. Especially teachers and scientists, pointed to the gap between priority and practice in their assessment (Table 2).

How it was addressed

Formulating scientific questions/hypotheses is one of the processing skills in critical thinking, creative thinking and problem solving (Cuccio-Shirripa & Steiner, 2000). Yet, this skill requires effort, as well as putting forward a demand in the classroom. That is, students need to be willing to invest effort in questioning, but of equal importance, teachers need to be able to demand this ability by appropriate strategies. Therefore, in the second CPD, a specific part of the CPD session was given to enhancement of this skill. The teachers were trained in formulating questions/hypothesis, as well as enhancing this ability in their own classrooms through hands-on experimentation. Based on the work of the Exploratorium Institute for Inquiry, we adapted the Raising Questions workshop (<http://www.exploratorium.edu/ifi/>). Teachers were asked to investigate an ice ball and to formulate investigable and non-investigable questions for scientific inquiry. Later, they were also given strategies showing how to transform their students' non-

investigable questions into investigable ones, by simple alteration of the variables (Photo 2).



Photo 2. CPD workshop examples to meet the need for formulating questions/hypothesis

Contexts, motives and situations

In the first round of the Delphi study, the stakeholders, among other things, very frequently emphasized *daily life related knowledge* as an area, or field of science that must be learned to be scientifically literate. Specifically, the teachers, as a group, held this viewpoint more strongly, compared to other stakeholder groups involved in the first round (Table 3). Specifically, almost half of the teachers thought science education must be integrated into the daily life of the students by means of connections between everyday life events and the science learned in school.

In priority assessments, there were significant differences about learning related to everyday life between students and teachers ($p < .000$), as well as teachers and scientists ($p < .039$). However, there were no significant differences in practice assessments in the same category.

In the second round, the results did not differ. Stakeholders were asked to rate the priority of situations, contexts and motives between a very high priority and a very low priority (1 to 6; 6 being

Delphi round	Area/ field of Science	Students	Teachers	Science educators	Scientists
1	Daily life related knowledge (percentages)	0	46%	19%	19%
2 (priority)	Learning related to everyday life (mean values)	4.21	5.32	5.00	4.73
2 (practice)	Learning related to everyday life (mean values)	4.21	4.01	3.50	4.00

Table 3. The results regarding daily life related knowledge based on the Delphi study

the highest priority). The results illustrated that teachers agreed to the high priority level (mean = 5.32) for *learning related to everyday life*, significantly higher than for other groups (4.20 < mean < 5.01) (significantly differing from students ($p = .000$) and scientists ($p = .0300$) at a 0.05 significance level).

How it was addressed

Considering that the teachers attributed a high priority to the integration of science into students' life, the structure of the PROFILES modules was carefully examined in the CPD. The modules were the centre of each CPD, first because of their role in facilitating teachers 'owning' the project, and second, because their structure directly addressed the interlinking of science with life. We especially focused on the role of the scenario in the modules, in order to demonstrate that the science was nothing, but integral to life itself. For example, we provided information about traffic accidents (modules named 'Can traffic accidents be eliminated by robots?' on www.profiles-deu.net) that had taken place in Izmir in one year, mainly because of drivers far exceeding the speed limitations. This was to enable students to realize that the issue was right in front of their face and they should start to think about the scientific problem related to this and then to address the problem and seek its solution.

Moreover, we were careful to use easy-to-find materials in all CPD sessions in order to exemplify that we don't always need a specialised laboratory in science, and that real life could itself be a laboratory. For example, in the second CPD, we asked teachers to try to address the problem of

erosion on a small scale and started to ask (or got students to ask) questions about it, in order for the teachers to understand that even the soil around them was enough to turn a class into a laboratory in search of an answer, and to enable students to be able to inquire into the topic by themselves (Photo 3). In another CPD session, we demonstrated to participants how small objects around us could be of use in science. For example, our guest scholar taught teachers how to use a cap of a plastic water bottle as a microscope, and showed what they could do with plastic straws (in addition to drinking soda!).



Photo 3. CPD workshop examples to meet the need for learning related to everyday life

The aim of the PROFILES project is to disseminate Inquiry-based Science Education (IBSE) in a

motivational and educationally relevant manner. The project strives for success by means of creating and using innovative, inquiry-based, education through science, learning environments and programmes for teachers' continuous professional development. Specifically, the continuous professional development (CPD) programmes in PROFILES are developed in order to enhance teachers' knowledge and pedagogy in inquiry-based science teaching, reflect on their teaching for motivation education through the science so that they will be able to enthuse, scaffold and encourage students to interact and discuss in acquiring the range of learning skills needed, such as formulating scientific questions and hypotheses, thinking critically, conducting scientific investigations, working as a group, undertaking a leadership role and reflecting on their learning in a society frame, etc.

Nevertheless, the views and requirements of the targeted teacher groups are very important to enable them to take ownership in more effective ways, so that as many students as possible benefit from the PROFILES teaching modules and approaches. Therefore, the PROFILES Delphi studies, designed to involve stakeholders in the project ideas and aiding the bridging of the gap between science education theory and practice, lead to a more desirable inquiry-based, education through science education within the school system.

Conclusion

This study is an attempt to reconcile the collective efforts in understanding the priorities and concerns of stakeholders, particularly teachers, and to respond to these through continuous professional development programmes. The results of the study illustrate how science teaching and learning is realized from the very beginning within the PROFILES project and how it is matched to the goals and emphases identified by means of Delphi studies, and the investment needed by teachers via CPD programmes.

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**SECTION 2:
CASE STUDIES ON PROFILES LEARNING
ENVIRONMENTS**



Case Studies on PROFILES Learning Environments

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This section of the book reports on case studies undertaken on the development or adaptation of teaching learning materials and their implementation in the classroom, geared to the philosophy and approach put forward within the PROFILES project. A summary of the PROFILES philosophy is given in the diagram below:

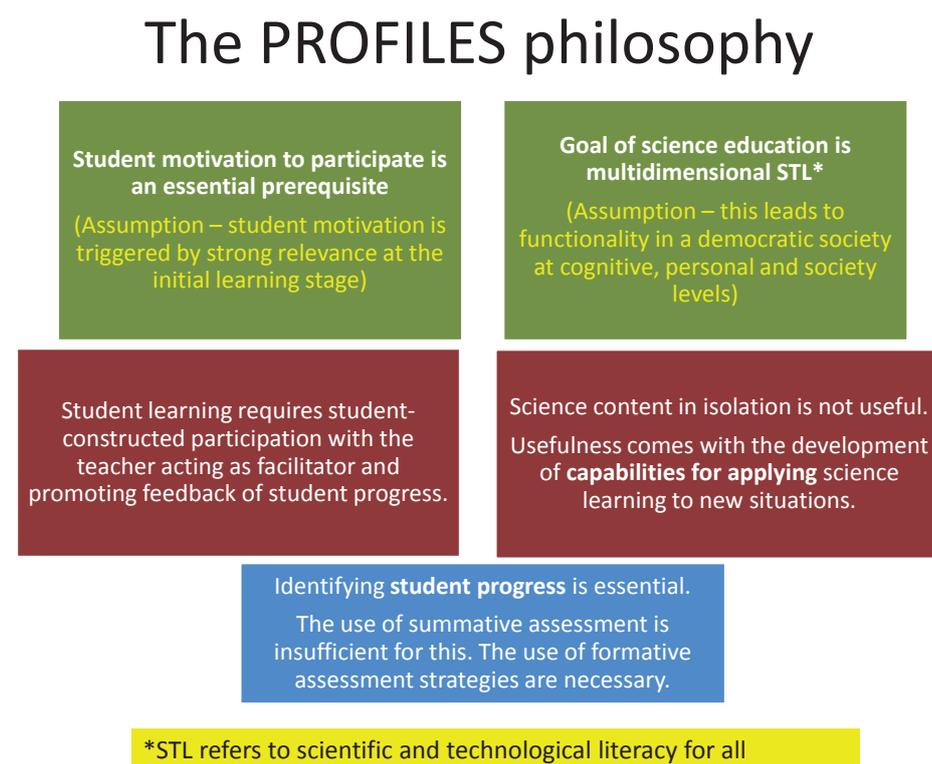


Figure 1. The PROFILES Philosophy

The teaching learning materials promoted within PROFILES are in the form of modules and inevitably they interrelate to the goals of education and the desired emphasis indicated, at least in part, by the views expressed by stakeholders. Such views were gathered by means of a Delphi study (see section 1 in this book). PROFILES anticipates a strong need to promote education through science learning, especially in terms of employability skills, in this context.

Guidance for teachers in the PROFILES ideas comes from a continuous professional development (CPD) programme which sets out to develop the teacher's

self-efficacy related to the PROFILES philosophy and teaching approach. PROFILES advocates that the devised professional development programme is based on actual teacher needs to meet the context-based teaching direction and emphasis being promoted through the PROFILES project. Carefully devised modules form an important

aspect of this professional development, as teachers view exemplars, seek to modify these in the light of the curriculum expectation within a country and try out the advocated ideas and approach through teaching using PROFILES modules in the classroom setting, within the CPD. This leads to teacher reflection on the teaching implemented, expected to show a reorientation from that usually conducted (and as usual with new development, more time consuming) as a further important component of the professional development (see section 3 in this book).

In some cases (see the approach to modules development by the PROFILES-Bremen team in this section), teachers with a strong background in STL and PROFILES ideas, are well positioned to develop new modules during the actual (extended) CPD programme. This is possible, of course, but is not promoted within the actual project for fear that the emphasis on a relevant, context-based approach with the attention to wider educational goals is undermined by reverting to more usual content-led teaching. The ability to move to PROFILES idea is likely to be indicated by the reflective feedback given by the teachers, after having the opportunity to operationalise context-based teaching in their

classrooms. With this in mind, the usual PROFILES approach advocates that teachers first develop their self-efficacy using existing (perhaps partner modified) modules, based the PROFILES ideas, and then later recommends partners to encourage interested teachers to include the new found PROFILES ideas in their regular, future teaching (almost inevitably meaning overcoming or minimising numerous constraints associated with: a lack of familiarity with the intended stress on student motivation based on a familiar, socially related perspective; unfamiliarity of the approaches to science teaching initiating by greater student involvement in operating IBSE so as to maximise learning, and finally promoting students' learning through developing decision-making skills in a meaningful context).

Modules, carefully developed and true to the intended learning, thus form a major outcome from the PROFILES project and although expected to follow the PROFILES philosophy and orientation,

can be expected to differ in meeting the teacher needs in a given country, or system. However, whichever module, the intention is that it goes beyond a simple promotion of inquiry-based science education (IBSE) and, also relates to seeing meaningful student learning as a major target i.e. the 'education through science' perspective (Bolte et al., 2012). Unfortunately, the 'education through science' learning component is often ignored by science teachers who see science content as the major, and maybe the only, goal of science teaching (perhaps here the textbook shares the blame!). Yet most school science curricula recognise the importance of generic educational skills, such as collaborative team work, promotion of creative thinking, positive attitudes towards the learning and encouraging student reflection on their learning to enhance the acquisition of conceptual science (the last point being a particular cause for concern in many classrooms). PROFILES recognises this wider educational view as illustrated in Figure 2.



Figure 2. PROFILES in Action

A science education model in the context of a relevant teaching approach

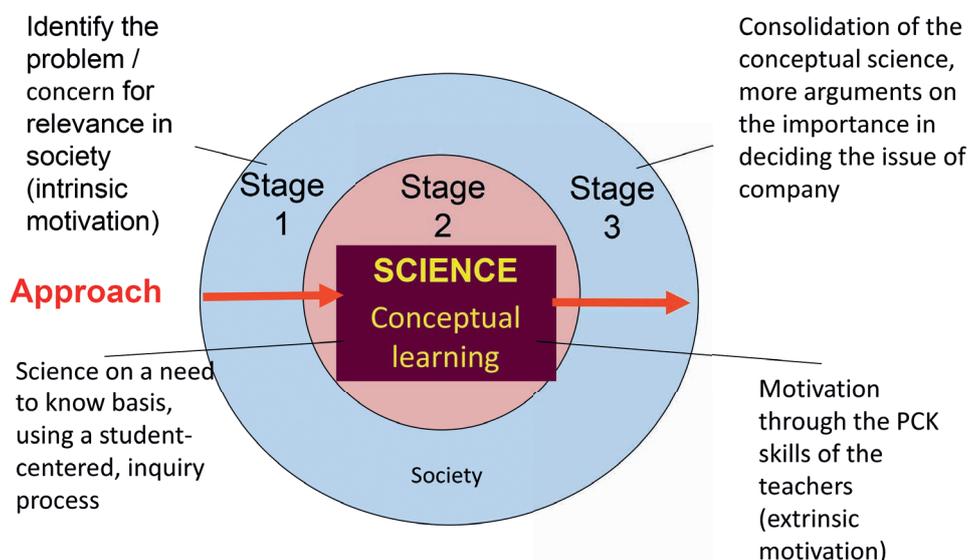


Figure 3. A science education model in the context of a relevant teaching approach

PROFILES modules thus differ from other teaching-learning materials. They are developed based on a 3-stage model, unique to PROFILES (Holbrook & Rannikmäe, 2012). The model can be described in a number of ways, but in all cases the teaching stages are not distinct in the eyes of the student and the model advocates the teaching and learning, based on a module presented as an inherent whole. A generic depiction of the model is given in Figure 3.

Module Criteria

As PROFILES modules are expected to be carefully constructed, they are expected to meet the philosophical and teaching direction for science education being advocated. This particularly relates to:

1. Promoting positive student motivation during the introduction.
2. Utilising a socio-scientific approach – a scenario (which by definition is context-based).
3. Encompassing student-led, inquiry-based, constructivist science learning.
4. Focusing on learning outcomes are competency based, encompassing learning associated with knowledge, skills, attitudes and especially

values (education through science)

5. Consolidating the gaining of conceptual science through transference by means of argumentation to a socio-scientific issue (the initial scenario).

PROFILES modules are based on those developed in the PARSEL project (www.parsel.eu) and are thus expected to meet similar criteria as outlined in Table 1.

The following articles set out to illustrate, through case studies, PROFILES modules and their application in science teaching.

An Estonian article relates the development of a PROFILES teaching-learning module with priorities for promoting competences within an academic, personal and society frame, derived from key competences proposed by the European Commission, the views put forward by Estonian stakeholders and illustrates how this meaningfully fits within the 3-stage model promoting relevance in the teaching of science.

The article from Finland reflects on a module on health and its enactment in the classroom based on the three PROFILES stages.

Criterion 1	Module title/layout has a socio-scientific orientation (it has familiarity to the student).
Criterion 2	Module addresses the need for relevance in the 'eyes' of students (it is seen as having a meaningful purpose from the students' point of view before the student engagement).
Criterion 3	Module includes a range of educational-appropriate learning objectives/competencies (not only conceptual science, but all goals related to the intended curriculum).
Criterion 4	Module enhances student ownership of the learning through participation (especially with respect to thinking).
Criterion 5	Module includes student first-hand experimentation/ modelling (IBSE is an intended component).
Criterion 6	Module emphasises higher order cognitive learning by students (learning goes beyond memorisation and beyond just an explanation of phenomena/observations).
Criterion 7	Module guides teacher ownership (there is a teacher's guide that suggests, not dictates – student worksheets, equipment, and any hand-outs are given as suggestions only).
Criterion 8	Module includes student appreciation of the nature of science (science is not portrayed as the truth; observation are seen as subjective rather than objective; laws differ from theories, hypotheses are more than guesses, science is based on evidence and science is seen as a creative endeavour and is influenced by society and culture).
Criterion 9	Module includes suggested formative student assessment strategies (relates to all learning outcomes not only those pertaining to pencil and paper approaches).

Table 1. Criteria applying to PROFILES modules

In the scenario stage, students familiarized themselves with 5 blogs written by other students about their health problems. In the inquiry stage, students investigate issues related to the teenagers' health problems, while in the decision-making stage, the students applied their new knowledge and skills in counselling the 5 teenagers.

The article from Cyprus seeks to incorporate the students' voice in the development and teaching associated with modules. The article highlights student views related to the role of the teacher, the role of the students and also the teaching materials. The findings provide empirical evidence to support the argument that the development of a learning environment, which takes students' perspectives into account, can result to substantial learning gains for students.

The article by the Bremen group focuses on how a group of teachers can work together to plan, design and create a new module based on PROFILES ideas. The paper discusses the development of modules utilising a participatory action research approach. The module is initiated through a socio-scientific issue as per the PROFILES approach, namely the

problem of growing amounts of waste caused by the short life-cycles of many technological products. Findings which emerged from the testing and evaluation process represent the justified points of view of the teachers, researchers and students participating in the study.

The Slovenian article examines the components associated with the development of a module and gives a range of examples from a Slovenian perspective. The collaboration between researchers and teachers in the PROFILES project in the Slovenian context is illustrated and GALC (Guided Active Learning in Chemistry) ideas are incorporated, based on developments in cognitive learning theories and classroom research leading to a structured approach based on why do I need to learn this, learning goals and outcomes, do I understand and can I solve the problem.

The article from Ireland examines the use of PROFILES modules for a particular age group which is termed a transition year (between grade 9 and grade 10). It outlines a number of case studies in which PROFILES teachers identify key areas of the CPD programme. The paper summarises findings

from “leader” teachers, who created the modules and puts forward the main conclusions drawn in terms of the effectiveness of the modules in the PROFILES intervention strategy.

The article by French teachers explores the teaching and student outcomes associated with a modified module. This case study explores the use of PROFILES in the development of students’ second language (in this case English where the mother tongue is French) through the teaching of science. Findings indicate the students found the learning of science in the PROFILES manner interesting and useful in gaining practice in developing their communication skills in a foreign language.

A further Estonian article follows through the development of a PROFILES module based on the 3-stage model, illustrating a networking approach, and then seeks student reactions to the teaching approach developed, using a Likert style questionnaire and 4 open ended questions.

The final article, a second from the Bremen team, introduces the use of new software during the PROFILES CPD, designed to assist the use of handheld and laptop computers in new ways of organising and displaying module materials. The article describes the software and how it aids the development and use of a module on Bionics.

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2.1 Case Study about Developing Student Competences in Science Class

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Abstract

Estonia has adopted a competency-based curriculum since 2010 and has developed new curricula promoting competences which can be grouped as academic, personal and social. As the purpose of science education in Estonia is expressed as promoting scientific literacy, the goals of education can also be expressed as developing the nature of science, personal development and social development. To determine priorities for promoting such competences in the teaching of science, support was sought from Estonian stakeholder views and related to this, the emphasis in the development of PROFILES teaching-learning modules. Student views were also sought on one module created based on such competences in answer to the questions – what did you learn and what did you like? This article reports on the competences identified for inclusion in the 3-stage PROFILES model and student responses following the teaching of this model.

Introduction

A competency-based approach to education has gained acceptance in many countries in recent years and Estonia is no exception. Based on the key competences promoted by the European

Commission (Eurydice 2002; 2012), Estonia adopted a new competence-based curriculum in 2011 for grades 1-12 (Estonian National Curriculum, 2011).

In Estonia, science teaching largely remains in the separate subjects of biology, chemistry, physics

	Sub-Group of competences	Scientific Literacy (Holbrook & Rannikmäe, 2009; Choi et al., 2011)
Academic competences	Academic knowledge	Knowledge, skill, attitudes and values associated with the nature of the subject; capability to interrelate and transfer knowledge to new situations, metacognition
	Academic skills	Inquiry skills: identifying a scientific problem, posing the research question, skills associated with planning and conducting experimentation, skills in interpreting finding and making relevant conclusions, scientific reasoning
Social competences	Competences needed in everyday life	Skill to search for relevant information and it's critical evaluation, communication skills, interacting with others, risk assessment, justified decision-making
	Competences needed for a career	Skills in leadership, cooperation, taking responsibility, adaptability, openness, enthusiasm, enterprise, independent work
Personality	Aptitude of personality	Objectivity, empathy, self-confidence, showing initiative, coping with stress, sense of humour, curiosity, adequate self-esteem
	Personal values	valuing others' ideas, observing healthy lifestyle, respect for human rights, a caring attitude towards other, tolerance, self determination

Table 1. Competences associated with Science Learning

and geography, but the new curricula focus on competences within each subject, which can be labelled academic (DiPerna & Elliott, 1999), personal (Seligman & Csikszentmihalyi, 2006) and social (Caldarella & Merrell, 1997; Gresham, Van & Cook, 2006), although the grouping of competences was not seen as isolating them from each other; for example Welsh, Parke, Widaman & O'Neil (2001) showed social and academic competence to be reciprocally related. The stated goal of science learning in Estonia is scientific literacy (Estonian National Curriculum, 2011) and this sub-divides into a conceptualisation of the nature of science, plus the development of personal and social attributes (Holbrook & Rannikmäe, 2007). The promotion of such competences and the development of scientific literacy are strongly related, as illustrated in the Table 1.

Although a range of competences are stipulated in the science curricula, the actual selection of competences developed for student learning, is undertaken by the teacher. However, previous Delphi studies show that a gap exists between the opinions of teachers and students about the importance of competences developed in the science classroom. While academic knowledge and skills were similarly appreciated by students and teachers, science teachers did not value the promotion of social competences so highly. Statistically significant differences between teachers and students opinions were also found in the evaluation of the aptitude of personality and competences needed for a career, and opinions

about personal values and competences needed in everyday life (see table 2) (Post, Rannikmäe & Holbrook, 2011).

In the following tables, comparisons of teacher and student opinions are given.

Data in Table 3 showed that students evaluated all competences in this domain higher than teachers. Especially large difference occurs in the evaluation of imagination. In the students' opinion, this competence was most needed for recruitment, but teachers did not value developing this competence in science lessons (value was below mean when compare with the data given in Table 2).

Data in Table 4 showed that students evaluated all competences in this domain higher than teachers. Especially large difference occurs in the evaluation of curiosity and sense of humour. In students' opinion, these aptitudes are highly valued, but teachers did not particularly value the development of these aptitudes during science lessons.

The goal of this case study is to show how a PROFILES module can be developed and used to promote intended competences and strive to decrease the gap between teachers' and students' opinions about the significance of competences developed within science teaching, using a motivational inquiry-based teaching approach associated with the PROFILES 3-stage model (Holbrook & Rannikmäe, 2010, 2012).

Group of competences	Subgroup	Mean (max = 6)	
		teacher's opinion	student's opinion
Academic competences	Academic knowledge	4,09 (SD=0,95)	3,94 (SD=1,21)
	Academic skills	3,88 (SD=0,94)	4,26 (SD=0,95)
Social competences	Competences needed in everyday life	3,90 (SD=0,90)	4,38 (SD=1,03)*
	Competences related to career	3,64 (SD=0,93)	4,41 (SD=0,98)**
Personal competences	Personal aptitudes	3,67 (SD=0,95)	4,47 (SD=1,03)**
	Personal values	4,90 (SD=0,91)	4,59 (SD=1,09)

* statistically significant difference at level $p \leq 0.05$

** statistically significant difference at level $p \leq 0.001$

Table 2. Mean of students' and teachers' evaluation across the competences

Competences	Mean of teachers' opinion	SD	Mean of students' opinion	SD
Leadership	3,36	0,81	4,12**	1,06
Openness	3,48	0,92	4,64**	1,03
Enthusiasm	3,56	1,04	4,40**	1,02
Imagination	3,60	1,00	4,86**	0,93
Enterprise	3,60	1,00	4,33**	1,11
Responsibility	3,80	1,08	4,69**	0,98
Independent work	4,00	0,87	4,55*	0,91
Cooperation	4,04	0,79	4,75**	1,00

* statistically significant difference at level $p \leq 0.05$

** statistically significant difference at level $p \leq 0.001$

Table 3. Mean of students' and teachers' evaluation of competences perceived as needed for a career.

Aptitude of personality	Mean of teachers' opinion	SD	Mean of students' opinion	SD
Sense of humour	3,52	0,82	4,80**	1,11
Empathy	3,52	1,05	4,35**	0,98
Risk-taking	3,52	0,82	4,56**	1,06
Adequate self-esteem	3,56	0,96	4,22*	0,99
Curiosity	3,72	0,94	4,93**	1,06
Self-confidence	3,76	0,78	4,40*	0,99
Objectivity	3,76	0,93	4,47*	0,81

* statistically significant difference at level $p \leq 0.05$

** statistically significant difference at level $p \leq 0.001$

Table 4. Mean of students' and teachers' evaluation of the aptitude of personality

Creating the PROFILES module

A created module needs to be consistent with the existing curriculum. The Estonian chemistry curriculum (grades 10–12) includes the topic 'organic chemical industry and energy' and this can be a focus to consider learning in the three

competence areas related to:

- Academic, conceptual learning e.g. concept of and investigations into; fuels; petroleum oil and refining (fractional distillation); fuel suitability for cars and alternative fuels in everyday life. The processing of a raw material

to a chemical product and the formation of its price. The connection of petroleum oil and its derivatives with the environment, economy and politics; related socio-scientific decision-making.

- (b) social competences is intended through collaborative learning (skills to search for relevant information from a variety of sources and its critical evaluation), use of relevant communication skills (written, interacting with others, symbolic communication), ascertain risk assessment, making justified decision-making), and
- (c) personal aptitude and values by focusing on self-development (creative planning; taking responsibility, leadership, adaptability) and valuing the ideas of others, openness, showing enthusiasm, exhibiting enterprise.

The module was developed within the PROFILE project, which advocates modules should be created in four major components –

- (a) a front page in the PROFILES design (giving an overview of the module and key teaching-learning aspects);
- (b) student tasks, based on an initial scenario;
- (c) a teacher guide to provide useful support to the teacher and within this, or as a separate section, suggested assessment strategies and
- (d) additional notes (if needed) for the teacher, related to the subject matter and useful references.

The module used as an illustration for this case study is entitled '**Petroleum Oil – King of the world or the Achilles' heel.**' It is developed, based on the promotion of the identified 6 sub-competences, all integral to the teaching within the science class for the developed context. The sub-competences to be gained by students are identified as:

- academic knowledge (explain the meaning of a fuel, the origins of petroleum oil and what is meant by the term hydrocarbon (giving examples); explain cracking and its purpose; detail requirements for a fuel to be suitable for car and compare the advantages and disadvantage of alternative

fuels. Compare the use of petrol and diesel as a fuel and explain the meaning of octane number; suggest meaningful reason for the fluctuation of the price of these products and their contribution to air pollutions and the build-up of carbon monoxide and 'smog' in urban areas; explain the meaning of a oil spill, how it can be caused and its effect on environment, economy and politics – explain ways to handle oil spills and their prevention; suggest ways to deal with wildlife and the environment in cases of oil spills);

- academic skills (illustrate experimentally, or by means of a model, how fractional distillation can be carried out in the refining of oil and the products formed (taking or recording appropriate safety precautions); show by means of a graph or otherwise the relationship between the relative molecular mass of a hydrocarbon and its melting point/ boiling point; devise ways to measure the impact of petroleum products on the environment (in terms of CO and particulates) and conclude ways to convert CO to more healthy products.
- competences needed for everyday life (undertake the above making use of appropriate information sources, working as a team and conceptualising the learning and justified values by means of a report of the experimental work and an essay conveying how the conceptualising interrelate to personal safety concerns and justified decisions related to the impact of petroleum fuels and their use on society).
- attributes and competences needed for a career (demonstrate leadership and cooperative learning through taking responsibility for independent work, guiding group work and ensuring all members of the team playing a meaningful role in the conceptualisation of petroleum oil, its immense value but its socio-scientific concerns both in the sense of the development of scientific endeavours and in meeting society needs).
- aptitudes or personality (objectivity, empathy, self-confidence – through conceptualisation of the chemistry of

hydrocarbons and petroleum oil in particular develop a sense of the value of the learning by the development of a concept map and the willingness to present such development and assisting others in gaining meaningful learning.

- personal values (illustrate intrinsic motivation through self-determination and self-direction in seeking suitable sources of information, putting forward meaningful ideas and showing enthusiasm for the tasks at hand both for the experimentation and in working with the group towards justified decision-making in a socio-scientific situation).

Stage 1. The module, again as per the PROFILES approach (Holbrook & Rannikmäe, 2012), strives to be motivational for students. For this the module strives to put forward an **everyday dimension** seen as relevant by students. In this case the initial scenario, introducing the scientific academic learning in a social interactive setting, is illustrated below. The script is taken, in part, from newsletters published by Äripäev (English: Business Day) – an Estonian financial newspaper in a tabloid format.

The scenario is provided in the students' section of the module (and for the actual teaching the teacher chose to give the first two parts to the students as separate hand-outs). The parts highlighted were a focus adopted by the teacher to ensure students had the appropriate scientific background to deal with the socio-scientific situation.

Part I – [Oil pipelines, through which 40% of the world's [crude oil] flows, are [highly vulnerable]. Also large [oil tankers] are threatened by pirates and terrorists, particularly when they are forced to go through such "bottlenecks" such as the Suez Canal and the Straits of Malacca and Hormuz. If terrorists succeed in these "bottle necks," or a residential area near oil tanks were to be blown up, it would be the closest thing to a [nuclear bomb explosion] (Äripäev, 15.12.2004).

Part II – The [explosion and fire] on an oil-rig in the Gulf of Mexico on the 20th April 2010 killed 11 people, the platform sank and millions of barrels

of [crude oil began to flow] into the sea. It was the biggest [environmental disaster] in U.S. history, which has already cost BP (British Petroleum) \$8 billion in compensation and damages. BP estimates that the final accident-related costs will approach \$32 billion (Äripäev, 19/09/2010). [Parts in brackets specifically relate to the powerpoint slides in stage 2]

Stage 2. Part III – Building on the background (self-learning) from parts I and II and consolidating the background ideas, a teacher slide presentation follows. The presentation is via 35 PowerPoint slides with the specific aim of introducing new/consolidating known conceptual, interdisciplinary knowledge about petroleum oil (4 slides on origins, hydrocarbon structure, isomers), (12 slides on separation techniques to obtain different fractions, cracking, storage, transportation and uses as a fuel and beyond), petroleum (6 slides), solubility/boiling point related to structure and a focus on oil pollution and its impact on the natural environment (8 slides) and ways of cleaning up polluting oil (5 slides). The learning is in the form of a whole class discussion, consolidating conceptualisation related to the following competences: academic chemistry on hydrocarbons (prior knowledge from earlier teaching), social confidence in participation and developing communication skills utilising scientific terminology and expressing personal values related to society operations related to petroleum oil. By the end of this slide show, the expectation is that students' background knowledge is consolidated related to the origins of petroleum oil, its chemical structure and physical properties and concerns petroleum oil can have for the society.

Part IV – Moving from the scenario to more detailed scientific exploration. Following the showing of the slides and the carefully teacher-guided discussion, students, individually, were challenged to pose meaningful scientific questions to research related to hydrocarbon fuels and to write these in their notebooks. Then, in small groups, students selected the best scientific question to research form the group and one member of the group wrote this on the blackboard. For the set of questions, the whole class selected two questions for further investigation (guided, if needed, by the teacher

bearing on mind the curriculum requirements and the resources available). The questions selected were geared to pollution aspects: “How best can crude oil be removed from the feathers of birds, which were coated with the oil?” and “What is the most efficient method to collect oil spilled at sea?”

Each small group selected one of these problems and set about developing a plan to answer the research question experimentally and carried out their experimental ideas (once approved by the teacher) to collect data. The work in the small groups was targeted to develop the following academic competences (knowledge and skills):

- (a) posing a scientific question in a meaningful way such that a scientific investigation could follow;
- (b) devising a suitable and effective experimental method, based on sound, prior chemistry knowledge (the experimentation was actually a test of the strength of the students’ prior chemistry learning in the eyes of the teacher);
- (c) undertaking the experimentation in a collaborative manner, paying special attention to safety issues (the teacher was interested here in the inter-student discussions and gaining an impression of students’ conceptualisation of the social issues faced in dealing with petroleum oil);
- (d) skills in interpreting findings (making use of ICT, diagrams, photographs, etc. as appropriate), and
- (e) making relevant scientific conclusions based on the evidence which would form the basis for further socio-scientific discussions and the writing of individual essays addressing the overall question as to whether petroleum oil was the king or the world of the Achilles’ heel.

Homework associated with the experimental work included writing a report on the experimental work and answering to the five questions given on the worksheet. It included applying knowledge about oil and petroleum in new situations, skill to search for relevant information and its critical evaluation, writing communication skills, objectivity and improving of self-confidence.

Stage 3 of the PROFILES approach (socio-scientific decision making) was by students writing an essay answering the dilemma “Petroleum oil – King of the world or the Achilles’ heel?” For this stage, the students clearly needed to draw on their prior knowledge (the discussion stage in the scenario stage) thus further consolidating academic competence e.g. properties of petroleum oil, and drawing on their academic skills, e.g. problem identifying and solving using knowledge gained in developing their social competence: skill to search for relevant information and its critical evaluation, communication skills (writing the essay in a meaningful and decision-making manner!) and incorporating personal values such as their views on respect for rights of living organisms, including human rights for the use of technology, a caring attitude towards living organisms and each other and tolerance.

Teaching, using the module

The module was used by a Chemistry teacher, teaching 11th grade students (18–19 years old). The teacher had worked as chemistry teacher in secondary and high school for 24 years. The students (N=36; 19 girls and 17 boys) had previously learned chemistry in high school through one course in general and inorganic chemistry and had begun to learn about hydrocarbons.

Instrument used to seek student opinions

Opinions were gathered after the experimental lessons using a very general, non-directional, open-ended questionnaire, which covered the following questions:

1. What did you learn during the module-related lessons?
2. What did you like?

Outcomes were also identified from the essays written by students individually.

Teacher opinions related to using the module

The teacher liked to use the approach based on the module rather than using chalk and blackboard – the traditional way. The teacher found the lessons interesting, because the lessons not only included chemical analysed, but also included economic and political aspects linking the petroleum-related chemistry with real life. Also, these lessons were more student-centred, not only in a manipulative sense, but in learning conceptual chemistry, because the students were involved in thinking, interacting with each other and brought forward arguments that were new to the teacher. The teacher understood that including emotional aspects in chemistry lessons can be effective in raising interest and raising the student involvement in the academic learning. Student emotions sometimes arose during the discussions as well as during the practical work. The use of the usual quiz, following the experimentation led to better outcomes than on previous occasions.

In the teacher's opinion, the module gave an opportunity for students to develop their reasoning skills needed in the science lessons and everyday life also. During the discussions in small groups, students listened to the opinions of others, formulated their own opinion, and highlighted the arguments for its approval. Through group interaction, the teacher was able to gain valuable insights into the students' academic learning, especially their conceptual chemistry knowledge.

The scenario – newspaper articles – gave an initial opportunity to discuss the issues of human rights and employers' obligations. In the BP accident, 11 people were killed and one reason was the use of outdated equipment. Students expressed tolerance, empathy and a caring attitude towards the employees killed. Students thus interrelated their science learning with the gaining of social and personal competences developed through science lessons in line with a competence-based curriculum. The teacher felt that using such modules was worthwhile in promoting the learning of competences in the directions advocated through the concept to 'education through science'

(Holbrook & Rannikmäe, 2007; Holbrook, 2010).

Students' opinions about learning this topic

1. *What students learned during the module-related lessons*

Table 5 showed that most students agreed they learned (in a self-determined way) competences in the school curriculum related to science knowledge, which are usually measured through teacher tests under academic knowledge. Less number of students identified that the learning of science knowledge and skills were developed together and allowed the development of a range of important competences.

Students showed also that they differentiate between learning in an academic subject sense and the attainment of general competences, cross-curricula in nature. Such attainment is not usually linked with science learning in the eyes of students (despite the strong recognition of these by employers in the Delphi study) and relate competences in these areas are mainly social skills, personal values and aptitudes, which students recognise are not assessed in a numerical manner and treated by teachers as being of secondary importance.

2. *What students liked*

Table 6 illustrates that students appreciated the promotion of all learning competences, which was the targeted goals of the module. However, boys were more open to express their achievement of competences than girls, especially in areas which included everyday skills.

Sub-Competences	Examples of student comments	Similar learning comments noted		Total number of cases
		by boys	by girls	
Academic knowledge	<i>“I studied petroleum oil acquisition and processing, and the composition of the oil. We handled it and tried sniffing, the oil - now I know exactly what it is. I understand that the transportation of petroleum oil is dangerous in many ways, and better appreciate why a quarrel arose between Ukraine and Russia over the natural gas pipeline.”</i> (Student 5)	14	18	32
Academic skills	Collaboration. <i>“Our group discussed extensively with each other in order to plan how to clean the oil from greasy birds (the use of an emulsifying agent). The funniest, initially, appeared to be Fairy washing-up liquid, but in the end we decided to just use its favour. Afterwards, it turned out they did just that to clean sea birds collected on polluted beaches in Tallinn.”</i> (Student 10)	9	5	14
Competences needed in everyday life	Searching relevant information and its critical evaluation. <i>“I learned to prepare an essay and not to trust always the information on the internet; at least not before thinking about whether it is right.”</i> (Student 11)	5	3	8
Competences needed for a career	Reasoning skill. <i>“We learned how to justify and reason the influence of petroleum on local environment. It turns out that if you say something, you should in some way seek scientific evidence to prove it.”</i> (Student 34)	7	5	12
Personal value	Healthy lifestyle. <i>“I learned that the mineral oil is used in creams made from oil. This is horrible- using this cream for face care. I no longer feel I can buy these cheap creams.”</i> (Student 17) Citizens. <i>“I would like to tax oil tankers calling at the port of Tallinn much higher, in order to raise funds for possible oil pollution cleaning and cleaning the birds.”</i> (Student 30)	2	2	4
TOTAL		37	33	70

Table 5. Students' opinions about what they learned

Competence	Example	Number of cases		Total number of cases
		Noted by boys	Noted by girls	
Academic skills	<i>"I liked this way of learning, which involved a lot of small group discussions, group work, and possibilities to do something myself. I understood all and I learned a lot about oil, which I definitely feel I will need to use in real life, problem solving. Well, for example, that the rise of the price of oil will cause changes in local fuel market consumption."</i> (Student 23)	6	2	8
	Inquiry. <i>"It was great; we got to plan experiments without the dictate of the teacher. We wanted to find out how you can collect the oil in the sea. We began to experiment with different materials to reduce the oil blotch in plastic cups and used, for this purpose, sawdust, sand, and coal crumbs. The better solution, proposed by a group of my companion, was to use rolled-up pieces of pantyhose."</i> (Student 2)	10	4	14
Competences needed in everyday life	Risk assessment skill. <i>"I liked that the teacher drew attention to the work of our group. We did not put the rubber gloves on our hands and did not use plastic cups, but glass beakers. Later on, we found we could not clean our hands and make clean the beaker; the teacher said that our risk assessment skills are low. It was, of course, right and in the future we will definitely think twice before performing experiments."</i> (Student 21)	4	1	5
Competences needed for a career	Collaboration. <i>"I like the team work, because it offered great support to me and I was able to collaborate with a group of companions."</i> (Student 10)	9	3	12
Aptitude of personality	Self-confidence. <i>"I like the collaboration of my team mates, because they corrected me when I'm wrong. As they made the learning fun, my self-confidence grew and in the future I want to be more active in group work."</i> (Student 12)	4	4	8
Personal value	A caring attitude towards others. <i>"I did not like the attitude of the British Petroleum leaders towards their workers. Why do they force them to work with outdated equipment? As a result there was a major oil spill in the Gulf of Mexico."</i> (Student 9)	5	3	8
TOTAL		38	17	55

Table 6. Students' opinions about the module lessons

About the essays

In the students' essays, there were three directions of focus. The first can be referred to as petroleum oil as the Achilles' heel, as oil production and

transport is dangerous, because it can cause huge losses to the environment. To avoid this, alternative fuels should be developed, for example, hydrogen-powered cars. However, the world has forces that are working against this direction, because life in

countries which sell petroleum oil, is easier and better. Young people around the world should be active and demonstrate the advantages of using alternative fuels.

The second direction is more conservative and environmentally associated with sustaining the current production but striving to transportation facilities safer. The main focus – petroleum oil is needed in the energy sector as well as in the chemical industry, although human life and the protection of nature have more worth than petrodollars.

The third direction – the oil as king of the world – was expressed only in three essays. These students wrote about how good it is to live in Saudi Arabia and other oil producing countries. Final Word wrote, however, that the welfare of these countries have hindered the development of science and technology, because money can buy everything from abroad. Although the essay portion of the king of the world when the oil began to emphasize, it was finally decided that it is more of an Achilles heel.

In most of the essays (about 80%) the problem-solving approach was used. In making a decision the information retrieved from various sources, as well as the results of their own experiment.

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2.2 Health Education through the PROFILES Teaching Approach

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Abstract

In the PROFILES Curricular Delphi Study on Science Education, the Finnish stakeholders, in particular students, highlighted health and nutrition issues as a starting point for science education. Furthermore, they also pointed out current topics designed to motivate students. In accordance with these ideas, the health and nutrition learning environments were planned around blogs and websites that related to students' current, everyday life issues: vitamins and nutritional supplements. In cases in which vitamins are used to prevent or heal diseases, they could be considered to belong to medicines; discussions on vitamins and nutritional issues belong to the field of medicine education and are a part of health education. In the scenario stage, pupils familiarized themselves with five teenagers, who had written blogs about their health problems. Based on the pupils' pre-knowledge, using blog texts, they counseled these teenagers about their health problems. In the inquiry stage, through assignments on the website learning environment, pupils studied issues related to the teenagers' health problems. In the decision-making stage, once again in blogs, the pupils applied their new knowledge and skills in counselling the teenagers. One teacher from the school, two teacher educators and three teacher students taught the classes, at the same time learning the PROFILES way of teaching; this also offered the teacher educators a good opportunity to network with the school. Here we present this case study.

Introduction

The use of medicines is a common activity for almost everybody, including adolescents (Dengler & Roberts, 2003; Hansen, Holstein & Due, 2003; Stoelben, Krappweis, Rossler & Kirch, 2000). Studies have estimated that 40% of all people take nutritional supplements. The major type of nutritional supplement appears to be a combination of vitamin/mineral supplements; these are consumed by 46% of users (see O'Dea, 2003).

Rational medicine use, a goal of medicine education, is defined as the right medicine taken in the right way at the right time for the right problem. Medicine education is a fairly new opening in the field of health education, and concerning the use of medicines there is a lack of suitable teaching and learning materials. It is not enough for health educators to teach only conceptual knowledge about the use of medicines. Instead, it is important to help young people to become better equipped to use their knowledge and skills in real-life issues concerning medicine use. Through medicine education, students can acquire knowledge and skills about the rational use of medicines that can

enable them to become empowered medicine users (Hämeen-Anttila, 2006).

In the context of medicine education, the empowerment approach would mean firstly acquiring sufficient information about medicines such as what should be known before taking them. Secondly, teaching the skills needed to use medicines, the steps needed for taking medicine rationally, as well as the important factor of how to avoid possible adverse reactions. Thirdly, with health care professionals, active involvement in discussion should be facilitated concerning the teenager's own medicines (Hämeen-Anttila, 2006). This kind of approach would build up the skills and competencies needed by young people to enable them to gradually take more responsibility over his/her own medicine use.

It should be noted that medicine education is not about urging still younger people to use medicines independently, nor to increase the use of medicines, it is about providing young people with an everyday life skill before personally becoming responsible for their own health (Hämeen-Anttila 2006). Both medicine education and the PROFILES approach encompass cognitive learning, but above

all, promote the development of the individual towards being capable of acting in a meaningful and responsible way. The important goal is that students are able to apply their conceptual knowledge to real life situations (see e.g. Bolte et al., 2012; Hämeen-Anttila, 2006). According to the principles of the PROFILES approach, particularly in the scenario and decision-making stages, discussion and argumentation need to be included in teaching and studying about medicines and their use.

Argumentation in science education

In decision-making, it is implicit to have the skill of being able to present an argued point of view (Kortland, 1997), and scientifically literate individuals are expected to be able to confront, negotiate and make decisions in everyday situations that involve science (Sadler, 2011). Science education emphasizes the ability to begin constructing arguments that link evidence and empirical data to ideas and theories (Driver, Newton & Osborne, 2000; Wellington & Osborne, 2001). Argumentation as a field of study, is concerned with how individuals make and justify claims and conclusions (Sadler, 2004) often in the context of socio-scientific issues-based instruction (e.g. Dawson, 2011; Evagourou, 2011; Sadler, 2004; Zeidler, Applebaum & Sadler, 2011; Zohar & Nemet, 2002).

Argument can be considered to be an individual activity, either through thinking and writing, or as a social activity within a group, a negotiated social act within a specific community (Driver, Newton & Osborne, 2000). According to Driver et al., in rhetorical mode, argument is used to inform others and persuade them of the strength of the case being presented. The dialogical or multi-voiced interpretation of argument is involved when different perspectives are being examined and the purpose is to reach agreement on acceptable claims or courses of action. The multi-voiced nature of argument construction is much more obvious within a group, as individuals take different positions over the claims advanced, and influence the nature of the argument that can be put together.

When students practice argumentation in groups, it is an important mechanism for scaffolding their individual construction of argument (see Driver et al., 2000).

Since Toulmin's theory of argumentation (1958), several analytic frameworks have been used in literature. Regardless of the diverse perspectives, according to Sampson and Clark (2008) these frameworks share several focal issues; three issues are seen to be of critical importance when studying the ways students generate argument in the context of science: the structure or complexity of the argument (i.e. the components of an argument); the content of the argument (i.e., the accuracy or adequacy of the various components in the argument when evaluated from a scientific perspective); and the nature of the justification (i.e., how ideas or claims are supported or validated within the argument). Also the soundness, the acceptability of the argument, and the relevance of the reasons used to support the conclusion, are valued. Good argument is relative to the context in which it takes place: the validity of an argument is a matter of informal rather than formal logic, and different areas of human activity will have their own distinctive forms of argumentation (Newton, Driver & Osborne, 1999).

According to Sadler (2004), the most fruitful interventions are those which encourage personal connections between students and the issues discussed; which explicitly address the value of justifying claims; and which expose the importance of paying attention to contradictory opinions. Discourse, argumentation, and debate, are necessary elements in a socio-scientific issues (SSI) centred classroom (Zeidler et al., 2011; see also Simon & Amos, 2011). SSI instruction can provide a forum both for working on argumentation skills, and for developing conceptual understanding of science content (Sadler, 2004). Evagourou (2011) documents ways in which students' use of evidence for argumentation improves over the course of a SSI unit. Her research also proves that various types of technologies can be used to support argumentation and decision-making within SSI instruction (Evagourou, 2011; see also Simon & Amos, 2011). Learning science through SSI instruction also shows

significant gains in students' reflective judgement (Zeidler et al., 2011).

In the scenario stage of the PROFILES 3-stage teaching model, students' argumentations embody pre-knowledge. However, in the decision-making stage, students apply new science understanding to the socio-scientific situations; argumentation skills are strengthened through group participation in consensus decision-making. The decision-making stage enables the teacher to gain adequate feedback on students' learning gains (Holbrook & Rannikmäe, 2012.)

This case study focuses on the arguments of seventh grade students concerning medicines as a part of health education lessons. Instruction is constructed to follow the PROFILES 3-stage model.

Design and method

Intervention was carried out during health education lessons in January 2013, at a comprehensive school in Eastern Finland; participants were 7th graders from three classes (N=39). In accordance with the school's curriculum, the learning objectives involved the rational use of vitamin preparations and nutritional supplements. During intervention, the students studied in small groups of 3–4 persons. The school teacher, two teacher educators and three teacher students were in charge of the instruction.

According to the philosophy of PROFILES, this teaching intervention embodied the scenario, the inquiry, and the decision-making stages (e.g. Bolte et al., 2012). The scenario stage comprised of one lesson, 75 minutes, in which the students familiarized themselves with five fictive teenagers, who had written blogs about their health problems and medicine use issues (Google blogger; Evagourou, 2011) (Table 1; Figures 1 and 2).

At the beginning of the scenario stage, as a social activity within their group, the students negotiated the fictive cases (Driver et al., 2000) and tried to solve the issues that were brought up in the blogs.

Based on their pre-knowledge, in the form of blog texts and as a group, the students counselled the fictive teenagers on their health problems.

In the inquiry stage (one lesson, 75 minutes), through structured assignments on the website learning environment, the students studied issues related to the teenagers' health problems (Google Sites; see Kärkkäinen, Hartikainen-Ahia, Keinonen & Sormunen, 2012) and used social software tools for inquiry and collaboration. In the decision-making stage (one lesson, 75 minutes), the students applied their new knowledge for making decisions, and once again used their blogs to counsel the teenagers. In argumentation, the students were assumed to be able to use new understanding of the topics to their advantage.

The aim of this study was to describe what kind of arguments the students created during the scenario and decision-making stages, in the blog environment.

Cases in blogs	Health problems and issues concerning the use of medicines
Antti's case	<ul style="list-style-type: none"> • anorexia nervosa • problems with the rational use of vitamin preparations
Anne's case	<ul style="list-style-type: none"> • anaemia • problems with the rational use of micronutrient (iron)
Milla's case	<ul style="list-style-type: none"> • distorted beauty ideals • problems with the rational use of vitamin preparations (the unnecessary use of medicine)
Niko's case	<ul style="list-style-type: none"> • issues about gaining big muscles • rational use of nutritional supplements (protein product)
Sanni's case	<ul style="list-style-type: none"> • food allergies • rational use of vitamin preparations (the necessary use of medicine)

Table 1. Blogs containing the teenagers' writings about their health problems and issues relating to the use of medicine.

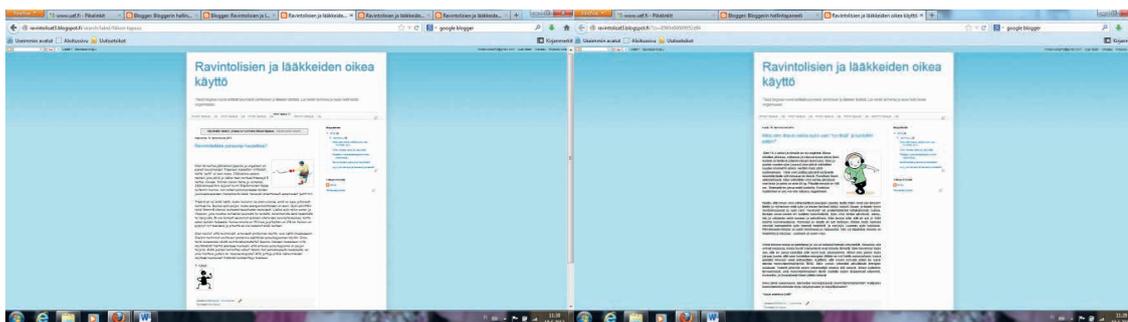


Figure 1. The Google blogger as a learning environment during intervention: Niko's case (issues about gaining big muscles) and Antti's case (anorexia nervosa)

Why am I fat, even though I eat healthily and exercise hard?

I am a 14 year-old boy and I have a big problem. My fat legs, stomach and arms disgust me. I must do something. I hate my body and I must lose weight! I have gone all out for dieting. In the period of half a year, I have run at least 6 km per day. I really do my best, even at night time I wake up to do exercises in order to loose the calories from the previous day. But still I AM FAT! Can you believe that? I weigh myself every day, even five times a day. The result is always the same, 48 kg. My height is 160 cm. I can't exercise more than I do now and I am tired of it all. Extra exercise cannot be the solution to my problem.



I know that I should cut down on my diet-intake but how can I do it? Even now I wrack my brains about my energy requirement. I keep an eye on my diet and I count my daily calories very carefully. I know what kind of food is healthy or unhealthy and I try to eat only healthy food; my meals contain protein and low-calorie foods. I know very accurately how much each food substance contains calories.

I eat five times a day: lunch and dinner as well as breakfast and two snacks. I only eat 1000 calories per day! I have abstained from all sweets and bread and I hate all food that contains fat. For breakfast I eat berries and fruits. At lunchtime I eat from the school catering and try to eat healthily. For dinner I eat tuna and cottage cheese, both of which are low-calorie foods. My evening meal and snacks only contain berries and fruits. I don't drink anything else except water.

Recently, I have been hungry and tired. In future, I hope that I will be more energetic and am well again. I want to get good marks at school and I want to be successful in my studies, good exam results are very important to me. Nowadays I have been good-for-nothing and school work doesn't go according to plan. As well as all that, I must do my exercise to consume all the energy I get from food. I know that I must have more energy, but I can't eat more, because then I will get even fatter.

I have thought that maybe I could substitute one or two meals with vitamin preparations. I have heard that multivitamin pills, POWER, might be good for me. My plan is that I could eat 400 calories less than now if I use POWER pills. These contain all the essential vitamins, micronutrients and minerals, without any calories! Naturally, I will continue to eat healthily, but less than I do now.

Have you any experience of multivitamin preparations? Could POWER be a substitute for meals? Maybe it will give me some power, then I will be more energetic and I can focus on my studies.

Please, help me! What should I do?

Antti

Figure 2. Antti's blog

Students' arguments in the scenario stage	Students' arguments in the decision-making stage
Antti's case	
<p><i>"Do not think that you are fat."</i></p> <p><i>"You must eat properly so that you get nutrients."</i></p> <p><i>"Do not run only. Take your exercise in different ways, e.g. press-ups, sit-ups, going to swim."</i></p> <p><i>"You must sleep at night time."</i></p>	<p><i>"Our conclusion is that you are suffering from anorexia and depression."</i></p> <p><i>"You must have 2580 kcal per day. You cannot lose weight any more. You must gain more weight."</i></p> <p><i>"Do not substitute vitamin preparations for food."</i></p> <p><i>"You are tired because you are undernourished."</i></p>
Anne's case	
<p><i>"You are suffering from lactose intolerance, therefore you have a stomach ache and the runs."</i></p> <p><i>"Don't eat too much iron supplements, they are not helping you."</i></p>	<p><i>"You eat iron supplements too much, therefore you have problems with your stomach and you have the runs."</i></p> <p><i>"You are suffering from anemia, that's why you must use iron supplements. Follow advice from the package instructions. An overdose of iron supplements can even add insult to injury."</i></p>
Milla's case	
<p><i>"You could take advice from the staff of a pharmacy. They know about vitamin preparations and they could give you advice about what kinds of vitamins are good for your needs."</i></p> <p><i>"Your parents could buy vitamin preparations for you so that it is cheaper for you to obtain them."</i></p>	<p><i>"You use vitamin preparation too much. Medicines will not help you to become more beautiful."</i></p> <p><i>"You can use B12-vitamin preparations, if you continue to follow a vegetarian diet. You will only need this."</i></p>
Niko's case	
<p><i>"Do not use anything. Continue training in the gym."</i></p> <p><i>"It takes time to get big muscles. If you want them, you must exercise regularly and more than you do now. But remember, your muscles must recover after a hard workout."</i></p>	<p><i>"You cannot get big muscles by using a protein product. Recovery drinks could be useful for you after training if you do not have enough time to eat food. Even so, you must eat properly and have a wide variety of food. If you use protein products, do not buy them from the Internet. The best place to buy them is in the shops."</i></p> <p><i>"You can also get protein from meat, fish, chicken, cheese, dairy products, cottage cheese, eggs, soya flour, etc."</i></p>
Sanni's case	
<p><i>"You can trust advertisements about vitamin preparations."</i></p> <p><i>"You can stop using vitamin preparations if you can manage without them. The use of vitamin preparation is hardly harmful to you. So, eat them. Vitamin preparations are not harmful and you do get something from them."</i></p>	<p><i>"We recommend that you ask for help from your doctor and pharmacist."</i></p> <p><i>"If you use vitamin preparations, you have to take into account the detailed instructions on how to use them, in order to avoid an overdose."</i></p> <p><i>"Because of your food allergies, you must eat a variety of foods suitable for you. You also need preparations that include calcium and vitamin D."</i></p>

Table 2. Excerpts from Students' arguments. Results showed that in the scenario stage, the students had a poor understanding of nutrition and the rational use of vitamin preparations and nutritional supplements.

PROFILES stage	Arguments			Themes
	Relevant	Irrelevant	Total	
Scenario	41/60%	27/40%	68	15
Decision-making	55/100%	0/0%	55	20
Difference	+14	-27	-13	+5

Table 3. Frequencies of the students' arguments in the blog environment

The groups' blogs (n=15) in the scenario stage embodied the students' pre-knowledge; in the decision-making stage, their writings (n=13) embodied their post-intervention understanding.

In this study, analysis focused on the content of the argument (the accuracy or adequacy of the various components in the argument when evaluated from a scientific perspective) as well as on the soundness, the acceptability of the argument, and the relevance of the reasons used to support the conclusion, at the same time taking into account the context in which the argument takes place (Sampson & Clark, 2008).

In content analysis, the students' blog writings were first broken down into arguments and each argument was analysed. The contents of the arguments were then classified into themes and the themes were grouped. Finally, the two main groups were categories of relevant and irrelevant arguments. In no way were the irrelevant arguments linked to the teenagers' health problems nor to the medication issues at stake. The relevant themes concerned diagnoses and recommendations for health counselling and medicine use. The quantity of the themes was also counted after qualitative analysis.

Results

In the scenario stage, the students presented 41 relevant and 27 irrelevant arguments in the blog environment (Table 2). The irrelevant arguments were in no way linked to the teenagers' health problems nor to medication issues.

Students' arguments in the scenario stage were monosyllabic and lacked justifications (Table 3); their conclusions and counselling were incorrect in relation to the teenagers' nutrition problems.

For example, one group of the students counselled Antti to do different sorts of exercises, even though Antti suffered from anorexia nervosa (Table 3).

In the decision-making stage, the students constructed 55 arguments, all of which were relevant (Table 2), and included 20 different content themes. Although the students' arguments were still very short, they were more knowledgeable than in the scenario stage, in many cases they also included justified claims. In addition, the students made correct conclusions about the teenagers' nutrition problems and counselled them competently, using new conceptual understanding. The students' arguments included special concepts such as anorexia nervosa, depression, undernourished, kilocalorie, etc. Both the quantitative and qualitative analysis of the arguments indicated that the students had learnt the content of health education that related to nutrition and the rational use of vitamin preparations and nutritional supplements.

Discussion

In this case study, after intervention, students' arguments in the decision-making stage showed improved knowledge. According to the results, it seemed that PROFILES' 3-stage instruction, combined with the use of fictive stories about the teenagers' health problems in the blog environment, was suitable to the health education context.

These results support previous studies associated with SSI instruction, showing students' improved conceptual understanding (e.g. Dawson, 2011; Evagourou, 2011; Puig & Jiménez-Aleixandre, 2011; Simon & Amos, 2011; Zohar & Nemet, 2002). The use of technology might have also supported argumentation and decision-making within the SSI instruction (Evagourou, 2011) as well as the negotiated social act within the group (Driver, Newton & Osborne, 2000). Although the seventh grade students' evidence-based arguments were better in the decision-making stage, it did not directly indicate the development of students' argumentation skills. Enhancing students' argumentation skills is a complex process that requires time and practice (Sadler, 2004). If teachers expect their students to engage in sophisticated argumentation, students need ample opportunities to practice justifying claims, paying attention to counter-positions and dissecting argumentation, in order to increase their awareness of what constitutes well-reasoned arguments (Sadler, 2004, p. 523).

The promotion of argumentation skills is a difficult educational goal (Sadler, 2004), but we could assume that the 3-stage model of the PROFILES approach could promote students' discussion and argumentation skills both in the context of science and medicine education. However, the data here being based only on arguments, we could not confirm the effects of individual factors such as technology and social activity.

Further analysis of larger data, collected in the context of the intervention, i.e. responses to the questionnaire, interviews and tape recorded student-student discussions, will in future, indicate in a more detailed way seventh grade students' knowledge, argumentation skills, study motivation and satisfaction.

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2.3 “Can You Listen to My Voice?” Including a Student Voice in the Design of a Chemistry Module Aiming to Increase Students’ Learning and Motivation

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Abstract

Science education has been criticized for failing to motivate young learners to learn science. This could be partially attributed to that even though curricula are designed for students, students’ views are often excluded from the curriculum design process. However, even though listening to students’ voices may result to more effective science curricula, such an approach has been barely practiced and has not received much empirical exploration. This work reports on a case study examining the development of inquiry-based module; participants included nine high school chemistry teachers (members of the PROFILES Cyprus 2012-13 professional development program) and their students who were consulted on their views regarding an ideal learning environment. The participatory design process adopted consisted of three separate parts: (a) the collection and analysis of students’ perspectives, (b) the development of the inquiry-based learning environment based on students’ views and (c) the implementation and evaluation of the learning environment. Empirical evidence indicates that the designed learning environment, which took students’ perspectives into account, resulted to substantial learning gains in terms of increased conceptual understanding and motivation.

Introduction

During the last decades, science education stakeholders have made several efforts to explore how to improve science teaching, as the literature reports that science education often fails to motivate or to meaningfully engage young learners (e.g. Eurydice network, 2011; EC 2007). Middle school, as well as high school, students seem to be unwilling to learn science and seem to have a lack of interest towards science (e.g. Eurydice network, 2011; Lyons & Quinn, 2010; OECD, 2006). As a consequence, it is not surprising that many students, all over the world do not pursue further science studies (Chubin, Donaldson, Olds & Fleming, 2008; Committee on Science, Education, & Public Policy, 2007; Jacobs & Simpkins, 2005; Sanders, 2008; 2009; Young, 2005).

Traditional science education has been criticized for focusing explicitly on teaching rote facts and scientific concepts, without helping students connect science learning with their own lives (Fensham, 2004; Holbrook, 2003; Osborne & Collins, 2001; Sjoberg, 2001). Fensham (1998) reported on the lack of collecting data on students’ sense of the relevance of the science topics included in the TIMSS achievement tests. Even though young people recognized the importance of science in

society, they often considered science subjects less engaging compared to other subjects (Jidesjö & Oscarsson, 2006; Oscarsson, Jidesjö, Karlsson & Strömdahl, 2009).

If one purpose of science education is to help students appreciate science, then it is of paramount importance to find out why students become disengaged with school science. Reports in the literature indicate that this problematic situation is largely due to a paradox: despite the fact that all curricula are designed for students, students themselves are excluded from the curriculum design process. According to Jagersma and Parsons (2011), questions about how and what to teach to students have been asked for decades; however, these questions have seldom been posed directly to students. This exclusion can have a negative impact on the learning processes since learners who do not feel connected to the curriculum may pose barriers to their own learning through disruptive practice (Rudduck & Flutter, 2000). In addition, as Könings, Brand-Gruwel and van Merriënboer (2010) have proposed, if students are denied opportunities to communicate their views or guide instructional change, their learning may suffer.

To sum up, listening to student voice and understanding students’ science beliefs may help

the design of more effective science curricula as well as of learning environments that can promote students’ engagement, and thus enhance student learning in science. However, despite the fact that students’ inclusion in the design of science education curricula is more ecologically valid and, potentially, a more sustainable approach for the design of more effective learning environments, it not often practiced. Therefore, according to Jenkins (2006) “*the untested assumption is that the more that is known about students’ interests, enthusiasm, dislikes, beliefs and attitudes, the more feasible it will be to develop school science curricula that will engage their attention [...]*” (p. 51).

This chapter reports on a case study of nine high school chemistry teachers. The teachers participated in the PROFILES Cyprus 2012–13 professional development programme and co-designed an inquiry-based learning environment which was informed by their students’ views regarding an ideal chemistry learning environment. The main aim of the PROFILES project was to familiarize the in-service chemistry teachers with the inquiry-based approach and thus to contribute to their professional development. More specifically, the professional development model used by the PROFILES Cyprus team approach took the form of participatory and collaborative design (Kyza & Nicolaidou, Under Review), according to which nine chemistry teachers jointly designed an inquiry-based learning environment. To listen to student voices, two of the high school chemistry teachers, who were working at the same high school, investigated their students’ perspectives regarding the components of an ideal learning environment that could motivate student chemistry learning.

As a result, in this chapter we report on the following questions:

- (a) What are the students’ perceptions of an ideal chemistry learning environment?
- (b) How are students’ perspectives integrated in the design of an inquiry-based learning environment?
- (c) What is the impact of an inquiry-driven chemistry learning environment, whose design was informed by students, on students’

learning gains?

Theoretical background

The present study was based on the premises of participatory design; more specifically, for the purposes of this study, participatory design includes any initiatives that are based on the involvement of students, as the end users of the design process (Könings et al., 2010). This model is based upon the belief that students’ views of instruction have a direct impact on their learning process, and eventually affect their learning outcomes (Elen & Lowyck, 1999; Entwistle & Tait, 1990).

Students are the primary stakeholders in education and experts on their own experiences (Oldfather, 1995). However, the fact that teachers have usually limited access to their students’ perspectives, results to large differences between students’ and teachers’ perceptions of learning and teaching, and this is likely to threaten the effectiveness of learning (Könings, Brand-Gruwel & van Merriënboer, 2011). Therefore, of paramount importance, may be to bring insights, observations and perspectives of teachers and students together in a dialogue on how the learning and teaching process can be improved. To put it in different words “*Students should help shape rather than simply be shaped by educational policies and practices*” (Cook-Sather, 2003, p. 22). As a result, participatory design aims to promote active participation of the users of any system in the design process as well as in decisions that will have an impact on them (e.g. Berns, 2004; Kensing & Blomberg, 1998).

Research design

In order to investigate the three research questions posed, we collected qualitative and quantitative data depending on the nature of the research question, in combination with the access to and availability of data sources.

First, aiming to investigate 11th grade students’ perspectives regarding an ideal chemistry learning environment, two focus groups were organized by

the two chemistry teachers. Each focus group was composed of twelve 11th graders and discussed such aspects as:

- (a) The factors which could engage or disengage students from a chemistry lesson,
- (b) The components of an ideal chemistry learning environment, and
- (c) Students' suggestions for the enhancement of traditional chemistry instruction.

Each focus group session was lasted 40 minutes, was recorded and subsequently transcribed. Students' perspectives were analyzed qualitatively using Attride-Stirling's (2001) thematic network analysis to identify emerging basic themes. These basic themes were then categorized under an organizing theme. Finally, all of the organizing themes were categorized under the global theme, which, in our case, was an "ideal learning environment in chemistry education."

Second, aiming to investigate how students' perspectives were employed for the design of the inquiry-based learning environment, we focused on the inquiry-based learning environment developed by the nine chemistry teachers who participated in PROFILES Cyprus 2012–13 as the final artifact. In this context, we analyzed the learning environment in order to investigate the extent to which students' views informed the final learning environment.

Finally, aiming to investigate the impact of the inquiry-driven learning environment on students' learning gains, data were collected through a test regarding students' content knowledge about energy drinks. The instrument was designed for the purpose of this study and was composed of five open-ended tasks.

In addition, student motivation data were collected through the MoLE-Questionnaire (Bolte, 2000) that was universally employed by PROFILES partners. The survey employed consisted of two different versions. The REAL version was administered before the teaching intervention and collected students' views of traditional chemistry lessons (Pre-test). The TODAY version was administered after the intervention and collected students' views about

the inquiry-based learning environment implemented (Post-test). Thus, the aim of the questionnaire was to examine student motivational gains, after their participation in the inquiry-based learning environment, by comparing the two versions. Both instruments were administered before and after the teaching intervention in three different 11th grade classrooms ($n=58$).

The final sample was composed of a total of 40 students, since the students, who had not completed either the pre- or the post-test for content and motivation, were excluded. As far as it concerns the analysis of the tests, the overall approach involved the investigation of the differences between pre- and post-test results on students' learning scores and motivation, employing the non-parametric Wilcoxon Signed-Rank Test for dependent samples.

Findings

Students' perspectives of an ideal chemistry learning environment

A visual representation of the results that emerged from the qualitative analysis of the two focus group sessions is presented in Figure 1. According to the main findings three organizing themes were identified and seemed to define an ideal learning environment for the 11th graders:

- (a) The teacher, in terms of his/her teaching approach,
- (b) The students in terms of their role within the learning process, and
- (c) The topic on which the learning environment is focused.

We next described these three organizing themes, focusing on the basic themes discussed and categorized under each organizing theme. The discussion includes indicative excerpts from the focus group sessions, translated from Greek into English.

Organizing Theme 1: The teacher

Students highlighted the role of the teacher,

explaining that a chemistry teacher could have a catalytic effect on the effectiveness of the learning environment. In this context, students highlighted that a chemistry teacher should integrate experiments, computers or audiovisual material in the lesson in order to shape an ideal learning environment for the students. Students also stated that a chemistry teacher should avoid or, at least, minimize the use of traditional teaching methods such as worksheets and textbooks or the use of lectures and demonstrations.

“I would prefer the lesson to be carried out with the use of interactive board and projectors. I would also prefer to participate in many more experiments (...).” (Student, FG1)

“I believe that the lesson would be much more interesting if we could employ computers. There was also some software that we could employ in order to carry out virtual experiments.” (Student, FG1)

“I think that it could be all about the medium (learning approach) that was employed. Instead of using the textbook, doing whatever is written in the textbook, reading the textbook, it would be much more interesting to watch a video [...] Anything else (would be much better than the

textbook)... It’s just so boring to use the textbook all the time and all that you had to do was to turn the page and read, turn the page and read (...).” (Student, FG1)

Organizing Theme 2: Students

Students also emphasized their role during a learning intervention, explaining that the way students were placed within the learning process could be decisive for the creation of an ideal learning environment. More specifically, students expressed that during an ideal chemistry lesson, the learning environment should be student-centered and thus, learners should have an active role. In addition, students expressed that it would be much better if they could have the opportunity to work in smaller groups as well as to collaborate.

“However, I believe that when you have the opportunity to do something on your own, then you have more chances to really understand it, instead of watching a demonstration by your teacher.” (Student, FG1)

“I think that we should work in smaller groups... Our teacher could not pay attention to all of us, as she could do if she would have to work for instance, with half of us (...).” (Student, FG1)

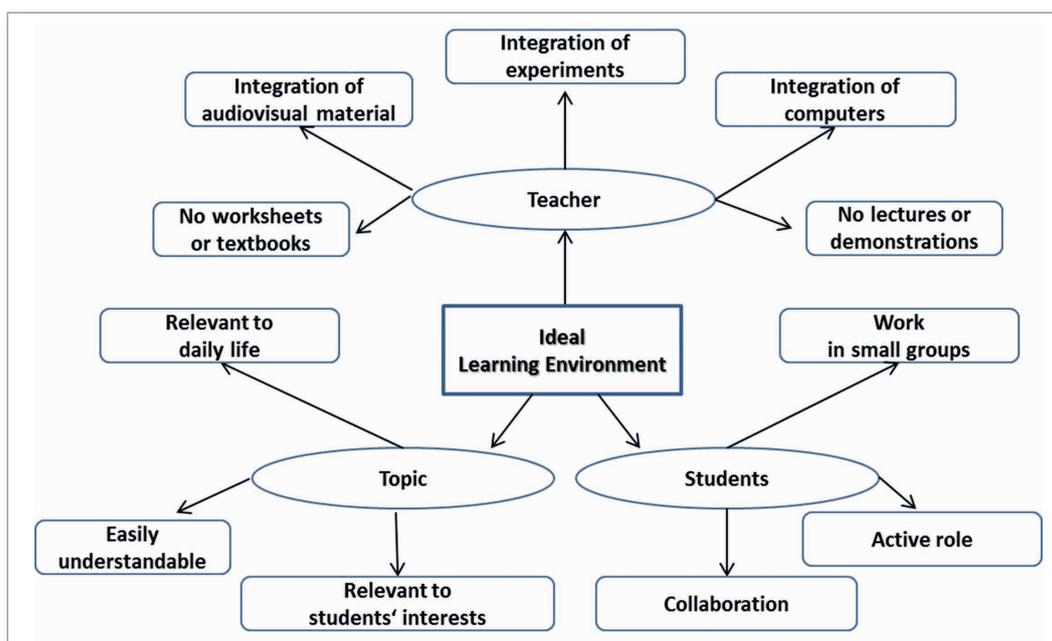


Figure 1. Representation of the results from the qualitative analysis of the two focus groups

“When students have the opportunity to collaborate they can better understand the experiments that are carried out as well as the lesson in general.” (Student, FG2)

“I would prefer to deal with topics from daily life that we could relate to from our everyday lives, that we could observe them and thus, we could investigate them much easier.” (Student, FG2)

Organizing Theme 3: Topic

Finally, the students highlighted that the topic of a module was a major variable that could result to an ideal learning environment. In this context, students indicated that it was of paramount importance for them to deal with topics that were relevant to their interests or with daily life, giving also plenty of suggestions and illustrations. At the same time, they stressed that the topic should be easily understood, explaining that they would prefer to avoid modules that give much emphasis on chemical equations and chemical symbols.

“I’ve heard that Cola zero causes multiple sclerosis when you drink it for a long period of time. I think that we need to be taught about such issues, in order to know what we consume as well as the impact on our health (...).” (Student, FG1)

“There are some chapters that we cannot really understand. Since we cannot understand, we are not really interested in (...).” (Student, FG2)

“Personally, I have a difficult time when I have to deal with chemical equations... There are so many chemical elements. I always forget their symbols and the numbers they get.” (Student, FG1)

Students' perspectives	Designing aspects
Topic: Relevance to students' interest	Focus on energy drinks consumption from teenagers
Topic: Relevance to daily life	Focus on energy drinks and their impact on humans
Topic: Easily understandable	Focus on energy drinks ingredients and their impact, avoiding chemical equations and symbols
Teacher: Integration of computers	Development of an inquiry-based learning environment on the STOCHASMOS web-based platform
Teacher: Integration of audiovisual material	Integration of audiovisual sources in the learning environment such as videos, photos and diagrams
Teacher: No textbooks	Use of authentic sources such as energy drinks labels, scientific or newspaper articles, scientific studies
Teacher: No lectures	Teachers as supporters, who scaffold students' investigation, when needed
Students: Active role	Students as active learners who are asked to collect data in order to take an evidence-based stance
Students: Collaborate in small groups	Students work in pairs
Students: Computer work	Students engage in computer-supported collaborative inquiry

Table 1. Students' view of an ideal learning environment as these were reflected through the learning environment developed

	MEAN VALUE		STANDARD DEVIATION		Z	P
	PRE	POST	PRE	POST		
TOTAL	3,44	5,34	1,24	1,48	-5,31	.000*
What is an energy drink?	0,60	0,84	0,26	0,36	-3,51	.000*
What are its main ingredients?	0,76	1,48	0,54	0,55	-4,91	.015*
What is its impact on human?	0,94	1,30	0,51	0,56	-2,43	.000*
What is its impact when mixed with alcohol?	0,74	0,95	0,36	0,53	-2,07	.039*
With what criteria would you buy an energy drink?	0,40	0,78	0,67	0,58	-2,79	.005*

*Statistically significant difference

Table 2. Descriptive statistics and Wilcoxon Signed-Rank Tests for comparing pre- and post-tests of conceptual understanding

Students’ views informing the design of the inquiry-based learning environment

Focusing on the design of the inquiry-based learning environment, the nine chemistry teachers, who participated in PROFILES 2012–13, made an effort to develop a learning environment which was informed by the students’ views, as these were elicited through the focus groups. An overview of the extent to which the students’ views informed the design is presented in Table 1.

In this context, aiming to respond to students’ views regarding an ideal learning environment, the teaching intervention designed by the PROFILES chemistry teachers took the form of an inquiry-based learning environment, which was hosted on the STOCHASMOS web-based platform (Kyza & Constantinou, 2007). The intervention was included four 40-minute lessons. More specifically, the learning environment integrated the inquiry-based philosophy since:

- It was based on an authentic scenario related to students’ interests: Students were asked to investigate whether the fainting of a teenager could be attributed to the consumption of energy drinks;
- It actively involved students with technology-enhanced inquiry-based investigations: students were asked to gather information regarding the ingredients of energy drinks as well as regarding their impact on humans through a variety of authentic sources (e.g.

- newspaper articles, scientific studies) and audiovisual material (e.g. video clips, photos);
- It engaged students in a decision-making process asking them to take an evidence-based stance regarding the consumption of energy drinks.

In addition, taking into account that the inquiry-based learning environment designed was implemented on the STOCHASMOS web-based platform (www.stochasmos.org), this not only allowed the integration of technology, but shaped and defined the roles of both teachers and students. More specifically, STOCHASMOS enabled students to assume an active role as well as to be involved in a collaborative investigation, while at the same provided computer-based scaffolding to support students’ reflective inquiry (Kyza & Edelson, 2005). At the same time, STOCHASMOS enabled teachers to assume a supportive role, in terms of scaffolding their students by providing individualized feedback when needed, through their interactions with the student groups.

Students’ learning gains: Conceptual understanding

As indicated in Table 2, the analysis of students’ conceptual understanding, as measured by the pre-post tests, revealed statistically significant increases after the inquiry-based intervention. According to the findings, there was a significant difference in the scores of the students before the teaching intervention ($M=3.44$, $SD=1.24$) and in

their scores after the teaching intervention ($M=5.34$, $SD=1.48$), $Z=-5.31$ - $p<.001$. More specifically, this comparison revealed that students increased their knowledge regarding what is an energy drink, what are its main ingredients, what is its impact on humans, what is its impact when mixed with alcohol, while at the same time students acquired more informed criteria regarding the choice of an energy drink (e.g. ingredients, quantity, impact vs. price, taste, etc.).

Students' learning gains: Motivation

As Table 3 shows, the analysis of students' motivation, as measured by the pre-post MOLE test, revealed a statistically significant increase after the inquiry-based intervention. According to the findings, it seems that there was a significant difference in the motivation of the students as shown by the comparison of their motivation before the teaching intervention ($M=4.51$, $SD=1.08$) and after the teaching intervention ($M=5.11$, $SD=1.18$); $Z=-5.49$ - $p<.001$). More specifically, this comparison revealed that students understood and enjoyed the inquiry-based lesson more, felt that they had more time to think before answering a question, had more opportunities to make suggestions and questions, collaborated to a greater extent with other students and were taught about issues that were more relevant to them.

Discussion

At a time of continued dissatisfaction with the state of science education in many parts of the world, science education stakeholders are investigating ways to promote students' appreciation of the nature of science, improve the quality of learning, and establish science learning as a meaningful and motivating activity. In this context students' disengagement with learning in science is being attributed, in many cases, to the fact that students' perspectives regarding teaching and learning in science are often neglected (Fensham, 1998). Therefore, Logan and Skamp (2008) suggest that "the importance of listening to and heeding the students' voice may be an even more critical concern in addressing the decline in students' attitudes and interest in science" (p. 501).

The present study was based on a participatory design model, according to which in-service chemistry teachers, who participated in PROFILES Cyprus 2012–13, designed an inquiry-based module informed by their students' views regarding an ideal learning environment. This process, as it has been presented, consisted of three separate parts: (a) the collection and analysis of students' perspectives, (b) the development of the inquiry-based learning environment based on students' views and (c) the implementation and evaluation of the learning environment.

	MEAN VALUE		STANDARD DEVIATION		Z	p
	REAL	TODAY	REAL	TODAY		
TOTAL	4.51	5.11	1.08	1.18	-5.489	.000*
Comprehensibility	4.85	5.38	1.35	1.43	-3.533	.000*
Opportunities	4.37	4.73	1.71	1.62	-2.267	.008*
Willingness	5.07	5.91	1.29	1.59	-1.545	.122
Cooperation	4.11	5.06	1.20	1.35	-4.102	.000*
Satisfaction	3.91	5.47	1.58	1.30	-5.135	.000*
Relevance	4.54	5.10	1.45	1.65	-2.679	.007*

*Statistically significant difference

Table 3. Descriptive statistics and Wilcoxon Signed-Rank Tests for comparing pre- and post-tests of students' motivation

Our findings provide empirical evidence to support the argument that the development of a learning environment, which takes students’ perspectives into account, can result to substantial learning gains for students in terms of increased conceptual understanding and motivation. Such findings are aligned with the participatory design approach according to which effective involvement of users in the design phase yields improved adjustment of the design to address users’ needs as well as higher levels of acceptance of the final design by the users (Damodaran, 1996). Despite the fact that participatory design is fairly new in school contexts, the present study has indicated that, if we wish to promote learning and teaching in science, we need to exploit this venue as a more sustainable approach for the design of more effective learning environments in science education.

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2.4 What Should I Do with my Old Cell Phone? A Case of Collaborative Curriculum Development within PROFILES-Bremen

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Abstract

This article presents a collaborative curriculum development case study from the PROFILES project in Bremen, Germany. The paper discusses the development of modules by teams of science educators and in-service teachers from different schools utilising a Participatory Action Research approach. The discussion is illustrated by a module answering the question “What should I do with my old cell phone?”. This module focuses learners’ efforts on various metals, their physical properties, and options for recycling technical products. The unit is embedded in a socio-scientific issue as per the PROFILES approach, namely the problem of growing amounts of waste caused by the short life-cycles of many technological products. Findings which emerged from the testing and evaluation process are presented. These represent the justified points of view of the teachers, researchers and students participating in the study.

Introduction

In 2010, the city-state of Bremen (one of Germany’s 16 federal States) implemented a new school reform. Part of this reform established a new type of secondary school called *Oberschule*. The *Oberschule* is comprehensive and inclusive. Attending students represent the whole learning range from very low to very high achievers, thus making individual learner differentiation a major issue in implementing the current reform. Additionally, in the *Oberschule* the former three independent subjects of Chemistry, Biology and Physics were integrated into a single discipline called ‘Natural Science’ for grades 5–8 (age range 10–14). A brand new governmental syllabus was released for this purpose, which centers around integrated science modules based on everyday life contexts and socio-scientific issues.

The Bremen school reform caused many challenges. Most teachers have only been educated in one or two of the three above-mentioned subjects. Many teachers felt themselves inadequately prepared to teach integrated science classes, especially in units covering topics outside their area of expertise. Bremen being a quite small state within Germany, with about 650,000 residents, meant that state-specific school textbooks which would address the new syllabus were considered economically unfeasible by the commercial textbook publishing

companies. Sample lesson plans and teaching materials were also difficult to find.

As part of the PROFILES project (Bolte et al., 2012), the University of Bremen created a curriculum development framework to assist schools in successfully implementing the reform. The PROFILES-Bremen coordinator and his team founded a network of teachers from different schools who participated in the PROFILES Continuous Development Programme (CPD) and were accompanied by science educators from the University of Bremen. Within this CPD, PROFILES-Bremen set out to try to support teachers in the development of their new science curricula and teaching practices, as well as developing new teaching materials to be distributed to other schools, maybe even beyond the state of Bremen. About 20 teachers per year participated in the PROFILES-Bremen CPD programme. These teachers worked in small groups of three to six persons, accompanied by curriculum experts and graduate students identified by PROFILES-Bremen team.

In a one-year cycle, each group of teachers developed one module and created accompanying teaching material and teacher guides on a topic selected from the governmental curriculum. The curriculum development framework was based on a Participatory Action Research (PAR) approach to science education, as suggested by Eilks and



Ralle (2002). Operationally, the teachers met once a month for a full afternoon in order to jointly negotiate, structure and reflect on classroom innovations. In accordance with the PROFILES philosophy (Bolte et al., 2011), lesson plans focused on science teaching by targeting general education skills, implementing a societal perspective, and promoting inquiry-based science education (IBSE).

In this article, the development of a PROFILES module under PROFILES-Bremen is illustrated by the example “What should I do with my old cell phone?” This module was cooperatively developed by three teachers from different schools, one graduate student who wrote his MEd-thesis in cooperation with the teachers, and one science educator from the University of Bremen. The group met eight times during the 2011/12 school year.

The developmental framework: Participatory Action Research in science education

The CPD component of the PROFILES-project in Bremen described in this article follow the model of Participatory Action Research in science education as described by Eilks and Ralle (2002). This model’s potential for innovative curriculum design has recently been reviewed (Eilks, Markic & Witteck, 2010; Marks & Eilks, 2010; Eilks & Feierabend, 2013), and proved also to cover long-term effects on teachers’ continuous professional development (e.g. Markic & Eilks, 2011; Mamlok-Naaman & Eilks, 2012), a specific goal of PROFILES.

The incorporation of PAR into the PROFILES-Bremen operation combined the research-based design of new classroom teaching-learning modules, the innovation of concrete science teaching practices, and in-service teacher education based on a collaborative and participatory action research philosophy (Eilks, 2013) seeking to go beyond the PROFILES CPD intention of teacher self-efficacy and promoting teacher ownership by seeking meaningful evidence. During this process, teachers and science education researchers worked side-by-side. During group discussions about science education, researchers and experienced teachers

used evidence-based knowledge combining educational research and practical experience from the classroom as complementary resources for educational innovation (McIntyre, 2005). This was supplemented by the participants’ intuition and creativity to provide a broad base for curriculum innovation, it being recognized that the PCK of the teachers was at a level well suited for the model development task in an IBSE and Education through Science frame (as per the PROFILES philosophy).

The research process was intended to eliminate, or reduce deficits in classroom teaching practices, discovered either through research or during teaching, by the design and implementation of improved teaching strategies, an important PCK component. The first step took the form of group discussions between university researchers and in-service teachers, based on an analysis of relevant scientific literature. These discussions were used to determine whether or not the potential focus was authentic and of general interest to improve science teaching and learning. Where existing empirical research evidence was identified, the discussions tried to determine whether the research evidence was specifically relevant to reduce any deficits in the field of practice in which the in-service practitioners worked. The group discussions reflected upon whether any suggestions from the literature review appeared to be feasible for improving the specific educational setting in question.

Within PAR, as a specific variation within the PROFILES philosophy, the main objectives were seen as the development, documentation and implementation of new or improved curriculum materials and teaching strategies. The goal was to cyclically develop classroom modules that were of potentially help in reducing learning deficits, while improving teaching practice in as many learning groups as possible. For this reason, the specific PAR approach chosen was an adaptation of that from Whyte, Greenwood and Lazes (1989) as suggested by Eilks and Ralle (2002).

Based on the initial group discussions, the teachers and researchers jointly negotiated the focus and operation of new lesson plans based on the literature and within the PROFILES philosophy.

They developed respective teaching materials and media that form the new PROFILES modules. The modules were then implemented, evaluated, and further revised, after joint teacher reflection as part of their CPD, with the objective of improving practices in the test groups in a step-by-step manner (Figure 1).

In order to assess the effects and to contribute the teachers developing a reflective focus on their professional practice, each testing cycle was analyzed and evaluated by taking the perspectives of all participants (teachers, students, and researchers) into consideration and discussing them in a group discussion format during the meetings of the PROFILES-Bremen groups.

Data and feedback were collected, e.g. by assessment tests, questionnaires on feasibility and motivation, verbal feedback, group discussions

among the practitioners, or sample interviews with the students. A qualitative paradigm was used for evaluating the data as suggested for Action Research in science education (Bodner, Maclsaac & Whyte, 1999). Data evaluation was driven by quality criteria for interpretative research as defined by Altheide and Johnson (1994): plausibility, credibility, relevance and importance.

Module framework: Socio-critical and problem-oriented science education

The structure of the module described in this chapter was structured according the socio-critical and problem-oriented approach of science teaching (Marks & Eilks, 2009). Such an approach is seen as compatible with the PROFILES 3-stage model of socio-scientific issues-based science education to initiate societal-related inquiry-based learning,

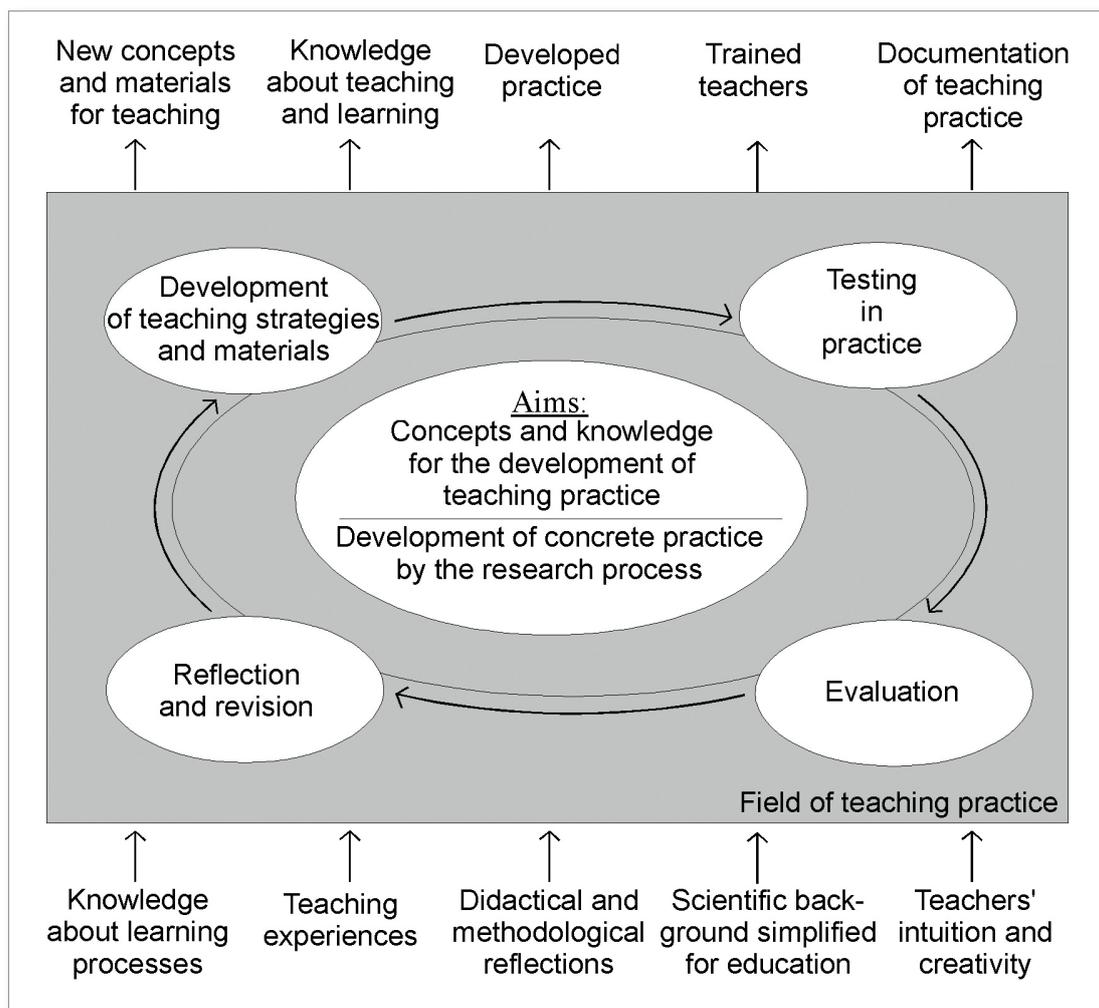


Figure 1. Participatory Action Research according to Eilks and Ralle (2002)

when the science gained is then applied to make decisions on the socio-scientific issue (Bolte et al., 2012; Holbrook & Rannikmäe, 2010; 2012). In this approach (Figure 2) the textual approach includes an authentic, relevant, controversial and debatable socio-scientific issue covered by authentic media, e.g. newspapers, brochures, Internet sources, or TV programmes (in PROFILES terms the scenario, Bolte et al., 2012). An approach to understand and evaluate the socio-scientific issue includes gaining essential science using student-active methods encompassing practical work. The debate is then resumed and reflection upon how much the science background knowledge aids learners when building their opinions occurs, including the aspect of decision-making about the controversial issue in question. Learning about individual and societal decision-making processes for socio-scientific issues is then undertaken by mimicking authentic societal practices. Examples of this include role-playing exercises in the form of political debates, working like a journalist, or mimicking political TV talk-shows (Bolte et al., 2012; Eilks, Nielsen & Hofstein, 2013; Holbrook & Rannikmäe, 2010; 2012).

All activities and methods of the socio-critical, problem-oriented approach to science education are student-centered. The general structure is problem-based, including both the inquiry activities embedded in the science learning phase

and the exercises mimicking societal decision-making processes in the module structure.

The Module: “What should I do with my old mobile phone?”

One topic in Bremen’s governmental syllabus for the *Oberschule* is called “Treasures of the Earth”. The syllabus for this topic describes the cognitive goals of learning about metals, metallic properties, and their uses. It also addresses available technologies for the recycling of such materials used in everyday products. Aside from content learning, psychomotor skills are supposed to be promoted by embedding practical work. The module is thought also to influence the affective domain, in order to sensitize the students to both environmental issues and the sustainable use of resources. The promotion of communication, evaluation and decision-making skills is also stressed by the curriculum.

One group decided to focus on the growing amounts of waste products stemming from technical products, due to the fast pace of technical innovations causing “old” electronic devices to become rapidly obsolete. In order to make the topic meaningful to students, the group decided to focus on cell phones. The module was named: “What shall I do with my old cell phone? The treasure in

Objectives	Criteria for selecting issues and approaches	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 science and technology	Methods provoking the explication of individual opinions	5. Meta-reflection

Figure 2. The socio-critical, problem-oriented approach to science teaching (Marks & Eilks, 2009)

my drawer”. An overview of the module is given in Table 1.

The main question in this module deals with the proper disposal and recycling of old cell phones. Because most students possess a cell phone and technological rates of development remain fast-paced, the disposal of obsolete cell phones is an authentic topic. However, the decision to buy a new phone and throw away the old one remains controversial, since this generates large amounts of waste. Recycling cell phones is a hot-button topic in the everyday media, since many of the components contain valuable metals such as gold or copper. This direct connection of a relevant, controversial issue with students’ personal experience was viewed by the PROFILES group as a provoking, motivating avenue to learning about metal recycling. The textual approach is composed of an authentic

newspaper article, which posits the existence of forgotten treasures in desk drawers. This is because people tend to ignore their old cell phones. The article mentions different Chemistry subject matter which is new for the students. Learners are expected to raise questions about the materials mentioned in the text, especially expensive metals like copper and gold. This leads to science content learning. All of the questions raised by the students, including the non-scientific issues, are collected in poster form and thus remain visible during the whole lesson plan.

The initial approach to understanding this issue and forming an opinion on the topic asks students to inquire into the science in the lab. This is accomplished by a “learning-at-stations” unit (Eilks, 2002). The students experiment with various metals and their properties. Different experimental

Phase	Topic and Method
Textual approach and problem analysis	<ul style="list-style-type: none"> • Students read a newspaper article discussing treasures in their desk drawer, which focuses on the materials in of old cell phones • Students develop questions that should be answered during the module using the think-pair-share method (Kagan, 1992)
Chemistry learning in a lab environment	<ul style="list-style-type: none"> • In a learning-at-stations laboratory the students learn about different metals and their varying properties • At additional theoretical stations the students learn about the Chemistry background of the most common metals used in modern technical products • In an egg race format, the learners set up their own experiment to win copper from copper oxide waste
Resuming the socio-scientific dimension	<ul style="list-style-type: none"> • The students reflect on questions about the production and recycling of metals (gold and aluminum) in an inside-outside-circle phase
Discussing and evaluating different points of view	<ul style="list-style-type: none"> • The students mimic a societal debate in a role-playing exercise
Meta-reflection	<ul style="list-style-type: none"> • The role-playing phase is reflected upon to determine whether it led to forming a consensus. This includes the role that the science aspects played in the overall decision-making process

Table 1. The structure of the module

stations are offered for investigating the physical properties of metals, including density, electrical conductivity, magnetism, and others. Then an even more open inquiry-oriented activity is added in the form of an egg-race (British Association for the Advancement of Science, 1983). Students develop their own experiment for the production of copper with copper oxide as the starting material. Finally, students are asked to present their results, after recognizing that it is impossible to remove the oxygen from copper oxide through “simple” separation processes. Beginning with this idea, the learners conduct experiments on the reduction of copper oxide to copper and write a lab report on their findings.

After the science learning phase, the focus is changed to the societal perspective. Since aluminum and gold also belong to the valuable metals found in cell phones, an inside-outside-circle (Kagan, Robertson & Kagan, 1995) the activity helps students to discover the ecological, economic and social aspects involved in the production and recycling of these substances. This phase addresses the non-scientific questions asked in the introductory phase. It is at this point forming personal opinions and making decisions about recycling or not can truly be thought to begin.

In the final phase, the module focuses on societal consensus-building and decision-making with regard to the various socio-scientific issues behind waste treatment and recycling. The students are asked to discuss and evaluate different points-of-view with the help of a role-playing exercise based on the societal decision-making process (Patronis,

Potari & Spiliotopoulou, 1999). Four roles exist, with each representing a different viewpoint of how to handle old cell phones. The roles are as follows: the telecommunications industry, an environmental protection group, a politician, and a consumer advisory expert. After the students are finished, a reflection period is used to examine the role-playing exercise itself, the individual decision-making process, and the societal consensus-building process.

Evaluation: experiences and findings

Using a case study approach, the module was tested and evaluated in various schools in Bremen. The main round of evaluation was made up of four learning groups (grade 7; age 12–14) with a total of 92 students. A short overview of the participants is given in Table 2.

Data collection focused on:

- the teachers’ perspective: After each lesson was finished, the teachers reflected on the lesson and documented this using narrative reports. These reflective experiences were regularly discussed during the meetings of the PROFILES group.
- the external researcher’s perspective: All four groups were continuously supervised by one of the external university personnel.
- the students’ perspective: All students took a knowledge test and were asked to fill out a feedback tool. This consisted of a combination of an open, Likert form and the MoLE questionnaire focusing on student motivation (Bolte, Streller & Hofstein, 2013).

		Number (Percentage) of Students (N=91)
Sex	Female	46(50,5%)
	Male	45(49,5%)
Age	11	1(1,1%)
	12	21(23,1%)
	13	66(72,5%)
	14	3(3,3%)

Table 2. Overview of the sample

All data were evaluated qualitatively and quantitatively with respect to the applied tool. All findings were triangulated to construct meaning.

Before testing, one of the four teachers expressed scepticism about the module. His biggest fear was that the students would not be able to work autonomously over such a long period of time. He was especially worried about the organization of the group work, egg-race experiment and role-playing exercise. From his perspective, the teacher thought that most students were unused to and ill-prepared for such pedagogies, especially role-playing. This form of learning in science education was also something new for the other teachers. Therefore, they partially agreed with the sceptical arguments of the first teacher. However, they were also more curious and optimistic about the overall success chances of the unit. Once the lessons were carried out and reflected on, all of the teachers were very enthusiastic about the teaching unit. They were happy with the materials and ideas which they had tried out with their students, including with the openness of the lessons and with the overall motivation of their students. All teachers appreciated the high levels of practical work. They pointed out the changes and differences in the teaching and learning methods employed during the lesson plan as compared with most of the previous lessons before the PROFILES project had begun. They all were very surprised at their students' involvement during the role-playing phase. They were astonished at how well their students had behaved when acting out their roles. Finally, the teachers reported high levels of success in the final assessments as compared to their initial experiences. Most of the students achieved unexpectedly positive cognitive end results. The students could reach maximum score of 20 points in the test. On average, the participants achieved a score of 14,9 points, which equals 74,4%. 56 students achieved 15 points or more. Only 5 students out of 92 ended with less than 10 points (a failing grade).

From an external perspective, the researchers observed that students immediately started talking about their own cell phones and how much worth they might represent. They compared their phones

and some students tried to find more information about their personal cell phones through Internet research at home. The learners were most enthusiastic about the egg-race phase, because the teachers presented the experiment as a competition between groups of students. In contrast, students viewed the text-intensive work on the production of aluminum and gold to be the most "boring" phase. Some of them had problems concentrating on the one-page text and summarizing the information. The inside-outside-circle method was considered to be a valuable pedagogy for helping with this task. Most students seemed very inexperienced in autonomous work. Some showed strong symptoms of depending heavily on their teachers. This became obvious because these students did not use the help cards offered at the teacher desk, if they had problems or were feeling insecure about their results. They preferred to ask the teacher for help. Only when the teacher refused immediate help did the students start to use the help cards. Nevertheless, the overall impression was very positive, especially concerning the high levels of independence and learner autonomy.

The opinions expressed by the teachers and the external researchers matched the students' perspective. The student feedback collected in the Likert questionnaires is presented in Figure 3. The learners viewed the lessons as remarkably good. They stated that they had had more fun during the lessons than in previous ones. This fact was also supported by the MoLE questionnaire, where the opinions expressed in the IS-situation and THE LESSON WAS-situation (Bolte, Streller & Hofstein, 2013) improved significantly. The students also enjoyed the role-playing exercise and the discussion at the end of the lesson plan. They found it easy to participate in these phases. With regard to the cooperative learning pedagogies, the students liked the idea of teaching their fellow students and taking responsibility for their own and other learners' knowledge. The results of the MoLE questionnaire also supported this viewpoint. When students were asked for their opinion about content learning during the lessons, more than 70% of them agreed that they had learned a great deal. The MoLE instrument also proved to be statistically significant with regard to students feeling that they learned

more during the current lesson plan than in previous teaching units. The participants agreed that the topic was interesting and relevant for their current and future lives. Almost 90% of the students agreed that the cell phone lessons had made them consider the environment and their personal behavior more closely, especially when it came to handling old cell phones. One student said:

„This issue is very important for us and our environment, because lots of people (or most of them) don't recycle their old cell phones. They just throw them away and don't think about them anymore.”

The MoLE questionnaire revealed that the students had a feeling of having more time to think about the content than in conventional lessons. They pointed out that the group work had given them this additional time. The results of the questionnaire also showed that students were more active during the lessons and tried to participate and understand the subject more frequently than they usually did. A vast majority of the students pointed out that they liked the different learning methods during the lesson plan, especially the role-playing. One of the students who performed the moderation for the role-playing said that she “(...) would wish to make

something like this again, but I would also like to try to play a different role, e.g. a male person.” These and other details are presented in Figure 3.

Conclusions and implications

This case study shows how valuable a collaborative approach as indicated through PAR approach can be used for cooperative curriculum design within the PROFILES project. This was also the case in previous projects (Marks & Eilks, 2010; Eilks & Feierabend, 2013). The cyclical and collaborative process results in highly feasible, motivating learning environments. The module presented here was considered to be well-structured from both the teachers' and the university personnel's perspective. It was judged to be motivating and effective by the teachers and students. PAR again revealed its potential for implementing innovative curricula and pedagogies in science classes. The joint process of developing changed curricula and teaching practices also contributes to shifts in teachers' attitudes towards more student-centered pedagogies. This cooperation helps teachers to integrate unfamiliar pedagogies into their teaching practice. By doing this, the teachers can gain valuable experience. There is also hope that this process will add to teachers' continuous

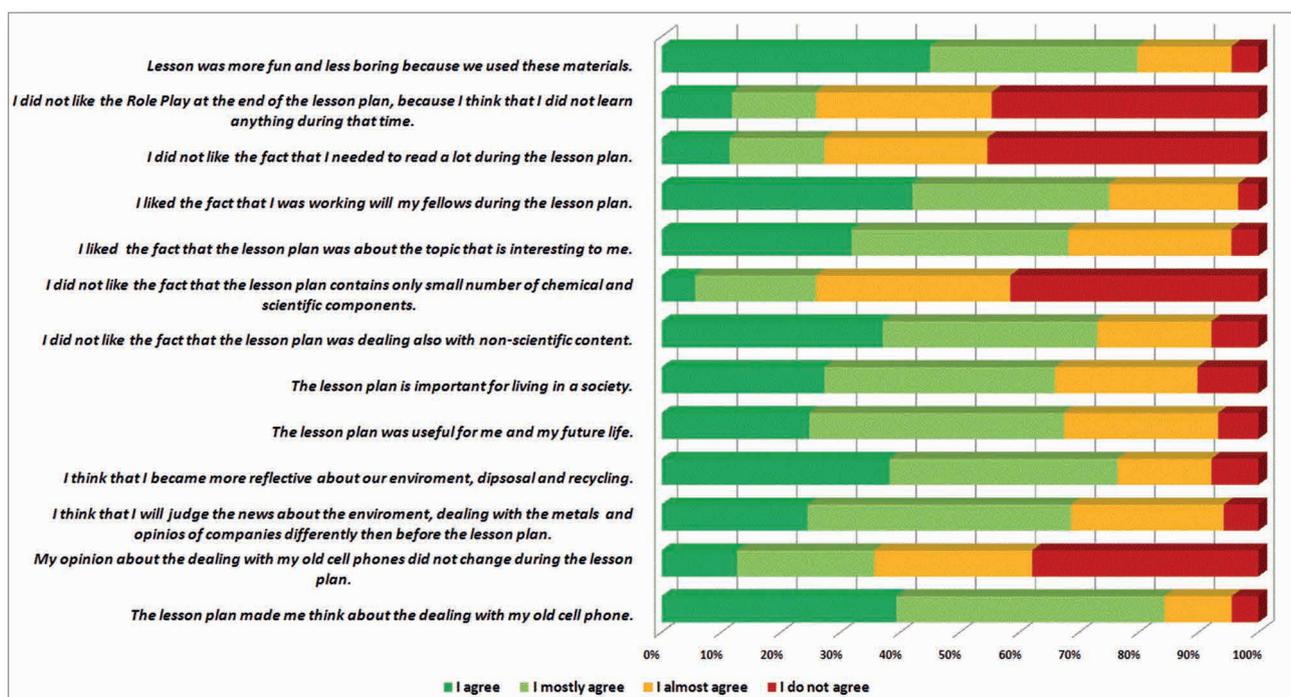


Figure 3. Student feedback on the Likert-questionnaire

professional development as discussed in Eilks et al. (2010), or Mamlok-Naaman and Eilks (2012) and be seen as a meaningful contribution to networking as promoted through PROFILES (Rauch & Dulle, 2012).

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2.5 PROFILES Modules in the Slovenian Context

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Abstract

Teaching science is challenging in the modern society especially because a lot of students are not intrinsically motivated for learning science. This means that teachers should undergo professional changes to make students believe that scientific knowledge that is determined by the national curriculum is useful for their future life even if they are not going to be in a profession tightly connected with science. These problems facing by teachers and also by students in the school science classroom can be at least partly solved by implementations of different educational strategies that can promote students science learning. One of such strategy that is applied across European countries is PROFILES teaching and learning science approach. Teachers need to use specific PROFILES teaching and learning modules while implementing PROFILES approach. This chapter illustrates Slovenian perspective to development of PROFILES modules.

Introduction

The PROFILES project promotes IBSE (Inquiry-based Science Education) – as the first of a number of innovations in the PROFILES teaching and learning science approach – through raising science teachers' self-efficacy, promoting a better understanding of changes in teaching science in schools and identifying the value of stakeholder networking. Initially, PROFILES involved the development of teachers on four fronts – teacher as learner, as teacher, as reflective practitioner and as leader (Hofstein & Mamlok-Naaman, 2012) – further consolidating ownership of the context-led approach by incorporating use-inspired research, evaluative methods and stakeholder 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 content more meaningful (Devetak, Vogrinc & Glažar, 2011; Bolte et al., 2011; Bolte & Holbrook, 2012). This interest for science learning can be stimulated by basing the initial teaching on a socio-scientific contextual issue – second innovation of the PROFILES teaching and learning science approach. At the end of the learning through a particular unit, students are involved in determined an appropriate and justified decision about the presented socio-scientific issue by using the science learning obtained in the central

(IBSE) part of the science learning in the unit. This is a third innovative aspect presented by the PROFILES learning and teaching science approach.

Teaching science is challenging in the modern society, especially because many students are not intrinsically motivated for learning science. They do not see the relevance of the traditional science knowledge for their future lives. Supporting teachers in this endeavour suggest that teachers undergo continuous professional development (CPD) in adequately designed programmes.

It is important for students to understand and to be aware of the usefulness of basic science knowledge for their future life when they will be responsible for solving specific problems and taking the right decisions in a range of occupational fields (cleaning, cooking, environmental issues, agriculture, medical decisions, transportation etc.), even if they are not going to be professionally connected with science. These problems facing teachers and also students in the school science classroom can be at least partly solved by implementation of different educational strategies that can promote students' science learning. One such strategy is the PROFILES teaching and learning science approach, in which teachers use specific PROFILES teaching and learning modules while implementing the PROFILES approach. A self-awareness and ownership of the PROFILES innovation is a target of the CPD programme where teachers are involved in the use of specially designed teaching and learning modules.

PROFILES modules development

Initially, PROFILES CPD involves the development of teachers on four fronts (teacher as learner, as teacher, as reflective practitioner and as leader), developing their self-efficacy in the context-led approach. In the school year 2011/12, 41 teachers (35 from primary school, 6 from secondary school and 14 pre-service teachers) and in the school year 2012/13 29 teachers (all from primary school) were actively involved in the PROFILES CPD programme in Slovenia. 11 teachers participated in both rounds of CPD – these teachers were considered to be ‘leading’ teachers, because they were also actively evolved in offering professional support to the novice teachers in the second round of the PROFILES CPD programme. At least one of the ‘leading’ teachers was assigned to each group.

In both rounds of CPD programme teachers were divided into groups according to their teaching level and according to the subject they teach (biology, chemistry, or physics). A consultant (a member of the national PROFILES team) was also 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. With the consultants’ and ‘leading’ teacher support, the teachers as part of their professional development developed three PROFILES modules in each group.

The collaboration between researchers and teachers in the PROFILES project can be summarized in four crucial steps, which are presented in Figure 1 (Wissiak Grm & Ferik Savec, in press).

Further information about teacher professional development programme in Slovenia is given in the article in this book by Devetak and Vogrinc (2013).

PROFILES modules structure in Slovenian context

Teachers in each group developed PROFILES modules according to the PROFILES philosophy (Rannikmäe & Holbrook, 2012), with elements of Guided Active Learning in Chemistry (GALC) strategy (Devetak, Vogrinc & Glažar, 2011; Kolbl & Devetak, 2012), with consultants supporting the whole process. The GALC strategy was upgraded by the philosophy of the PROFILES project and the approach was applicable not only to chemistry but also for biology, physics and science education. Applying GALC learning strategy to science content was intended to raise students’ awareness of:

- (1) their preferred mode of learning and of their learning strengths;
- (2) their prime motivators and self-confidence to succeed;
- (3) the issues they should consider, such as the significance of water, nutrition, sleep and a positive learning environment;

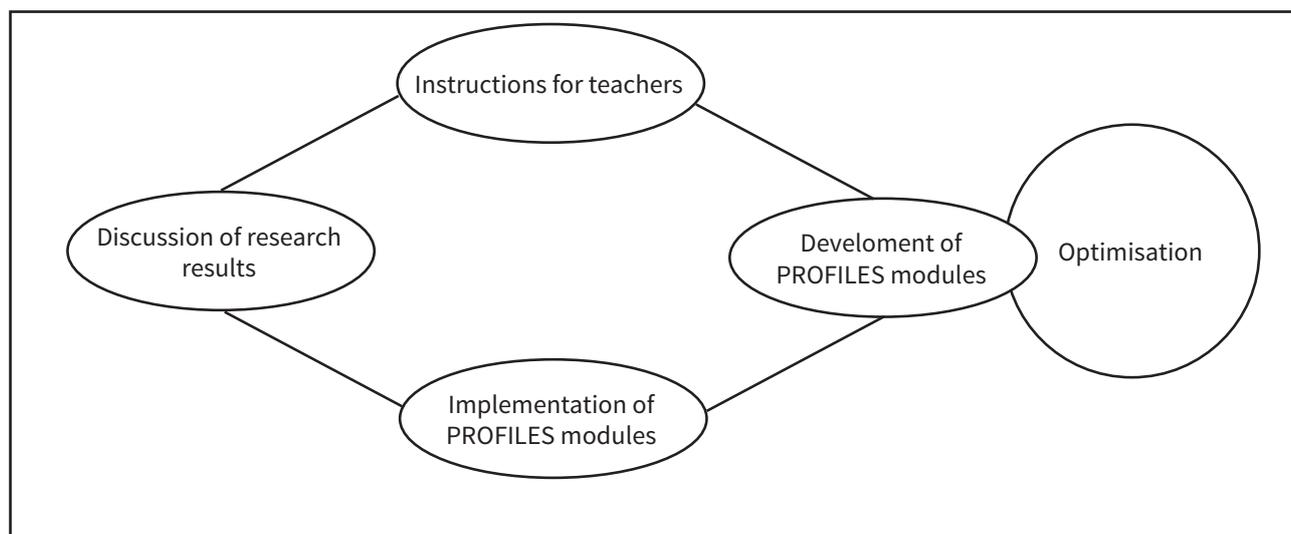


Figure 1. Crucial steps of collaboration between researchers and teachers in the PROFILES project

- (4) some of the specific strategies they can use, for example, to stimulate their memory or to make sense of complex information, and
- (5) some of the habits they should develop, such as reflecting on their learning, so as to achieve improvement in future.

The GALC ideas are based on developments in cognitive learning theories and classroom research show that students generally experience improvements in learning when they are engaged in classroom activities that encourage developing their own knowledge following a learning cycle (Farrell, Moog, & Spencer, 1999). Students need to work together, not only because of their preparation for team work (in science and most of the professions), but because they learn better through social interactions. Students should reach their own conclusions and not be called upon to verify, for example, what the textbook or instructor has indicated to be the expected result of the experiment. The student must be an active learner (Hanson & Wolfskill, 2000).

In turn, the GALC approach was based on the *POGIL* (*Process Oriented Guided Inquiry Learning*) pedagogical method, the purpose of which was to teach process skills (such as collaboration and written expression) as well as the content using the inquiry-based approach (Farrell, Moog & Spencer, 1999; Minderhout & Loertscher, 2007). This approach is usually applied according to the theories on cooperative and collaborative learning. *POGIL* and *GALC* are both based on the guided inquiry approach to learning and on the constructivist principle; i.e. it is assumed that students learn better if:

- (1) they are actively engaged and thinking in the classroom;
- (2) they develop knowledge and reach conclusions themselves by analyzing the data and discussing ideas;
- (3) they learn how to understand concepts and solve problems together;
- (4) the teacher adopts the role of facilitator to assist groups in the learning process; and
- (5) where the teacher does not provide answers to any questions, so that the students are reasonably expected to provide answers

themselves (Farrell et al., 1999).

The difference between *GALC* and *POGIL* is in the organization and adaptation of the *POGIL* method to the Slovenian 45-minute periods of lessons and to the *PROFILES* philosophy. The *GALC/PROFILES* learning modules can be used by the teacher in the classroom during one learning period (or more) and can be adapted to serve the teacher according to the standards and competences set by the national curriculum. The experimental work, which is incorporated into the *GALC/PROFILES* modules, is also a further difference between *GALC/PROFILES* modules and *POGIL* learning units.

The *GALC/PROFILES* learning modules have their specific sections, which follow consecutively and guide the student through the learning module. At the end of each learning module, the students are expected to be able to solve problems in connection with the learning. Each learning module has a *title* which is expressed as a problem question, mostly referring to the concrete environmental, or socio-scientific situation, with which students are more or less familiar.

In the next stage, when students have realised the purpose for studying the particular chemistry learning content and for understanding the embedded concepts. In the section *Why do I have to learn this?*, an environmental or socio-scientific issue is presented in more detail. Thus, this part deals with the content of the learning module in a wider context, implying plausible answers to the question posed in the title. The text of this part is purposely designed to be interesting for the students in order to stimulate their motivation to delve further into the learning module. The sections *Learning goals* and *Learning outcomes* are placed prior to the concrete activities, which students are to pursue, before they reach the set goals of a particular learning unit. A further three initial sections cover:

- (1) *Prerequisites* composed of the very concepts and learning contents, respectively, which are crucial for the students to understand new concepts, models and data;
- (2) *Additional resources* provide some additional

- literature and sources in which students can find additional information on the discussed learning content of the module; and
- (3) *New concepts* that students will be presented within the learning module.

In the *Information and Models* section, groups of students begin with learning new material (careful reading and discussing the material). In this part of the learning module the learning content is presented and some activities regarding IBSE are introduced. The answers to the *Key questions* comprise the very pieces of information which are provided in the *Information and Models* chapter, thus again leading the students to more detailed reading and mutual discussion on the topic. When looking for answers to the key questions the students analyze the data and establish connections among them and evaluate the syntheses. By doing this, the students reach higher cognitive levels themselves. This aspect is the lowest level of task solving, because students are more or less expected to mainly reproduce data.

The gathered knowledge of the specific learning content is afterwards applied by students at solving more simple tasks in the *Exercises* chapter. This work contributes to developing the students' self-confidence in applying new knowledge. The *Exercises* chapter is upgraded with the *Do I understand* chapter, in which students provide answers to a series of questions, thereby adding to their knowledge and establishing their comprehension of the learning module material. This part is mainly devoted to the metacognitive process and continues with the last, most demanding learning stage, i.e. problem-solving tasks.

The last stage is devoted to the *Problems* chapter, in which students solve the posed problem task by applying synthesis and evaluation of the acquired knowledge, transfer of the knowledge to the new context and specific strategies on the basis of IBSE that should be used. The process of learning sequences in GALC/PROFILES module is presented on Figure 2.

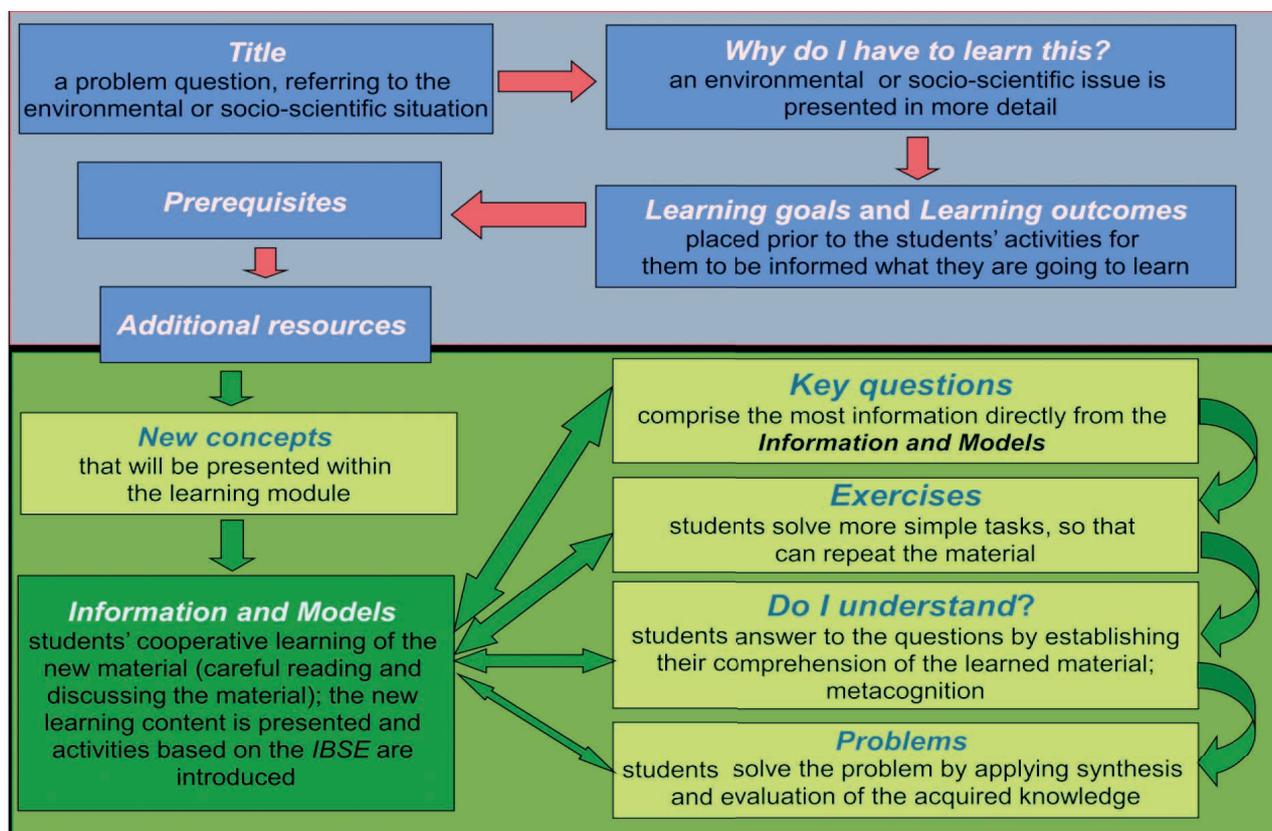


Figure 2. General structure of the PROFILES module and the process of active-cooperative learning sequences.

Each PROFILES module was designed for students to learn science concepts collaboratively. This means that students have roles to follow set by the PROFILES modules. The module presented below entitled “Should athletes undertake high altitude training?” is slightly modified, because it emphasises the teachers’ role in presenting the new concepts (see at: <http://www2.pef.uni-lj.si/kemija/profiles/english.html>). For that reason all the concept explanations regarding circulatory system was transferred into the Teachers note. Originally, these concepts were situated in the Information and models part of the students’ activities, because students were expected to read and learn cooperatively these new concepts and teacher just had a leading role.

But in the PROFILES strategy, teachers can also have a more active role explaining the new concepts and for that reason information about the new concept is not needed in the students’ activity sheets.

Student activities cover all three stages of the PROFILES model. This means that students should read for themselves a motivational socio-scientific problem that involves interesting topics from students’ lives. After that students perform numerous tasks in the context of IBSE and at the end they solve the decision-making problem that refers to the socio-scientific issue at the beginning of the module. Before decision-making, students answer consolidation questions where they repeat and try to understand the knowledge presented in the module.

The teacher guide comprises general and specific information about the nature of the PROFILES modules. Teachers become familiar with the modules’ learning expectations, what are learning outcomes by lesson, what are the competences students have to achieve and how they do this.

The third part in the module is a part where teachers get information about suggested assessment by:

- (1) assessing based on skills acquired comprising social values, personal skills, and using science method,

- (2) assessment by lessons, and
- (3) assessment based on teacher strategy i.e. assessment tool based on the teacher’s marking of written material and assessment tool based on the teacher observations.

Each module concludes with the teachers’ notes, where some suggestions for experimental work are presented, possible answers to the consolidating questions are suggested and additional information for teaching the topic are illustrated.

PROFILES modules implementation

In all of the teacher groups, two or three modules (3–6 school lessons each) were applied in the school environment/practice. The MoLE questionnaire was used at the beginning and at the end of each module application. Data from these questionnaires were/was electronically gathered to evaluate students’ attitudes and level of motivation for learning science. Each group of teachers also developed paper-pencil pre-knowledge and post-knowledge test that were applied to evaluate students’ knowledge achievements.

All teachers, if they had the opportunity in the school, taught the same topic as it was presented in PROFILES modules, in their own traditional manner of teaching; by using the same teaching methods as usually in presenting the selected to the students (control group).

‘Leading’ teachers developed PROFILES modules will be implemented using a pre-post research design in the school year 2013/14. The preliminary research results from cognitive and motivational aspects indicate that the pupils needed some time to adjust to the PROFILES approach, which then eventually contributed to their better achievements in chemistry (Šket et al., 2012; Ferik Savec & Devetak, in press). Further data, obtained in the process of PROFILES modules implementation, will be presented in future publications.

Conclusions

In order to address the challenges of teaching science in modern society, across European countries PROFILES teaching and learning science approach has been implemented.

Students who are exposed to working with the PROFILES learning modules tend to delve into the contents if they can actively participate in the learning process more profoundly and they also understand them better, thereby contemplating about the content to be studied and learning to work in a team. Their knowledge is developed by the data analysis and the discussion on ideas pertaining to the learning content. Attention is also paid to written and verbal communication and to team work. Consequently, the individual concepts within the content are easier to understand, and students also develop problem-solving abilities based on the IBSE approaches. Team work in which research methods are applied, motivating students and enabling the teacher to be provided with immediate and permanent feedback on the students' understanding of the discussed concepts.

The metacognitive process is crucial in the PROFILES approach to teaching science, enabling the students to be aware of the learning process through self-reflection, self-evaluation, self-planning and self-regulation of the educational process. In this process the teacher's role is only to be a facilitator, providing assistance to the students in the learning process. The prime goal of implementation of the PROFILES strategy in the science lessons is to encourage students to build up their knowledge within a social learning context in a guided manner through discussion and IBSE strategies and to attend to more or less demanding tasks (Devetak & Glažar, 2010).

After the process of PROFILES modules development and optimization, the modules were implemented in school classrooms. Thereby, classes in which PROFILES modules were implemented were regarded as experimental groups, while the other classes, in which teachers taught their students in their usual way, were regarded as control groups. During the intervention

in school practice also pre-post research design was used to assess students' knowledge gain in the experimental group alone, and MOLE questionnaires were completed prior and after each of the modules to follow motivational aspects of students' learning. The preliminary research results from cognitive and motivational aspects indicate that in some subject and some topics using the PROFILES approach, students achieve significantly better results in comparison to the traditional ways of teaching.

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2.6 Using PROFILES to Teach Science in a Foreign Language – a Case Study

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Abstract

In France, it is possible for students to study additional science in a foreign language, such as English. This case study explores the adaptation and use of a PROFILES teaching/learning module with grade 9 students, where a major focus is the development of the language through the teaching of science. The case study focusses on part 2 of the 3-stage approach advocated in PROFILES and thus explores the teaching of inquiry-based science teaching. Students are asked to put forward a hypothesis, plan experiments to answer the scientific question, interpret results and draw conclusions. Findings indicate the students found the learning of science in this manner interesting and could use it to gain practice in developing their communication skills in a foreign language.

Introduction

This case study examines science teaching using a modified version of a PROFILES module in a CLIL (Contact and Language Integrated Learning) class. In the CLIL class, students study science subjects – Chemistry, Physics, Biology and Mathematics – in a foreign language. The foreign language in this case is English, but it is not necessarily the case in all schools. The focus is on communication and not simply on the acquisition of new knowledge. Usually the students have already gained, or will acquire major scientific skills in French and so the CLIL class is seen as a good opportunity to develop inquiry learning skills.

The case study was undertaken by a teacher in the ICASE-MICE group (so-called so as to highlight ‘motivational inquiry learning in science education’). This group of French science teachers is involved in teaching CLIL classes and is interested in the philosophy and approach put forward by the PROFILES project (Bolte et al., 2012). The group functions under the guidance of ICASE (International Council of Associations for Science Education). Although the group recognizes that teachers do not teach the curriculum – rather they teach students – the teachers of MICE work together to select modules that are seen to suitably match with the French curriculum, adapting them for their lessons while bearing in mind the teaching is in a foreign language. The teachers then try out their

adapted modules with their students and reflect on their observations among members of the MICE group.

Background

French school teachers are convinced that enhancing scientific literacy is a fundamental goal in teaching science subjects. In line with modern definitions such as that from the PISA study (OECD, 2007), or work by others (Holbrook & Rannikmäe, 2009; Choi et al., 2011), the teachers realise that science content is not enough and skills to be able to communicate the ideas (for this case study – in a foreign language), using appropriate terminology, are also a crucial part of developing scientific literacy. This also is very much in line with the concept of ‘education through science’ (Holbrook & Rannikmäe, 2007) which is well accepted by the PROFILES project. This approach again recognized the importance of focusing the teaching for the students in a specific context, being taught by a specific teacher familiar with the strengths and weaknesses of the individual students in the class.

The inquiry-based approach in science teaching (IBSE, or IL in the PROFILES name) is also not new to French teachers. French teachers are very familiar with seeing IBSE being approached from a stated science question and followed up by students by:

- stating an hypothesis;
- elaborating an experiment that might validate this hypothesis;
- discussing the results of the experiment;
- making a conclusion related to whether the scientific question has been solved.

It is usual, nevertheless, for ICASE-MICE teachers to use a worksheet with the students, because trying to operate in a foreign language requires both oral and visual support). And because students are asked to communicate in a foreign language, the worksheet allows better understanding of the necessity of knowing the right vocabulary and being able to make simple and understandable sentences. Learning science in a foreign language using an IBSE approach is thus a good way for students to clarify the scientific concepts and to improve their skills in interacting in this language.

The PROFILES module

The module used in this case study is an adaptation from two modules, which originally were compiled under the PARSEL project. These were – ‘Where do the fizzy bubbles in fizzy tablets come from?’ (developed for grade 6–7) and ‘The gas we drink – Carbon Dioxide in Beverages’ (developed for grade 10–11) (www.parsel.eu).

The first PARSEL module covered properties of substances, comparing substances and establishing relationships between the uses and the properties of substances through inquiring, explaining, laboratory work, building models, group activities etc. for 4 lessons of 45 minutes. The objectives or competences were not explicitly indicated, but, in general, referred to observing scientific phenomena and describing them by using every day examples, as well as investigation and description of the change of substances in a chemical reaction using simple experiments.

The intended teaching approach follows up on the question in the title in the course of an experiment on using fizzy tablets, before a further question follows – How much gas is produced from one tablet? The PARSEL script suggests that the analysis of the

problem gives students possibilities to develop their own ideas and suggestions for a solution. Also, in studying the amount of gas produced, students are likely to realise that tablets from different manufacturers produce different amounts of gas. This finding allows a group discussion about the experimental set-up, possible sources of error and once again about the composition of fizzy tablets. Such an approach depends on student motivation coming from the inquiry learning, where a student-centred investigation is linked to conceptual understanding. This is stage 2 in the PROFILES approach and, as indicated, the scientific question is given to the students rather than building from a stage 1 perspective, where students can be guided to put forward the scientific question for themselves and when the follow up can be in terms of structured, guided or open inquiry (Holbrook & Rannikmäe, 2012).

In this PARSEL module, the activities suggested are to undertake:

1. A self-inflating balloon. (Put a balloon containing some effervescent powder over a flask filled with water and observe what happens).
2. What makes a fizzy drink fizzy? (Which substance from those given in the packaging for the effervescent powder is responsible for the fizzing?)
3. How much gas does fizzy powder, a fizzy rock and/or a fizzy tablet produce? (First, write down the amounts you assume will be produced, then carry out the experiments and, finally, fill in your results. Then try to come up with an experiment or an experimental setup that allows you to check your assumptions as accurately as possible).
4. How to build a fizzy rocket. (You can make a small rocket fly by using effervescent powder or tablets. How could that work and, more importantly, does it work?)
5. A home-made fire extinguisher.
6. My own fizzy drink recipe. (My recipe for my own fizzy drink is ...)

The teacher’s guide added little to the student script and is seen as disappointing as it indicated little

on the teaching issues that can arise or aspects on adding extrinsic motivation of students.

Short summary of the 2nd PARSEL module

Bottled or canned carbonated beverages provide real-life applications of science. From this the follow science areas can be studied – gas solubility in liquids, gas pressure, gas laws, physical and chemical equilibrium, and acid–base chemistry. For the original version of the module (www.parsel.eu), the overall objectives/competences are given as:

1. Get to know that gases dissolve in liquids and study the dissolution of carbon dioxide in water.
2. Realise that carbonated beverages are under high pressure.
3. Working in groups, propose and execute a method for determining the amount of carbon dioxide that is contained inside a carbonated beverage.
4. Devise methods for estimating the pressure inside a sealed bottled or canned carbonated beverage.
5. Apply the ideal-gas equation in the estimation of the above pressure.
6. Consider the experimental errors that enter in various procedures for estimating the pressure.
7. See a demonstration of a “carbon dioxide fountain” and explain it using the knowledge gained through the previous investigations.

The activity involved student group work in the laboratory (in groups of 3–5 students) for 5–6 teaching periods at school, plus pre-activity preparation at home. For the CLIL class, competences 5–7 were not considered and are not described further.

Students’ task description

The 4 student tasks which were considered are indicated below;

1. Study the properties of gases and the physical and chemical properties of carbon dioxide. Place emphasis on gas solubility in liquids and the gas laws.
2. Develop a simple method for determining the amount of carbon dioxide that is contained inside a carbonated beverage.
3. Devise a method for determining the pressure that prevails inside a closed bottle or can containing a carbonated beverage.
4. Attempt to explain the observed phenomena and account the experimental errors involved.

The teacher guide provides support for tasks, where needed, e.g.

- (a) for task 2 – Open a bottle of carbonated beverage. Observe the bubbles of carbon dioxide escaping, and suggest an explanation. In addition, using two bottles with the same carbonated beverage, one having been kept in the fridge, the other in a warm place, observe and try to explain the amount of bubbles that escape from the end of the tube into a container with water.
- (b) for task 3 – Record your measurement and report it to the rest of the class. Collect findings from different bottled beverages and record outcomes as a table.

The student tasks include answering the following questions.

1. What factors affect the solubility of a gas in a liquid?
2. Some kinds of fish require more dissolved oxygen in water than others. Salmon, for example, is found only in northern seas, where the water temperature is under 15°C. Explain this observation in relation to oxygen’s solubility in water.
3. In lakes that are at high altitudes, life seldom appears in the water. There is no fish in the lakes. Explain this observation.
4. In water tanks with cultivated fish, where the water is sometimes not renewed properly, a number of fish die in the summer time. Explain this observation.
5. Carbon dioxide is an approved food additive

in the European Union, and its code number is E290. For what purpose is carbon dioxide added to carbonated beverages?

6. Compare the pH of a carbonated beverage immediately after you open the container, and then after having collected the contained carbon dioxide.
7. In carbonated beverages gaseous carbon dioxide is dissolved, Sometimes we refer to these beverages as containing carbonic acid. What is the relation of carbonic acid to carbon dioxide?

From the teacher guide, the teaching emphasis indicates:

1. The initial emphasis is on gas solubility in liquids and the gas laws.
2. Students think of and propose a simple method for determining the amount of carbon dioxide that is contained inside a carbonated beverage.
3. Students devise a method for determining the pressure that prevails inside a closed bottle or can containing a carbonated beverage.
4. Students are given the opportunity to explain the observed phenomena and account the experimental errors involved.

For phase 1 the teacher guide recommends:

- Each group be assigned the task to bring to school for the next lesson one or more bottled carbonated beverages, whether this related to safety, or was focusing on health.
- The bottles should be made of glass and have the same content (e.g. 330 mL).
- The bottle must have been kept in the fridge for sufficient time, so that it is at a low temperature. In this way, when the bottle is opened, there will be less loss of carbon dioxide.

Comment on the recommendation. While the approach is socially related, it is focused on the scientific aspect. A socio-scientific concern related to carbonated beverages whether this is a safety concern, can be a health issue or possible trying to relate this to the greenhouse gases and global warming.

For phase 2 the PARSEL teacher guide recommends:

- Open a bottle of carbonated beverage and observe bubbles of carbon dioxide escaping; allow students to suggest an explanation.
- To make the plastic stopper with the glass tubing passing through it use a plastic stopper that tightly fits the glass stopper. Make a hole in the bottle and pass a thin glass tubing through it, with a diameter of 3–4 mm. One end of the tubing should go down into the bottle nearly reaching the bottom, while the other end, above the stopper is bent to make a 90° angle. To this end, attach a piece of plastic tubing, the other end of which is introduced into the base of a eudiometer.
- In addition, use two bottles with the same carbonated beverage, one having been kept in the fridge, the other in a warm place, attach the stopper with a tube passing through it and observe and try to explain the amount of bubbles that escape from the end of the tube into a container with water. In this way, study the effect of temperature on the solubility of gases in liquids.
- Plan an appropriate experimental set-up for collecting and measuring the volume of carbon dioxide that is contained in a carbonated beverage. The teacher acts as an advisor, commenting on the proposals and suggesting ways for improvements. After the teacher approves the experimental set up, students can start the activity.

Comment. These modules, although interesting in terms of the science involved, are weak in meeting the criteria for the PROFILES 3-stage model approach. The title of the first module (Fizzy bubbles) does not have a particular focus; at best it identifies, by observation and probably suggesting a well-structured approach, to the making of fizzy bubbles. Thus the title does not suggest a simple path to the scientific question – a key element for inquiry-based learning, in which the students are heavily involved. And such a pathway is important because self-determination theory (SDT) (Ryan & Deci, 2000) recognizes the value of the motivation generated in students when they can become

involved and tackle a situation in which they have a direct interest.

While the first module over-emphasises observation and is not in a sufficiently inquiry-based focus, the second PARSEL module is also found wanting. The emphasis is heavily on the chemistry and physics involved and less on the development of a range of competences as befitting the idea of 'education through science' (Holbrook & Rannikmäe, 2007), an aspect promoted through PROFILES as the last two letters in the acronym.

Further it is recognised that both PARSEL modules omitted a social (or socio-scientific) component – very much seen as the important motivational element in the 3-stage model (Holbrook & Rannikmäe, 2010; Bolte et al. 2012a). For example, a social element could lead the students to wonder if it is good for their health to drink (a lot of) fizzy drinks. Not only could such an introduction generate student oral discussions (very meaningful in promoting communication in a second language), but it could also lead students to ask scientific questions so that they could explore fizzy drinks in more detail and better understand the scientific ideas in a social context. Furthermore, this question could be referred to a second time, after the students had acquired scientific learning associated with the properties of carbon dioxide, so as to undertake a debate on this health issue between the students and perhaps even discussions with the nurse of the school. The discussion would be expected to include ideas in the science learning from the module as well as health, economic and other social issues.

Using a modified version of the modules

The PROFILES-MICE group of science teachers see PROFILES modules as very interesting in the proposed 3-stage teaching context, because they provide science learning which is linked to the usual life of the students, thus enhancing their intrinsic motivation. The group also welcomes the opportunity to use such materials in English while discussing about scientific subjects and working as a collaborative group. They thus produced a

modified module.

In this case study, we pick up the teaching after the scientific question has been put forward 'Where do bubbles in beverages come from?' This case study thus reports on the work carried out with a group of 20 students in grade 9 in one school in an inquiry learning approach.

The classroom operation

In the modified module, the class 9 students work in groups of 4 and undertake their own investigations. This requires the students to follow an inquiry-based approach, guided by the scientific question, 'where do the bubbles come from?' Annex 1 gives the first part of the worksheet distributed to the students. It contains only the scientific question and reminds the students of the four stages involved when conducting IBSE. It is common practice to give students as little direct guidance as possible so that the students gain practice as researchers as much as possible. This approach is a modification from the original PARSEL modules (www.parsel.eu).

The second part of the worksheet was included by the teacher, when necessary, to give hints to students who have more difficulties to start, or to design their experiment. It allowed them to work with more or less autonomy. The students thus planned according to their own ideas, but the teacher was next to them to answer their questions. The teacher also decided whether to allow the group to follow a false idea because by making errors the teacher saw this as a good way to make progress and is also a realistic way of discovering how science was undertaken in the actual laboratory situation. This interesting point was not mentioned in the original unmodified PARSEL modules.

Putting forward a hypothesis

The students put forward and recorded their hypotheses. This was expected to be a fairly easy exercise for the students as they were very familiar with carbon dioxide, both as a substance and as a term in English. Unfortunately this was not really the case. While they were used to recording their

hypothesis, and they had knowledge of carbon dioxide, some of them didn't link the carbon dioxide directly to the bubbles. One group (see example 2 in appendix 2) thought that the salt was linked with the bubbles, because the beverage drink contained water and for them water with bubbles always tasted like "salt". Then their discussions led them to speak about other components and they finally tried, in their experiment, to produce bubbles with the different components contained in fizzy tablets (the fizzy tablet contained vitamin C). When they had tried all the possibilities, they finally discovered that their first hypothesis was not correct and they were then able to make progress in their construction of scientific knowledge.

The other groups had a more "classical" hypothesis and experiment and they tried to collect the gas contained in their beverage and test the gas with limewater. They showed that the gas was carbon dioxide (as in examples 1 and 4)

Comparing volume of gas for different beverages or different temperatures

For the faster groups, the teacher proposed questions to guide students to go further (see part 3 of annex 1), such as *can you compare the volume of gas in different beverages* (see example 3 in annex 2), or *what is the effect of the temperature on the volume of collected gas*.

Presentation

But that was not the end. After completing the investigations, the groups were required to explain their work to the other groups, using slides. The teacher assessed the students during the class and, at the end of the sequence, students completed a questionnaire about what they had learned (part 4 of annex 1). A final mark was developed based on their involvement during the workshop and on their oral skills.

Assessment

The assessment of student progress was carried out in the usual way: as the global mark was 20 points, 4 points were allocated for final presentation, 4 points

for undertaking the experiments (including safety ...), 4 points for leadership and communication within the group, 4 points for their responses to the individual questions (to see if they have individually acquire knowledge and understood what they were doing), and the remaining 4 points for language skills.

Teacher's role

Once the worksheet had been handed out, the teacher discussed with the students and gave them what they needed to perform their experiments. For example, one group (example 2) chose to investigate the role of salts on the formation of bubbles and the teachers gave them different salts and distilled water. After a while these students also asked for an effervescent tablet to carry on their experiments and they investigated the role of each component of the tablet. Other groups tried to test the gas contained in the bottles immediately, but they were later given additional tasks such as comparing different beverages or determining the effect of temperature of the gas (leading to the idea of lower solubility of gases in liquids with increase in temperature.

Lesson learned

All the students took an active part in the activities. Each group had its own idea as indicated by the hypotheses put forward and with the help of the teacher they were able to perform experiments that led to a conclusion. The teacher recognised that students could be guided to put forward their own ideas, but of course this needed to be taught and students given opportunities to develop this skill over time. Students were not able to be creative in putting forward their ideas if they were not encouraged to do so and to be guided to build on prior practice.

The final exchange (*the student presentations*) was lively and everybody was interested in the work of the others. This session allowed students to have very good opportunities to speak in English and being motivated, students willingly took part.

The PROFILES module gave students an opportunity to work in groups, to present their results in front of the class and to argue about their experimental approach. Student collaboration was thus strongly established as a learning target and the presentation also promoted leadership skills.

But of course, the science learning was also present. Within the IBSE experimentation, the students learned to solve a scientific problem with the four steps of inquiry (see Annex 1, worksheet part 1) and at the end of the lesson, they all knew that the bubbles in the beverages were due to carbon dioxide which was dissolved in the liquid and they learned about the factors which can affect this solubility.

Final comments

Several modules have been used by the ICASE-MICE group, either in English or in French. Most students are highly motivated in working in this way and they improved through working in groups, in undertaking argumentation, giving oral presentations and in carrying out experimentation in answer to a scientific question.

Nevertheless the group keeps in mind that there are some drawbacks in using a modular approach and placing emphasis on student involvement.

- (a) Some teenagers are unsettled by the fact that they do not get a “standard lesson” as module lessons start from a society perspective rather than the science directly.
- (b) Some students like investigating, but don't like learning in their lessons. After a while there is the danger that the scientific content is forgotten (just like with a “classical lesson”). We need to find ways to ensure the science learning is consolidated before moving to a new topic. Holding debates and discussions, in which the science ideas need to be incorporated in the correct manner is one approach (this is stage 3 in the PROFILES 3-stage cycle).

If the teacher is aware of these drawbacks, PROFILES modules are a very good way to make students love science.

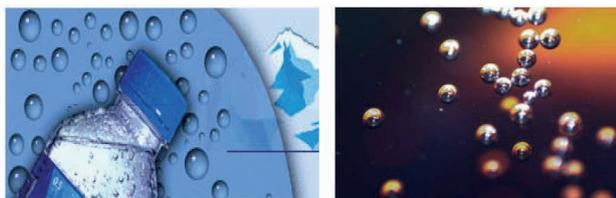
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Annex 1 : Worksheet (handed out to students)

1. Given at the beginning:

The gas we drink – Bubbles in beverages module
Where do the bubbles in some beverages come from?

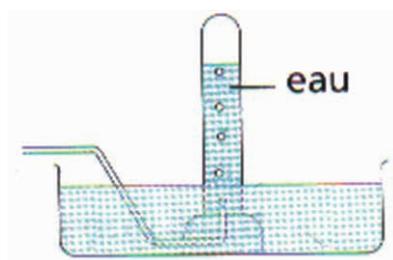


Student Tasks. In your report:

- write your hypothesis.
- propose an experiment and describe it.
- give your results.
- write your conclusion.

2. Hints given, if needed:

- Bubbles are gas which escapes from the liquid when you open the bottle. Which gas can it be? How can you test it? Do you know experimental methods for collecting and measuring the volume of a gas?
- Bubbles are carbon dioxide dissolved in the beverage which escapes from the liquid when you open the bottle. Do you remember the test to identify carbon dioxide?
- Here is a method to collect gas :



3. Extra tasks – going further:

Question: Does soda have less bubbles than carbonated water. If so, why?

Hint 1: You can try two different variables :

Either the temperature of the beverage,
or the type of beverage

Hint 2: To test the effect of the temperature, use two bottles with the same carbonated beverage, one having been kept in the fridge, the other in a warm place, and observe and try to explain the amount of bubbles that escape from the tube's end into a container with water. In this way, you will study the effect of temperature on the solubility of gases in liquids.

Record your measurement and report it to the rest of the class.

4. Given at the end:

Questions to see if you have understood the activity:

Please answer the following.

- Do you see bubbles in the beverage before the bottle is opened? Why?
- What factors affect the solubility of a gas in a liquid?
- Some kinds of fish require more dissolved oxygen in water than other kinds. Salmon, for example, is found only in northern seas, where the water temperature is less than 15°C. Explain this observation in relation to oxygen's solubility in water.
- In water tanks holding cultivated fish, the water is sometimes not appropriately renewed, and in summertime a number of fish die. Explain this observation.
- Carbon dioxide is an approved food additive in the European Union, and its code number is E290. For what purpose is carbon dioxide added to carbonated beverages?

Annex 2 : Examples of Students' work

Example 1

→ Where do the bubbles drinks come from?

We think the bubbles come from the CO₂.

LEGEND:

- Fizzy drink
- Lime water
- muddy water.

* The water become muddy, so there is CO₂.

* The bubbles come from CO₂.

Example 3

We compared the volume of Gas in the Orangina and in the cola.

- We think that orangina has more bubbles than cola.

- Expérience =

We shake the flasks of orangina and cola. The gas go in the tube. And the volume of water become lower.

- Results =

cola = some of Gas.
Orangina = 120 ml of Gas.

- Conclusion =

Orangina has more Gas than Cola. So, more bubbles in Orangina.

Example 2

hypothesis
We thought there is salt in fizzy drinks.
We thought there is sodium sulfate in fizzy drinks.
We thought there is acid in fizzy drinks.

experience & result

water wrong	water + salt wrong	water + acid wrong	water + sodium sulfate wrong	water + salt + sodium sulfate wrong
water + acid + sodium sulfate wrong	water + salt + sodium sulfate + acid wrong			

conclusion:
with that, we have no bubbles.

We think there are sodium bicarbonat and acid in fizzy drinks. The teacher give us a table we have read on the box the sodium bicarbonat and acid.

sodium bicarbonat + acid = it creates bubbles
right

Conclusion:
to create bubbles we need a reaction between acid and

Example 4

Hypothesis: I think that the bubbles come from the gas which is in the fizzy drinks.

Experiment:

Results:
The lime water become mist when we shake it.

Conclusions:
There is CO₂ in the fizzy drinks and when it moves, it makes bubbles.

Barthélémy, Alexis, disa.

2.7 The Implementation and Evaluation of Inquiry-based Science Education PROFILES Modules in Second-Level Schools in Ireland

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Abstract

This paper outlines a number of case studies in Ireland in which a PROFILES team, involved in a UCC/ICASE partnership, developed ten motivational, inquiry-based science education modules for implementation with students in the 15–16 age range in Ireland. The paper indicates the initial stages of getting teachers involved in the project through collaboration with ICASE and the Irish Science Teachers' Association and goes on to identify key areas of the CPD programme provided to the teachers and the level of support needed by the teachers as the PROFILES project developed. Arising out of the CPD programme, ten teachers were asked to be “leaders” in the development of UCC/ICASE modules. The module titles and contents were chosen by the teachers themselves and modified in the light of discussions with the teachers in accordance with the objectives of PROFILES guidelines. The paper summarises some of the main findings from the ten “leader” teachers, drawing from the documentary evidence in their portfolios and analysis of questionnaires completed by the students. Finally, the paper puts forward the main conclusions drawn from this UCC/ICASE collaboration in terms of the CPD model that was developed and the effectiveness of the PROFILES intervention strategy.

Introduction

A recognised goal of introducing PROFILES in Ireland is to promote more motivational IBSE, noting IBSE is heavily related to student experimental work. The current Junior Certificate (grades 7–9) course requirements do not seem to meet expectations, based on teacher comments, while the introduction of PROFILES, in the transition year, seems to be positively received. The question thus arises – could a PROFILES approach, with its accompanying assessment procedures, play a stronger role at the Junior Cert. level, as well as within the transition year? A subsidiary to this question is perhaps – how positive is the PROFILES project in encouraging students towards including science in their senior level studies beyond the transition year?

An important emphasis within PROFILES in Ireland has been very much on IBSE. This is in line with the MoLE intentions to try to introduce a strong sense of student involvement, above and beyond ‘following experimental instructions’ and with this, student involvement in determining the direction of investigation (identifying the science question to be answered using a problem-solving approach), the planning of the investigation, interpretation of findings

and appreciating whether the problem has been solved.

However, it is also recognised that PROFILES, being unique among FP7 European Commission Science in Society Projects, goes further and hypothesises that *student motivation* is a key element besides IBSE and for this, a context-based approach, stemming from a familiar socio-scientific issue, is required. The project thus identifies a 3-stage approach to ensure the IBSE has relevance in the eyes of students and that the science gained is applied to the context i.e. in addressing the socio-scientific issue.

Student motivation

Student motivation is recognised as a complex concept, comprising two factors – motivation coming from the student (intrinsic to the student) and motivation driven by external sources (which at the junior cert. level is heavily driven by the teacher, but also by other factors such as school culture, home environment and examination pressure). However, this is not to suggest these two factors are necessarily independent – many instances can be cited of good teachers motivating students to become intrinsically self-determining.

Nevertheless, it is suggested that a context-based approach, which is seen by students as familiar, relevant and worthy of further attention, is a step forward in enhancing student motivation for the learning of science subjects, as identified in the school curriculum.

The PROFILES learning target

Yet student motivation, in itself, is not the goal. It is a step towards promoting the IBSE target and hence the real uniqueness of PROFILES is in stimulating students within a familiar, socio-scientific issue, and, from this, guiding students to recognise the need for, and the desire to be involved in, acquiring the science associated with the socio-scientific issue. But can this be achieved? Can students be guided to voluntarily put forward the scientific question (or questions) which, once investigated, can lead to the conceptual science learning that is the major target? And not only that, can the students be guided to go one step further and consolidate their science learning by being involving in reflecting further on the socio-scientific issue and learn, through acquisition of strong argumentation strategies, to arrive at a well-reasoned decision associated with the socio-scientific issue?

Inquiry-based science education

Inquiry-based teaching has been defined by Hattie (2009) as

“the art of developing challenging situations in which students are asked to observe and question phenomena; pose explanations of what they observe; devise and conduct experiments in which data are collected to support or contradict their theories; analyse data; draw conclusions from experimental data; design and build model; or any combination of these.”

In recent times, there has been increasing emphasis, at the European Union level (EC, 2007), on focusing on acquiring the cognitive and process skills of inquiry-based science education (IBSE) in classroom teaching of science. Wenning (2010) has

emphasised the strong case that exists for making use of IBSE in teaching:

“While traditional teaching by telling and explaining focuses on the destination; inquiry teaching focuses on both the journey and the destination. Why settle for one when one can have both? Isn’t science both a product and a process? Teaching only the facts of science is akin to teaching history. Science consists of both product and process. Teaching the content without the process is to inculcate faith in an instructor, not the ways of science.”

Background

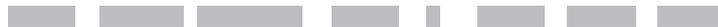
A revised Junior Certificate Science syllabus was introduced into schools in September 2003 (NCCA, 2003). Whilst the syllabus document is non-prescriptive in terms of pedagogy, the Teacher Guidelines (NCCA, 2006) made clear the emphasis on an investigative approach to science teaching:

“The syllabus emphasises an investigative approach to science, which is aimed at facilitating students in the development of skills, knowledge, understanding and attitudes that are appropriate in a society increasingly influenced by science and technology.” (NCCA, 2006)

This syllabus was ground breaking, as, for the first time in Ireland, compulsory practical work was introduced into the Junior Certificate (grade 7–9) science programme. In the introduction to the syllabus, the National Council for Curriculum and Assessment makes clear the purpose of such experimentation:

“In conducting an experiment, the student follows a prescribed procedure in order to test a theory, to confirm a hypothesis or to discover something that is unknown. Experiments can help to make scientific phenomena more real to students and provide them with opportunities to develop manipulative skills and safe work practices in a school laboratory.” (NCCA, 2003)

Students were also required, in the third year of the course (grade 9), to undertake two investigations,



set by the State Examinations Commission. The overall aim was clearly outlined in the introduction to the syllabus:

*“The term **investigation** is used to represent an experience in which the student seeks information about a particular object, process or event in a manner that is not pre-determined in either procedure or outcome. Such experiences can enable the student to observe phenomena, select and follow a line of enquiry, or conduct simple practical tests that may stimulate thought or discussion, thus leading to a clearer understanding of the facts or underlying principles. It should involve the student in following a logical pattern of questioning and decision-making that enables evidence to be gathered in a similar way to that used by scientists.*

Investigations can be used to develop skills of logical thinking and problem-solving, and can give the student an insight into the scientific process. Thus, the student can appreciate the importance of using a ‘fair test’ in order to arrive at valid deductions and conclusions, and the significance of making and recording measurements and observations accurately.”
 (NCCA, 2003, p.6)

A similar approach has not been introduced at the senior secondary level. When teachers were asked whether they would like to see this type of inquiry-based investigations introduced to the senior cycle science subjects, teachers raised the question of reliability of the assessment of students undertaking these investigations. A total of 74.3% respondents disagreed with such a proposal and their responses are summarised as follows:

- It discourages the Junior Certificate science students from further study of science.
- Investigations are not a good measure of a student’s ability at practical work.
- An external examiner should monitor a practical examination.
- Investigations involve more work for the teachers and more time taken up doing it.
- Teachers have to give lots of help to the students and it would not be a fair examination

at senior cycle level.

In Ireland, there appears to be a direct contradiction between the concept of what can be achieved by investigations as outlined in the introduction of the syllabus and the experience of the science teachers themselves. In short, research data clearly shows a significant sense of negativity among science teachers in Ireland towards the introduction of IBSE via investigations. This suggests a lack of understanding by teachers of the value of IBSE and perhaps a lack of recognition of the purpose of teaching science in school. There seems to be a strong sense that students learn science to pass the external examination and only that stressed in the examination is meaningful to promote in school science. It further points to seeing experimental work as an extravagance, included for making science interesting and that the concept of inquiry-based science education included to promote a strong cognitive approach related to problem-solving linked to unknown solutions, is not a needed feature of science learning.

Introducing IBSE in a transition year via PROFILES modules

In the educational system in Ireland, there is a “gap” year called a transition year. This year is undertaken by students who have completed the Junior Certificate science programme (12–15 age group; grades 7–9) before they undertake the Leaving Certificate programme (16–18 age group: grades 10–12). While the precise nature of the programme varies from school to school, in general, students in the 15–16 year age range undertake a great variety of activities and study a wide range of subjects to enable them to get a “taste” of these subjects before choosing the seven subjects studied in the senior school. In view of the flexible curriculum of the transition year, it was felt by the authors that this curriculum would be ideal for introducing PROFILES into Ireland and provide teachers with the freedom to focus on enhancing students’ scientific literacy in a multi-dimensional sense (Bybee, 1997).

Introduction to PROFILES

- What is PROFILES all about?
- PARSEL type modules – their purpose.
- Focus group discussion on identifying teachers' CPD needs for PROFILES teaching.

Inquiry-based Science Education

- What is Inquiry-based Science Education?
- The constructivist teaching approach.
- The use of data-logging in promoting inquiry-based science education.

PROFILES Intervention Modules

- Components of a PARSEL type module
- Writing and designing PROFILES intervention modules.
- Multiple Intelligence Theory – What every teacher should know
- Teaching difficult ideas in Science Education.
- Teacher self-efficacy related to the PROFILES approach.
- The 3-stage PROFILES model

Research Methods in Science Education

- Teacher as curriculum developer.
- Teacher and Action Research.
- The Reflective Practitioner.
- Focus groups

Developing the PROFILES Intervention Modules

- Peer group presentations on draft intervention modules.
- Focus group discussions.
- Finalising of topics.
- Planning of implementation in January 2012.
- Summarising implementation findings by means of posters.

Table 1. Some of the topics covered in the first CPD programme

Continuous professional developments (CPD) of teachers

The first group of UCC/ICASE teachers to undertake CPD for introducing PROFILES in the transition year (and also at the junior cert. level) consisted of 30 science teachers. These science teachers were recruited through the branch network of the Irish Science Teachers' Association (ISTA). Fortunately, ISTA is a member of ICASE and hence full co-

operation from ISTA was obtained in advertising the PROFILES project to ISTA members. All teachers involved in PROFILES were classroom practitioners. The CPD training began in September 2011 and continued until May 2012 for the first group of teachers. A summary of some key topics covered during this time period is given in Table 1.

Ten of the 30 teachers from the group were asked to be the "leader" teachers in developing the UCC/ICASE transition year modules. The topics for the modules were chosen by the teachers themselves and arose out of their own needs in the classroom. In view of the flexible transition year curriculum and the enthusiasm of the teachers, it was felt that the teachers of transition year Science would be ideal curriculum developers for the transition year. The ten modules developed by the teachers are given in Table 2.

UCC / ICASE PROFILES Modules (access URL1 for more details)

1. Does it give you wings?
2. Enzymes are they really needed?
3. Getting things moving.
4. Grip it or slip it.
5. Mouthwash – does alcohol really make a difference?
6. Organ donation – opt in or opt out?
7. Sweaty Betty – Which is the best deodorant?
8. That makes me sick?
9. Which antacid remedy is the most effective in dealing with excess stomach acid?
10. Body at War

Table 2. PROFILES modules developed by the UCC/ICASE team

Providing the title for the modules

Overwhelmingly, the titles used language that was familiar to students from everyday life, although a few titles e.g. Body at War, did not directly indicate the area of familiarity, but focused on student intrigue (seen as another approach to intrinsic motivation). Most titles were expressed as questions and this, taken with the societal orientation, suggested that they were addressing an issue. Each issue included a scientific element and it is the learning of this science that was the

focus of the inquiry-based learning. While the non-question titles were more vague, they could also be construed as an issue; its familiarity or the issue, however, is not directly indicated.

Research findings

Each “leader” teacher was asked to present a written report and poster at the end of the first year of implementation in which they discussed their experience of developing and implementing the PROFILES project modules. The themes emerging from these reports may be summarised as follows:

- **Module titles and scenarios.** In the case of some modules, teachers reported that the students were relatively slow to engage with the title and scenario. This fact might not be surprising considering students were not used to engaging in cognitive experiences in which they were asked to indicate their prior learning and take the initiative in suggesting a direction for the science learning in an investigatory style. Transition year students were regularly involved in exciting, extrinsically motivational hands-on experiments and demonstrations but with little attention to a longer term enhancing of scientific literacy in a multidimensional sense. Teachers reported that the written title might not be intrinsically motivational for students as a standalone and that the scenario might not be sufficiently engaging to allow students to appreciate the socio-scientific issue affecting their lives. It was suggested by some teachers that some element of teacher demonstration or more directed student involvement accompanying the introduction of the title and scenario could enhance its ability to intrinsically motivate students through developing personal interest rather than be seen as only promoting situational interesting (Knapp, 2003). **Comment.** Clearly the motivational aspect of either the title or the scenario or both needs to be carefully considered. The uniqueness of PROFILES is dependent on the students’ initial exposure to the module reflect a positive response and a personal interest in

exploring further.

- **Promotion of IBSE.** In the CPD programme, it was pointed out that a major focus of the PROFILES project was the promotion of Inquiry-based science education. Hence the effective implementation of IBSE could be considered as one of the key indicator of the success or failure of the module. The positive responses to the MoLE questionnaires (an instrument seeking motivational responses) provided a significant body of evidence that the modules were being positively received by the students. One key hallmarks of IBSE was that the teacher played the role of a guide, or facilitator, helping students to carry out their own investigation and make their own discoveries rather than that of an instructor. From the reports of the teachers, it was clear that students felt that they had to think more often from use of the module and there was a large increase in the number of questions and suggestions being made. An increase in these three factors (thinking, asking questions, making suggestions) was consistent with the picture of a group working independently, discussing ideas, questioning the teacher, analysing the data and proposing solutions to problems. **Comment.** The greater student involvement and independent working is seen as a plus for PROFILES, although by operating in the transition year this limited comments on time constraints or examination pressures. If such an approach is seen to lead to greater student numbers taking up science in the senior school, PROFILES will have played a key role in guiding teachers to a reappraisal of the important goals of science education and how these can be attained,
- **Student cooperation.** All teachers involved in the PROFILES project reported a significant increase in cooperation amongst students in the classroom. This was also accompanied by an increase in the level of effort that students were making, both individually and as a class. Teachers commented on the strong indications that effective

group work was being implemented in the classroom and that many tasks were being student-led as part of the group activities.

Comment. The increased student effort is taken as a real positive sign, especially if this can be translated into greater student self-determination and self-efficacy, as this can be taken as a sign of students learning to be independent learners and thus less reliant on the teacher to guide their learning. This of course has implications for learning at higher levels and also learning in subjects other than science.

- **Scientific process.** One of the defining characteristics of IBSE was that it placed as much emphasis on the scientific process as it did on the resulting scientific theory. In some cases, teachers provided evidence of this increased emphasis. For example, in the module, *Grip It or Slip It*, students were investigating the effect of area on friction. Upon completing their investigation and finding that the area of contact had no effect on friction, the students approached the teacher and said that they must have made a mistake. They were encouraged to repeat the experiment a second time. When they obtained the same results the students were forced to re-examine their original theory and were able to make sense of their misconceptions and thus conclude that area was not a factor. It was the students' rigorous application to the task and eventual acceptance of the scientific process that allowed them to clarify their own misconceptions. Not only did the students expand their own scientific knowledge, but they gained an invaluable insight into how scientific discoveries were actually made. This clear example of students thinking and questioning themselves at the evaluation level of Bloom's Taxonomy was also consistent with the literature finding that inquiry encouraged higher order thinking in students (Mamluk-Naaman, 2008). One of the most significant advantages of inquiry-based instruction was that it forced students to use higher order thinking. When students were given a set of step-by-step instructions

to follow in carrying out an investigation they very often only needed to think at the knowledge, comprehension and application level of Bloom's taxonomy (Bloom, 1956) and too often did not engage in meaningful learning. However, when students were faced with an open-ended inquiry, they were forced to operate at the analysis, synthesis and evaluation level of Bloom's taxonomy. This allowed students to learn science with considerable understanding (Wenning, 2005).

Comment. It is encouraging that the positive dimensions of inquiry-based teaching emerging and that the students are willing to participate. Would this still be the case where examination pressures are present? This suggests that a re-appraisal of the actual intended learning associated with scientific literacy is called for and with this assessment measures that effectively relate to the learning.

- **Teacher guide.** The teacher guide sections of the PROFILES modules were very well received by the participating teachers – particularly by those teachers who were teaching outside their specialist subject areas. Teachers reported that they found that the guides were a key strength of the PROFILES modules and contained exactly the kind of information required by teachers. The teacher guides allowed the teachers to anticipate the needs of their students and to plan in advance – something which could be difficult to do in an open inquiry. This gave the teachers enhanced confidence to adapt to an IBSE approach in the classroom and made it easier for the “leader” teachers to convince their colleagues to try out the PROFILES modules in the classroom. It was clear from the feedback that the teachers saw the teacher guide as an essential component of the module and its importance could not be overemphasised. In Zion and Shedletsky's (2005) analysis of the Biomind programme (a pilot project based in Israel involving the use of open inquiry in biology lessons), they found that open inquiry methods required a much greater deal of flexibility on the part of

the teacher and the students than normal. This caused much difficulty for some teachers who felt they needed “(...)to see the whole picture in advance.” Unfortunately it was an inherent part of the inquiry process that every eventuality could not be planned out in advance. Teachers needed be capable of adapting to their students’ discoveries. This required a very deep understanding of the relevant scientific knowledge and a great deal of skill on the part of the teacher to work effectively with a number of different groups, each conducting their own distinct inquiry.

Comment. The teacher guide is indicated as one component of the module. This is alongside a front page (giving an abstract and specifying the intended learning outcomes from an ‘education through science’ perspective) (Holbrook & Rannikmäe, 2007), student guidelines (providing a scenario setting the scene for the intended learning and tasks for the students) plus also a section suggesting possible assessment strategies (Bolte et al., 2012). It is gratifying that teachers find the teacher guide a useful support.

- **Group Work.** Teachers reported some difficulty with adjusting to increased levels of group work in the classroom, yet central to the success of teaching using inquiry was the effective use of group work. If a teacher was not proficient in implementing group work effectively, i.e. following Johnson’s five basic elements of effective group work (Johnson & Johnson, 1994), they were very unlikely to succeed in teaching a cohesive lesson using inquiry.

Difficulties in finding topics which were suitable for students of all ability levels in the classroom were also reported. This could lead to some students “hitchhiking” off the other students in a group leading to a lack of individual accountability, which was seen as a disconcerting feature of ineffective group work. Inquiry also offered excellent opportunities for group work.

On the positive side, teachers reported

that once they had the groups operating effectively, the team members were observed discussing the problems they were facing and consulting with one another on possible solutions. This was one of the hallmarks of good team work (Kim & Song, 2006). The questions they asked of each other were helping to advance their learning and also develop the key social skills required to work effectively as part of a scientific team in the future. This led to perhaps the key advantage of inquiry-based learning, i.e. it taught students to appreciate scientific methods which were clearly one of the key aims of science teaching.

Comment. The group work, although problematic for some teachers to handle, seems to be leading to the desired social learning intended in an ‘education through science’ approach. Not only is group work an important element in undertaking stage 2 of the 3-stage PROFILES cycle (Bolte et al., 2012), but it also facilitates the stages 3 learning where collaborative, communication and especially argumentation skills are developed to incorporate the newly gained science into a socio-scientific decision-making situation.

- **MoLE questionnaire.** The MoLE questionnaires were felt by the teachers to be effective in assessing the overall impact of the module on students’ motivation. This was evidenced by the fact that after completing the PROFILES modules, students responded more positively when asked:

- (a) how important were science lessons;
- (b) how important they themselves felt, and
- (c) how well they understood the subject matter.

The combination of these three factors indicated that the module had a positive impact on students’ motivation. These positive effects might be attributed to the group nature of the tasks, compelling all of the students to participate. Also, the design of the module made it easy to differentiate the tasks for students thereby allowing them to undertake a challenge

that was in keeping with their abilities. **Comment.** Although the responses are positive, it is perhaps necessary to give more attention to redeploying the gained science in the socio-scientific issue and hence involving students in the argumentation activities that lead to reasoned decision-making, in which the science learned is considered alongside the social elements e.g. economic, environmental, ethical, moral, political and social.

- **Identification of variables.** One of the problems highlighted by teachers was the difficulty encountered by students in identifying variables and understanding the different categories of variable. This was not a new problem (Zion & Shedletzky, 2005) and teachers found that it took a good deal of practice in class experimentation for students to improve their ability to define and isolate the necessary variables i.e. the variables to be measured, the control variables and the concept of a fair test. **Comment.** This probably points to the lack of exposure students have had in this area and suggests that by introducing PROFILES modules at the Junior Cert level, more attention can be placed in this aspect of teaching.
- **Students' background knowledge.** All teachers reported that they found it necessary to give a “refresher” talk on the background knowledge needed by the students prior to implementing the PROFILES modules. Whilst the Junior Certificate programme consisted of the fundamentals of science for the 12–15 age group, many students appeared to forget a lot of fundamental science once the examination is over! **Comment.** The findings point to the need to evaluate the effectiveness of PROFILES modules for stimulating real learning and hence, promoting retention of science knowledge and conceptualisation of the science ideas. If attention is given to the follow up to the inquiry learning, to ensure science conceptual gains, then the introducing

of PROFILES modules at the Junior Cert level can be seen as a very positive step in promoting real learning.

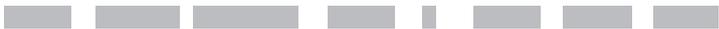
Conclusions

Overall, it is clear from the data gathered that the introduction of PROFILES into Ireland via the UCC/ ICASE partnership has met with an overall positive response from both teachers and students. This positive response is particularly pleasing in view of the negativity expressed by teachers throughout the country as a result of the introduction of IBSE via investigations in the Junior Certificate curriculum.

One of the challenges that lies ahead is to move PROFILES from being used solely in the transition year to mainstream science teaching in the Junior Certificate curriculum and the Leaving Certificate curriculum. The PROFILES modules involve a lot of “hands on” activities in the laboratory environment and not all science classes have full access to school laboratories for all science lessons. In addition, some PROFILES modules are more time consuming than mainstream science classes due to the high levels of group work involved and the greater involvement of students in self-determination discussions on topics which may not have been previously appreciated as being part of mainstream syllabi e.g. justified decision-making. One possible way to progress PROFILES into mainstream class teaching can be through the development of a range of shorter modules so concept maps can be created directly related to curriculum coverage perhaps in a more interdisciplinary sense. As much emphasis in science teaching in Ireland is placed in following the curriculum very closely, teachers may be a lot more willing to try and incorporate smaller PROFILES modules into their everyday teaching, allowing students greater use of their new found self-learning skills. We look forward to the challenges ahead!

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2.8 A Case Study to Determine Student Opinions Related to Science Teaching Using PROFILES Modules

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Abstract

Six teachers from two schools in Viljandi, Estonia designed a PROFILES 3-stage learning module, entitled “You’ll be the owner of the land” and explored student opinions about learning science through this module. Findings indicated that students liked the scenario, because they felt it to be relevant for their lives and also, in general, they indicated the lessons were more interesting and active. Furthermore, working in groups was preferred to working alone as this allowed the development of skills of sharing and delegating tasks. The students noticed that this approach made them more involved and creative, and they were better able to concentrate on the lesson. They were satisfied with the results of their learning, seeing this as something socially useful and practical.

Introduction

PROFILES modules are designed to raise the interest of students in the studying of science and to make the science more relevant and context-based (Bolte et al., 2012). In this way, the science teaching is made more meaningful for the students and as such, the use of PROFILES modules is seen as an attempt to guide teachers away from traditional teaching methods, repeatedly shown to be poor in helping students gain the intended learning, as put forward by the curriculum. In addition, a competence-based focus is seen as more appropriate in preparing students for the future and especially in recognising the need for greater student self-determination (Ryan & Deci, 2002), more emphasis on creative thinking (Cheng, 2010; Hadzigeorgiou et al., 2012) and also more attention to student justified decision-making (Sadler & Ziedler, 2005; Roth & Lee, 2004), all attributes that are within the science curriculum.

In Estonia, the curriculum has changed to being competence-based and is driven by eight key competences indicated by the European Commission (Eurydice, 2002), but called general competences in Estonian documents (Estonian Curriculum, 2011). All eight competences relate to science education and hence finding ways to implement the role of science education in playing its part in developing the goals of education is of much importance. The eight competences are:

- Communication in the mother tongue
- Communication in foreign languages
- Mathematical competence and basic competences in science and technology
- Digital competence
- Learning to learn
- Interpersonal, intercultural and social competences and civic competence
- Entrepreneurship
- Cultural expression

This case study explores the ideas put forward in designing a specific PROFILES module under the format of a 3-stage model, relates this to key (general) competences and explores students’ reactions to learning related to each of the 3 stages.

Theoretical background

Competence is a term gaining greater attention in educational circles, especially in Europe (Eurydice, 2002; 2012; OECD, 2005). Although its definition is not uniformly accepted, competences are recognised as covering the knowledge, skills, attitudes and values associated with learning, put together not as isolated aspects, but forming a coherent, integral focus on the learning, preferably in a context-based approach. The term, competence, entered the educational vocabulary very much from a vocational perspective, where the focus was task-related and the person was seen as able to fulfil the expected job specifications as a whole, not simply as a collection of sub-tasks.

Thus, science education no longer recognises that learning science knowledge should be isolated from the context for which it is appropriate, refuting the claims of an academic stimulus befitting the ideas of a change of behaviour in isolation from society, propagated in education half a century ago (Skinner, 1953). This random acquisition of isolated science knowledge is seen as inappropriate in an age of exponential knowledge growth and where issues within society, although incorporating scientific/technological competence, are also interacting with social concerns such as environmental, economic, social, ethical, morale and political aspects. Today, there is a strong recognition that science education needs to interrelate not only with the cognitive development, but also with personal and social developments (Holbrook & Rannikmäe, 2007).

The PROFILES project introduces a 3-stage model (Holbrook & Rannikmäe, 2010) to address a more relevant and more meaningful science education. The 3-stage learning model connects scientific cognition and the associated process skills with a context-based approach, incorporating socio-scientific learning. For this, the teaching approach using scenarios from everyday life, builds on this to identify scientific problems driving cognitive science learning through an inquiry-based, often experimental, approach with a view to seeking scientific answers, which can then be applied in an everyday social context.

The aim of adopting a 3-stage approach is to strive for relevance of learning (its minimal use lamented by an expert group report on inquiry-based learning – EC, 2007), further the learning by focussing on raising the self-determination and motivation of students to learn science (Ryan & Deci, 2002) and develop multi-intellectual abilities, especially those related to creativity, problem-solving and decision-making (Holbrook & Rannikmäe, 2009; Choi et al., 2011). The hypothesis for such a process is based on the belief that learning achieves better results (especially where the students are enabled to learn to learn – UNESCO, 1996), if the students can feel themselves as active and important participants in the learning process and that the learning has relevant, both within the society and for student's individual futures.

Using this approach, the student is at the centre of the learning process, has the possibility to learn new science through co-operative working with their peers and from receiving meaningful advice and guidance from competent teachers. With this in mind, it is rational to use the synergies of several teachers working together (networking in the PROFILES project – Rauch, 2012) enhancing interactions between teachers of both natural and social sciences in developing and putting into practice new modules with the purpose to advance students' education at a more interdisciplinary and advanced level, closer to life outside the school.

The PROFILES module

This article is based on the desire by a group of teachers to develop a new PROFILES module entitled “You'll be the owner of the land.” The module was developed following the PROFILES structure of a ‘front page’ giving specifications and intentions, student tasks, teacher guide, suggested assessment strategies and additional notes for the teacher. In this article, the emphasis is on the teacher interactions in developing the components that make up the 3-stage approach so that the competences identified (in the frontpage) can be promoted and the student activities identified (student tasks). The article then indicates how the module is tried out and seeks student reactions by means of a 5-point Likert scale questionnaire.

Research questions

This case study is driven by the following three aims each relating to a specific research question and asked in association with the development and use of a new module, based on the PROFILES 3-stage ideas and approach.

- 1) To initiate a relevant situation to relate soil science with students' everyday life, inspiring students to think about soil as a natural resource and ask questions about issues interrelating science and society (Stage 1 of the 3-stage PROFILES approach). The stated question is: what kind of scenario can inspire

students to wish to take a closer insight into this aspect of curriculum learning?

- II) To try different possibilities of organizing experimental work, finding useful additional information and to compile reference materials and worksheets (The inquiry-based stage 2 of the PROFILES approach). The posed question is: in which form can the science learning be promoted such that students like to study and are able to reach the planned competences (learning outcomes)?
- III) To model the ability of making decisions – to stimulate making socio-scientific decisions and learning ways of argumentation and expressing the recently gained science within social points of view. The posed question is: which way of expressing the results of their studies with in the socio-scientific scenario could be developed which was both meaningful and interesting for students?

Research design

Six teachers of different subjects (two teaching physics, one geography, one biology, one chemistry and the sixth, an IT specialist) from two Viljandi schools designed a 3-stage learning module called “You’ll be the owner of the land.”

The process of developing the module was divided into 9 steps:

- 1) Introducing the theoretical and methodical background of the 3-stage module undertaken by five colleagues who initiated the planning of the module.
- 2) Choosing a topic connected to the national curriculum – soil as a part of the environment.
- 3) Being familiar with the applied science ideas connected to the subject; teachers collected different literature material on soil and visited the relevant university laboratories.
- 4) Developing social aspects – finding a relevant, socio-scientific point of view connected to the scientific activities; choosing the appropriate technique for presenting the scenario and undertaking the inquiry-science learning.
- 5) Developing the teaching activities; creating student instructional worksheets; providing suitable materials for the experiments; designing assessment strategies.
- 6) Designing a student feedback questionnaire with other PROFILES teachers guided by the University of Tartu.
- 7) Testing the module with students and collecting feedback during and after the process (the teachers observed the lessons and discussed afterwards, the students filled in the feedback questionnaires – given in the appendix for this article);
- 8) Improving the learning materials following the PROFILES structure of a ‘front page’ giving specifications and intentions, student tasks, teacher guide, suggested assessment strategies and additional notes for the teacher.
- 9) Introducing the module-learning ideas and special materials to the teachers of science subjects in the region (Autumn 2013) and incorporated into a poster session used in a workshop for teachers at the Conference of European Geosciences Union (Spring 2013).

Developing the module

The intensive work on the PROFILES module began in the Autumn of 2012 and the teachers met every week over two months to discuss the progress of the module and to determine needed information. The teachers shared the additional technical information gathered, compiled and corrected student tasks and worksheets, made agreements for using computers and laboratories, determined which of the students’ work needed to be undertaken at school or at home, finalized the principles of assessment, and scheduled the lessons needed for implementing their 3-stage module. The process in the development is illustrated below:

1. Identifying the most appropriate scenario

Stage 1 of the 3-stage model included the introduction to the teaching via a scenario. The goal here was to make this relevant and attractive to the students. The group of teachers created and discussed different scenarios, eliminating

suggestions in a step by step process. The discussions focussed on the anticipated reactions of students, as well as the content and format of the scenario as a meaningful learning exercise.

The following scenario formats were created and discussed:

- 1) Short video – students, using the school drama studio, produced a story of a young family choosing a plot of land on which to build a home and start some kind of enterprise. It encompassed their dreams and first expressions of country life.
- 2) An article in the press – the reasons and results of degradation of fertile soil regions.
- 3) Websites of different organizations – real estate brokers' data on land transactions in Estonia, geographical maps from the Land Department and data on sites by the Environmental Department.
- 4) A good joke! – How crazy ideas come to people when they see a picture of a field or a forest as their hypothetical property.
- 5) An extremely absurd story – a politician advising how to sow rye in the spring (it has to be sown in August!).
- 6) Presenting a leadership position (role play) – a student as a specialist or a person with property or a leader.

The chosen scenario was to use the video produced by students. The teacher team indicated that

“the best way to present information was visually, making use of video-clips of reality. ‘We miss education films in our national (Estonian) language; but at the same time the skills of using foreign languages can be developed if we use films in English, German, etc.’ The younger the students are, the more difficult it is to find attractive scenarios connected to their previous knowledge.”

The team felt that the teachers' role was to stimulate students to ask questions, focused on the socio-scientific direction and to encourage the students to raise scientific questions which could be the start for a scientific investigation. The

teachers determined the video was the best way of achieving this.

Based on the chosen scenario, the group searched for additional information about global problems connected with soil, together with economic aspects. For the actual teaching, a class discussion was planned, following the scenario, on how it would be profitable, but not harmful for the environment, to make use of a plot of land. This then led to the idea of students' "inheriting a plot of land as their property," which, in fact, they were expected to choose by themselves in their home region. The educational goal here focused on determining students' background science knowledge related to the best way to use the land and to get a meaningful product from it.

The focus then shifted to the selection of 'best questions,' (scientific questions) which formulates the problem for the next step (the inquiry-based learning in the PROFILES stage 2). Here the teachers organized the inquiry-learning by students in groups (using worksheets, if the teacher considered this appropriate – this aspect was seen as dependent on the ability of the students in the class) and monitoring each group to ensure the group understood the learning tasks and was working equally (cooperatively).

The module was ready for testing with 16, grade 11 students from Viljandi in Spring, 2013. These students had different educational backgrounds, coming from different secondary (grades 5–9) schools and living both in the town and in the countryside. The student group consisted of 5 girls and 11 boys.

To solicit meaningful feedback from the students, questionnaires were administered related to the 3 stages in the module (appendix 1), although the stages were not made explicit to the students. The feedback questionnaire was developed by an Estonian PROFILES team (12 teachers and 3 university staff) and the validated instrument consisted of 22, 5-point Likert type questions (1 not at all ... 5 very much), plus 4 open ended questions. The questionnaire was validated by testing using 11th grade students from one school in Tartu (N =

30), followed by appropriate modifications made by the 3 university staff.

Findings about the suitability of the scenario

According to questionnaire feedback from using the scenario with the Viljandi students, the mean value on the 5 point Likert scale indicated by students (N=16) on the question “I liked the scenario” (Q3) was $3,25 \pm 0,66$. This indicated that the scenario was considered to be satisfactory, by the majority of students. The students responded positively mainly using 3 (50%) and 4, (38%) with only 2 students indicating a low value as 2.

The feedback from student responses to the scenario differed, some wishing more freedom in decisions as well as more limits (students’ opinions from open-ended questions): “nothing should be raised on field”; “the area of the property should be limited.” The students asked help from the teacher in selecting better sources of information before they were ready to continue towards the inquiry-based learning. An open quiz helped to select the best research (scientific) questions raised by the students and the next steps going into stage 2 were planned.

II. Organizing the inquiry-based experimental work

The teachers proposed and discussed the following choices to undertake the inquiry-based approach to the learning process (stage 2), associated with the module:

- 1) Working in groups, or individually.
- 2) Experimenting – in an open, structured, or guided form (the difference was explained)
- 3) Searching for information in all stages of the module – the teachers search pre-information, the students search pre-information on the subject, on his own questions and problems to solve and the teacher had a consulting role when needed.

Working in groups was selected, with 2–3 student teams determined by lots so as to promote an ability to work in different ‘collectives.’ Preference

was for working in groups as a “family model“ i.e. mixed groups. Individual tasks were chosen and divided by the members of the group. Structured or guide experimentation was planned, meaning a worksheet was prepared which could be used as a whole or in part by the teacher. Student searching for information was recommended to teachers so that students gained competences in seeking and evaluating sources of information.

Findings related to the group work

The highest Likert mean score was given for group work (Q1) ($4,06 \pm 0,74$), 12 students gave 4 or 5 points and no student indicated 1 or 2. In answer 4 to the relevant open-ended questions, students commented: “two heads are better than one“, “we could discuss and support one another“, “we learned to listen to partners“, and “group work was convenient.“ The students indicated that they especially liked the discussions and the sharing of ideas.

Planning the experimentation

For students to undertake the experiments, pre-information was planned to be given by the teacher and the students were free to choose between several experiments and methods. Additional questions were given by the teacher, as appropriate, to help students seek useful information (prices, fertilizers, yields, plant growing conditions, etc.).

Very different student abilities and competences were exposed in this part of the module learning. The teacher sometimes needed to help to organize the working in groups, ensuring a purpose for all members was made more equally (limited student collaborative competence). Also safety could not be forgotten.

Some students commented that they would have liked to be supplied with better key-words (limited student self-determination); these students found the searching for information the most difficult part, when the topic was new to them. Thus, it was found helpful for instructional materials in the module to be given more useful key-words, these being seen as more universal by students, than

just internet links. Furthermore, it was recognised that the teacher could download some of the more useful information and save this to ensure student accessibility when internet connections were unstable. The teachers recognised that references should be properly given; this was recognized as an important social aspect to avoid plagiarism by students using materials but refraining from indicating their source.

Findings related to the experimentation

The students considered that they were learning quite actively Q 8 ($3,37 \pm 0,70$). They indicated that they felt they were active in finding different information Q 9 ($3,69 \pm 0,77$). The students assessed their planning activity (Q 11) as $3,37 \pm 0,60$, positively, in general, but this thinking exercise was less liked than other learning aspects. Actually, as a structured experimental session was planned, where the students were called upon for choosing between proposed methods, the outcome with responses to Q12 was as expected ($4,25 \pm 0,66$).

Comments

The choice of experimental equipment sets limits on the designing of experiments by the students. The teachers suggested that, in organizing this part, it is best to allow a couple of days between the student planning and the actual experimenting, so that the groups can equip themselves with additional materials, or change their plans if needed.

While using instructional worksheets can give results more defined and more quickly (more structured), it reduces the creative (open) part of discussing the planning process, making agreements within the group and thus providing opportunities for students to take responsibility. An alternative can be a choice of instructional methods when making a choice between them is a voluntary learning process. The most active students are actually incredibly creative in recycling materials and using them in making constructions.

III. Modelling student abilities in making decisions

The 3rd stage of the PROFILES model is to turn back to the socio-scientific issue, after gaining the conceptual science through the problem-solving approach, and derive a justified socio-scientific outcome. The stimulus for enabling students to being involved in making a socio-scientific decision begun with the students discussing the issue in the 1st stage of the model. However, at that time, the needed science learning was missing. The science learning came through carrying out the experimentation and making conclusions (solving the problem). This 2nd stage could involve different ways to develop the conceptual science and also could allow students to interrelate this to other scientific ideas already previously gained and also in the ways of presenting the results of their co-operative work.

The teacher team discussed the possibilities for the way, indicated in the student tasks part of the module, how students could be guided to present outcomes from the socio-scientific decision-making in the 3rd stage (undertaken by discussion, debate, role playing, etc.): considerations were centred on using traditional posters, or slide sessions, making a film, listing information, or developing an advertising product, using communities.

After the IT specialist had consulted other teachers and students and the teacher team had discussed outcomes, a decision was made to use, as student outcomes, google drive documents and google maps, designing the planned objects and making comments to them. In this way it was felt that everyone in the class community could see and share the ideas.

Based on this, the student groups were guided during the actual teaching to present their justified "future farms" and "country-house" ideas. They had included thoughts of chicken-houses and greenhouses, promenades and water-bodies, playgrounds and camel farms as exotic tourism attractions and, of course, American-style grill-places connected to an Estonian style sauna.

Findings on the justified decision-making component and overall

Students rated their involvement in finding solutions to problems as Q10 ($4,00 \pm 0,71$), indicating a clear preference for being involved and learning to work collaboratively. The students felt they were active in making decisions giving a mean score on the Likert scale for Q 21 as ($3,87 \pm 0,93$). Overall, students indicated the lessons were more interesting Q 16 ($4,13 \pm 0,86$) and more connected to the real life Q 18 ($4,00 \pm 0,71$) than usual lessons.

Other findings

The students indicated that they felt their creativeness within this module was high Q 22 ($3,75 \pm 0,75$). Mostly they thought that the discussions helped them to understand the issues better Q14 ($3,63 \pm 1,11$). In the third open-ended question, they commented:

“I liked to be involved in a project on ‘my property,’ because it is a very important consideration that I recognized as having to do with my real life.”

Discussion

According to the feedback, this PROFILES module, used as an approach to learning in science lessons, was more interesting than traditional methods; 81% of students gave a higher score than the medium (Q16). Students indicated they obtained special skills, liked to plan experiments and could hold much more discussions than in traditional lessons [Q15 ($3,75 \pm 0,66$)]. Working in groups was preferred to working alone, allowing the development of skills of sharing and delegating tasks. The students noticed that this approach made them more active and creative and they were less distracted being able to concentrate more on the learning. They were satisfied with the result of their work, seen as something socially useful and practical.

The answers to the open-ended, questions 1 and 2, showed that the students had very few critical comments about the module; mostly they wouldn't like to change anything (69% of answers);

- 2 students would have liked to have more freedom in the third phase;
- 2 would have liked to get “more specified patches of land to plan”;
- 2 would have liked to work individually rather than in a group;
- 1 indicated the need for more help in finding information;
- 1 did not like the approach to making the socio-scientific outcome.

The students' individualities, as indicated, can clearly be taken into account during the learning process.

The open-ended question 3 was more informative;

- the students most liked the experimentation part,
- student recognised their freedom to discuss the problems,
- students felt creative in planning their own land,
- students had a feeling of being supported by the group.

All students indicated differences from traditional lessons (open-ended question 4):

- more practical work and discussions;
- cooperation required;
- more group-work;
- more cognitive thinking;
- more planning required;
- interesting and promoted creativity;
- required specific information to be identified.

Teacher reactions

The teachers found that the module-based learning allowed:

- Students to become creative and the process less strenuous (more able to concentration on the learning).
- Students to develop cooperative competences and their capability of dealing with the need for multi-functional abilities stimulated.

- The teacher could divide of tasks according to student abilities and this stimulated learning by the whole group.
- More efficient working by the students when students had been exposed to such an approach at secondary school.
- A more collective approach to the development of the instructional materials and organizing lessons (which is a lot of work for one teacher), not only giving good learning outcomes for student, but was also favoured by students.
- Dividing the assessment of students between the three phases and also allow inclusion of assessment of additional competences such as activeness and socio-scientific competence of students.

Recommendations for using PROFILES learning modules

A number of recommendations can be made, based on this case study.

1. Using carefully constructed, socio-scientific modules based on issues or concerns relevant in everyday life, integration of learning across biology, chemistry, physics, geography etc. is possible.
2. Using modules advocating integrated learning could be used at secondary school level, even within the actual organization of the current schedule. For example, if in secondary school learning, teaching is organized in 7-week blocks with say 5 lessons per week for the integrated subjects, it is easy to use modules and allow within these the careful consolidating of the conceptual learning, possibly via integrated concept maps.
3. The secondary school students become more skilled in gaining inquiry-based competences across the knowledge, skills, attitudes and values spectrum. And with strong attention to promoting student's self-determination and encouraging self-efficacy (with respect to competence and confidence), the students acquire greater responsibility for their own learning and thus progress at a faster pace

than in a controlled teacher-centred lesson delivery.

4. With multiple exposure to PROFILES modules, instructional materials can vary, from being initially more structured to enable students to play a greater role through a teacher guided approach to the various stages of inquiry-based learning to an open approach (project work) where the students can take responsibility for determining the science question to investigate and the various learning stages that follow e.g. predicting, planning, undertaking, interpreting, concluding and conceptualising the learning in relation to other scientific concepts. This truly enables a learning progression in the gaining the key competences through science lessons.
5. The modules stimulate student thinking about other creative ideas and can thus be a major stimulus for encouraging students to undertake further science at higher levels of learning.

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Appendix

Questionnaire based on Likert-type questions
(N=16)

Nr	Question	Mean value	SD	No. of 4's and 5's indicated	No. of 3's indicated	No. of 1's and 2's indicated	Comment
1	I like to work in a group	4,06	0,75	12	4	0	Group-work is well accepted by students
2	I like to study independently in seeking solutions to problems	2,94	0,75	4	7	5	It was not easy to make compromises in groups; independence from teachers' guidance
3	I liked the scenario in the module	3,25	0,66	6	8	2	In fact the scenario pointed to the future possible responsibilities of students and needed much fantasy
4	The scenario made me interested in learning this topic	3,00	0,71	2	11	3	
5	The issue in the scenario was important for me	3,31	1,10	8	4	4	
6	This problem-solving was interesting for me	3,38	0,78	7	7	2	
7	During the module I acquired new knowledge	4,00	0,71	12	4	0	The aim was met
8	During the module I needed to learn actively	3,38	0,70	6	9	1	The work seemed less strenuous than in traditional lessons
9	During the module I searched for new information myself	3,69	0,77	8	8	0	3 ways to find information – given by teachers, found by classmates, found by oneself
10	We used group work to find solutions to problems together	4,00	0,71	14	1	1	Positive cooperative abilities
11	Independently I needed to plan and carry out the practical work	3,38	0,60	7	8	1	Planning was mainly in groups
12	Teacher gave us instruction for the practical work	4,25	0,66	14	2	0	Actually, a choice of instructions was given
13	During the module, I collected and analysed data and made conclusions	3,88	0,93	13	2	1	Much work with all kind of new information
14	Within the module we needed to understand and solve the problem	3,63	1,11	11	12	3	They understood the main aim
15	Module lessons differed in that we had greater opportunities to discuss problems with each other	3,75	0,66	12	3	1	Students felt more freedom
16	Module lessons were more interesting than other lessons	4,13	0,86	13	2	1	In the end it seems they accepted the role the scenario gave to them
17	I had to work harder to understand the learning in the lessons	2,50	0,81	2	5	9	This suggests we can add a more information to process or tasks
18	Module lessons were more relevant to everyday life	4,00	0,71	12	4	0	The social aspect was successful

Nr	Question	Mean value	SD	No. of 4's and 5's indicated	No. of 3's indicated	No. of 1's and 2's indicated	Comment
19	During the module, I had the opportunity to express my views	3,50	0,63	8	7	1	The students learned actively and mostly liked to learn science in this wider context
20	The module developed my argumentation and reasoning skills	3,00	0,87	5	7	4	
21	The module developed my decision-making skills	3,25	0,83	8	4	4	
22	The module developed my creativity	3,75	0,75	11	4	1	

Open-ended questions:

1. What would you change in the scenario?
2. What more would you wish to change in the module?
3. What do you like most in the module? Give your reasoning.
4. What's the difference between this module and other lessons?

2.9 Using PREZI-Technology to Promote Inquiry-based Learning on 'Bionics'

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Abstract

This paper describes an example of module development under the umbrella of the PROFILES project at the University of Bremen. The case study described in this paper focuses on the use of new presentation software called PREZI to initiate and structure inquiry-based science learning in the classroom and to contribute to teacher continuous professional development concerning the use of modern technology for guided inquiry learning. The discussion will be illustrated by a module on bionics. Experience and feedback from students and teachers will also be reported.

Introduction

In the 1990s, the establishment of the Internet created a new source of information and a new way of exchange between people. However, it was mainly used by the military and research institutes in the beginning (Tuvi & Nachmias, 2003). Over the last two decades this situation has changed dramatically. Today the Internet connects the whole world and makes information available in a way never seen before. The Internet has achieved a central role in all areas of modern life. It has also become an important part in the life-worlds of today's students and an important source of information for learning for young people (Frailich, Kesner & Hofstein, 2009).

Just as ICT has become important in the lives of our students, it has also changed teachers' lives. Most teachers today use the Internet and related media, e.g. learning tools, animations, or databases, to improve teaching and learning (Dori, Rodrigues & Schanze, 2013). Improvement in hard- and software makes the use of ICT in teaching easier and more broadly available from year to year.

In the last twenty years, various pedagogies have been suggested for working with the Internet and computers in education, including science education (Dori, Rodrigues & Schanze, 2013). New developments in hardware such as Smartphones, Tablets and Interactive Whiteboards, as well as continuous improvement in the available software, lead to constant challenges to invest in educational innovation practices based on modern information

and communication technology and research about it. The continuous change and development in technology asks for inclusion of learning of the use of ICT, e.g. to support inquiry-based science education into teacher continuous professional development (CPD) which is one of the central goals of the PROFILES project (Bolte et al., 2012)

Quite early in this developmental phase, research found evidence that using modern ICT forms like animations and visualizations can benefit learning processes (Williamson & Abraham, 1995; Falvo, 2008). Yet the benefit of using ICT in education is not self-evident, since ICT can only support learning if many principles for its use are taken into consideration. For example, Mayer (2003) found that digital media in education support learning only under certain conditions. Text and associated figures must be well-structured and carefully combined, irrelevant information must be deleted so as not to distract learners' attention. Texts and visual information should be presented in close proximity to one another, and texts must be written in a style which closely mirrors colloquial language. Before reflecting upon the inclusion of information and visualization, however, content matter and its pedagogical refinement must first be taken into account (Kerres, 2000). As in any other media and learning environment, it is important that content is well-structured, but nevertheless provokes personal activity and cognitive engagement in the learner.

This paper presents an approach using a new presentation software development called PREZI

(www.prezi.com), which takes advantage of the broad availability of handhelds and laptop computers in order to improve inquiry-based science education. Through software releases such as PREZI newer ways of combining and presenting information to learners constantly become available. Information can be presented in a new format with PREZI technology, thereby combining various types of media and information in a networked, layered, dynamic format to promote inquiry-learning between a structured and guided mode. PREZI opens the door to a new way of organizing and displaying information, which allows learners to dictate their own learning speed and to structure their own strategies for coping with new information. PREZI suggests a possible learning pathway without forcing learners to follow a prescribed learning sequence. As a sym-medium it allows for the combination of different sorts of media (text, video, animation, supportive materials on experiments, Internet searches or practical inquiries), all of which can be accessed by learners in whatever sequence and pace fit them best.

This paper describes a case study on module development within the PROFILES project at the University of Bremen, in which PREZI technology is

used to support inquiry-based science education. At the same time the collaborative module development by teachers and science educators is carried out to contribute to the CPD of the participating teachers concerning inquiry-based science education, a central target of the PROFILES project, but also in the use of modern ICT. The focus is an example for junior high school science education on the topic of bionics. PREZI is used to structure the inquiry-learning process and embeds the learning into the PROFILES 3-stage model for socio-scientific issues-based science education (Holbrook & Rannikmäe, 2010, 2012).

PREZI – A new presentation software

PREZI is a presentation software which was developed in 2007 and first published in 2009 by a Hungarian artist, Adam Somlai-Fischer, and a computer scientist, Peter Halacsy. PREZI can be considered as a more elaborated and interactive version of traditional presentation software, like Microsoft PowerPoint. Unlike PowerPoint, however, PREZI allows users to present information in a more highly-networked manner which includes a more dynamic layout.

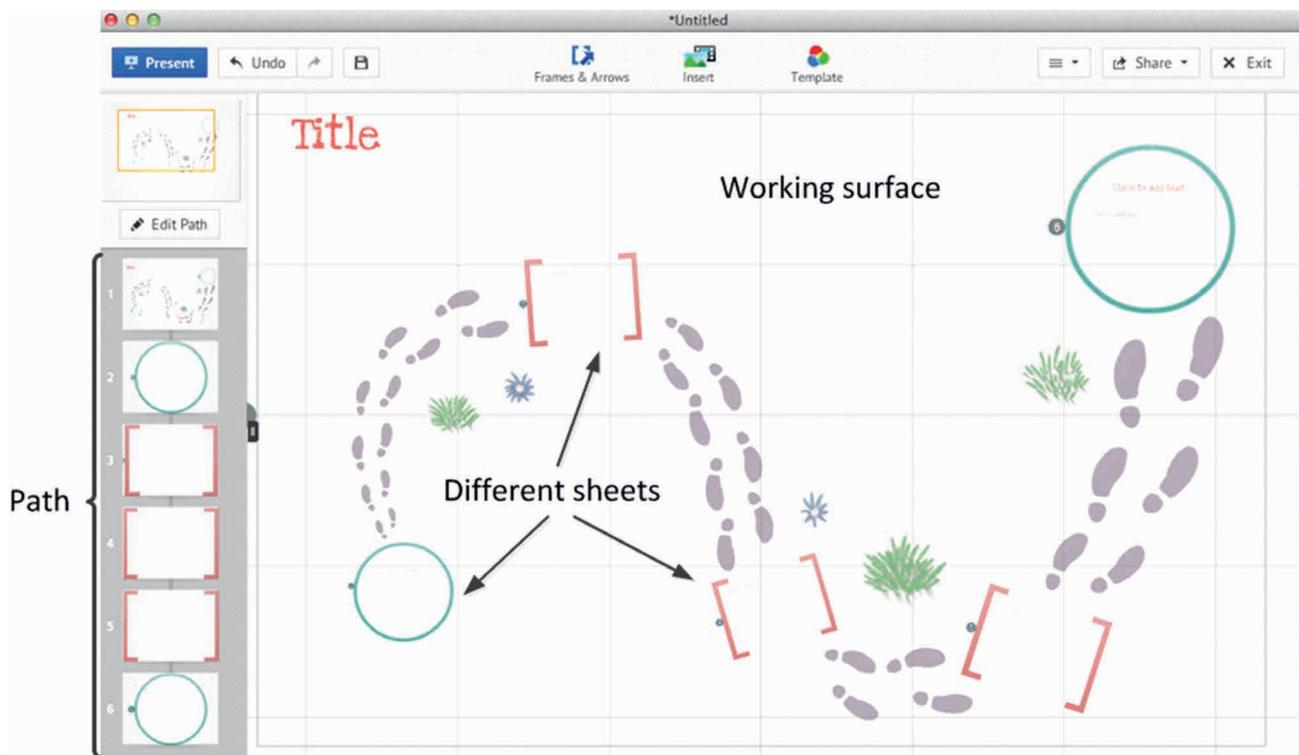


Figure 1. Sketch of a PREZI user interface

PREZI is based on the idea of a large desktop (Figure 1) on which different information slides can be set up. These slides can be arranged quite freely; nevertheless they are interconnected in a specific sequence. While organizing the slides, the creator can attribute them to different layers. That means slides not only can be arranged in a specific sequence, but also layered in depth where supportive information is considered to be helpful. This allows a three-dimensional structuring of information, in which presentation of information in a specific order or sequence is available, yet zooming in on as many specific points is easily accomplished.

Use of the pre-organized structure is possible by visiting the slides and the attached information, thereby following a pathway prescribed by the author. However, the user can also flip from one point on the desktop to another, including the decision of which points to more deeply explore. The user can choose a given path, leave it and then to come back to it later. Additionally, every PREZI slide allows additional material to be offered, e.g. further texts, pictures, videos or downloads, which can be accessed directly by the PREZI environment.

Using PREZI either with the PREZI software or as a stand-alone tool, we find a highly networked and multimedia-supported information resource. PREZI creates a dynamic impression, since the different slides and media are presented as if the user can drive or walk through the information cells. This mirrors the experiences young learners have when they use modern technologies like Smartphones. It differs largely from more static impressions in traditional technologies such as PowerPoint or HTML-based environments.

Background, method and objectives

PROFILES-Bremen is carrying out a strategy for the CPD of science teachers based on collaborative curriculum design and innovation. The strategy of PROFILES encourages teachers and science education researchers to form a partnership for innovating science teaching practices, to develop new modules and pedagogies, and researching the

effects of changed teaching practices in authentic school environments.

The collaborative strategy of curriculum design and innovation in PROFILES-Bremen is based on the model of Participatory Action Research in science education as described by Eilks and Ralle (2002). This model's potential for innovative curriculum design as well as to contribute to long-term teachers CPD has recently been reviewed in Eilks and Feierabend (2013) and Mamlok-Naaman and Eilks (2012). The combination of a research-based design of new classroom teaching-learning modules, the innovation of concrete science teaching practices, and in-service teacher education based on a collaborative and participatory action research philosophy is seen as a special way to contribute to the PROFILES CPD intention of promoting teacher self-efficacy and ownership by creating meaningful evidence of changed teaching practices.

The focus and objectives of the initiatives within groups of teachers and science educators are jointly negotiated, but in this case were inspired by the assumptions of the PROFILES teaching philosophy. The process of development takes place in the authentic school environment of the participating teachers and is structured in regular, monthly meetings of the group. Within these meetings, new teaching ideas are presented and discussed and new strategies are worked out and refined into practical classroom activities. Then the new teaching modules are cyclically tested, researched, reflected upon and revised by the group until the practitioners and the accompanying researchers are satisfied that the intentions of the project have been fulfilled.

The module to which this paper relates was inspired by a group of teachers who felt a need for more thoroughly implemented learning about bionics in their science classes. Structuring and refining the module was performed over a period of roughly one year. This process was accompanied by two science educators from the University of Bremen. Records were kept in the regular meetings of the PAR group in order to track and evaluate the effects and perception of the newly-developed modules. Additionally, open and Likert questionnaires were

used to collect student feedback on whether the module was considered feasible and motivating by the learners. The research aim of this case study was to improve teaching and learning about bionics in lower secondary school science education. This included an inquiry into the potential strategies and effects of using modern educational technology (in this case PREZI) to support inquiry-based science learning and to operate the 3-stage PROFILES teaching-learning model (Holbrook & Rannikmäe, 2010, 2012).

First insights into the module's feasibility and effects were gained from the pilot study in two 8th grade learning groups, each containing 12 students (age range 13–14). An open questionnaire asked the students (I) to explain the differences in using the module when compared to conventional science lessons, (II) to name the positive features of the module and (III) to list potential issues for further improvement. This open questionnaire was followed by a Likert questionnaire with different items focusing on aspects of feasibility, students' self-perception of the learning process, and their experiences while working within the PREZI learning environment.

Using PREZI to structure interactive learning environments in science education

As already described in a previous section, PREZI was created as presentation software. It was not designed for educational purposes ranging beyond presentations in class. However, the obvious question is why such a tool for networked and multimedia-based structuring of information shouldn't also be used for creating computer-based learning environments for student self-directed learning. PREZI seems well-suited for presenting content matter and media information to learners,

either individually or in small groups in a self-directed, autonomous manner.

In such a learning environment, content can be offered in a prescribed way in order to offer orientation to the learner. But, the flexibility to freely move between the parts found within the different layers allows learners to find and structure their own learning pathways. By doing so, freedom to interact with content matter is much higher than with conventional presentation software. This is also due to the fact that each PREZI environment can also be distributed via the Internet and be used with every conventional web browser. This means that learning is possible beyond the classroom, e.g. in homework assignments or during individual preparation for assessments and tests.

Although the technical possibilities of PREZI technology are quite developed, the improvement of PREZI is still in progress. Today, many types of media can be embedded, including videos, animations, and supplementary documents. Nevertheless, several tools are still missing, especially those for assessment and self-assessment, such as multiple choice items or cloze tests. Currently, these are not available in PREZI. But, PREZI learning phases and assessment between these learning phases can be combined and embedded in a broader environment. Different components (PREZI, cloze tests, etc.) can be linked and offered via one single Internet environment (see Figure. 2). Within this environment, students can learn either individually or in small groups. They can learn, discuss and assess their learning autonomously, a factor which has proven to be motivating and effective for computer-supported learning environments in the past (Rodrigues, 2010).



Figure 2. A potential structure for a PREZI-based learning and assessment environment

Insights into the learning environment

The learning environment, called “Inspired by nature: bionics“, is structured for German science or biology education in grades 8–9 (age range 13–15). The whole module consists of three different parts: (I) the lotus effect, (II) the gecko on the wall, and (III) from bird to plane. All three parts begin with an everyday life context and use inquiry-based science education to promote science learning. In detail, the module intends to:

- integrate authentic contexts to promote situated cognition,
- use multiple contexts to allow for the development of applicable knowledge,
- integrate multiple perspectives to promote applicability of the learned knowledge,
- cause socio-scientific constructivist learning, and
- offer instructional support to avoid excessive cognitive demands.

All three parts of the module start with a short, challenging story borrowed from everyday life and presented as a story. These stories are meant to create access to science-related questions and issues, which are then used to initiate the processes of scientific inquiry. After the inquiry, the initial contexts are re-visited to see how science learning helped to better understand the original socio-scientific issue of applying bionic in everyday life. This way was chosen to implement the PROFILES 3-stage model for socio-scientific science learning (Holbrook & Rannikmäe, 2010, 2012).

The computer based teaching-learning-module offers instructional support, supporting materials and potential learning pathways, which allow gradation of the lessons between the extremes of structured to open inquiry with respect to learners' abilities. The learning environment offers questions and ideas for inquiry activities, which will contribute to developing an understanding of the issue in question. All of these impulses, questions,

The screenshot shows the website 'www.bionikundco.de.vu' with the title 'Natur inspiriert – Bionik'. The main content is for the 'Der Lotuseffekt' lesson. It includes a navigation bar with 'Startseite', 'Der Lotuseffekt', 'Dem Gecko auf der Spur', and 'Vom Vogel zum Flugzeug'. The main text welcomes users and lists activities: 'Du wirst dir kleine Präsentationen anschauen (Abb. 1)', 'Du wirst Experimente (Abb. 2) durchführen', 'Du wirst dir Videos anschauen', and 'Dein Wissen überprüfen (Abb. 3)'. Below the text are three preview images: 'Abbildung 1: Vorschau einer Präsentation', 'Abbildung 2: Vorbereitung auf ein Experiment', and 'Abbildung 3: Wissensüberprüfung'. At the bottom, a timeline shows the lesson structure: Introduction, The dirty house wall, Short test, Surface tension, The surface of leaves, Short test, The Lotus Effect, and Final test.

Figure 3. Structure and start of the lessons on the lotus effect

ideas and supporting materials were integrated into a set of PREZI presentations. Assessment tools were also structured to be used for assessment and self-assessment. Figure 3 gives an overview of the structure of the learning environment for the lotus effect. This part consists of four PREZI environments and three assessments.

The module on the lotus effect is outlined here in more detail. The textual approach is created using a short narrative about a boy named Max. Max is curious, because he observes that after it rains, some plants in the garden still appear to be dirty while others look very clean. The short story is meant to provoke thinking about potential reasons for the different appearances of the single plants. Within the PREZI environment, the character of Max appears repeatedly. The story proceeds, along phenomena, experiments and technical applications based on bionics, until the mystery of the different plants is solved.

The central problem the students face is the question – which plants seem to self-clean themselves and why? Within the learning environment, students are asked to collect the leaves of different plants,

both with and without the self-cleaning effect. The learners are motivated to inquire into how the different leaves behave, if they are placed in contact with dirt and water. Students are asked to express their own hypothesis and to develop self-planned experiments to test their assumptions. For example, students can start by characterizing the behavior of water drops on the different leaf surfaces. They also can start by contaminating the leaves with dirt and then observe whether or not (and how) the different leaves are cleaned by water. Figure 4 gives a screenshot of the PREZI slide in the learning environment. We can see different questions, tasks and supporting materials. In the lower right corner we find a miniature of a new slide, which allows the learner to zoom to deeper layers, where additional materials and support are offered step-by-step. To accompany PREZI, teachers developed printed materials where students can write down all their ideas and observations. An icon on the slide suggests that this is the correct place to document ideas and experimental inquiries on the handout.

Selbstreinigung von Blättern

Max hat in seinem Korb verschiedene Pflanzenblätter und Materialien gesammelt. Er möchte herausfinden, wie Blätter unterschiedlich mit Schmutz umgehen. Deine Aufgabe ist es, Max bei seinem Versuch zu unterstützen.

Plane zu den folgenden Fragestellungen einen Versuch:

- Wie verhalten sich die Wassertropfen auf den Blättern?
- Welche Form nimmt ein Wassertropfen auf den Blättern ein?
- Wie gut oder schlecht lässt sich der Schmutz entfernen?
- Gibt es Unterschiede beim Reinigen zwischen den Schmutzsorten?

Max hat in seinem Korb folgende Materialien:

- Efeublätter
- Asche
- Petrischale
- Pipette
- Wasser
- Frische Kohrabiblätter

Hilfe zum Versuchsprotokoll

Note the accompanying material

Additional information

Figure 4. Example of a PREZI-Slide



Ergebnisse des ersten Versuchs



Max hat unterschiedliche Beobachtungen gemacht. Er hat aber noch nicht für alle Beobachtungen eine Erklärung. Als erstes hat Max auf ein Efeublatt und Kohlrabiblatt kleine Tropfen Wasser pipettiert und die Entfernung von Asche auf dem jeweiligen Blatt beobachtet.



1. Er konnte beobachten, dass die Wassertropfen auf dem Efeublatt sind.
2. Bei dem Kohlrabiblatt konnte er eine andere Beobachtung machen. Die Wassertropfen waren und konnten sich auf dem Blatt .
3. Der Dreck ließ sich auf dem leichter und mit weniger Wasser entfernen, als es auf dem der Fall gewesen ist. Begünstigt wurde dieser Effekt durch die kugelige Form des Wasser, die den Dreck herunterspülte.

Antworten überprüfen

Löse den Lückentext mit den folgenden Wörtern:

Efeublatt, kugelig, hin- und her bewegen, abgeflacht, zerlaufen, Kohlrabiblatt

Figure 5. Online assessment in the form of a cloze test

After finishing this first PREZI unit, students are given a cloze test for self-assessment (see Figure 5). The computer offers learners instant feedback on their learning success and any mistakes made.

A theoretical understanding of the leaves' surface structure and properties is necessary in order to discover the behavior of the different plants. A second PREZI environment provides suggestions for guided inquiry into the phenomena of surface tension. Investigating into the forming of drops is suggested. Students use the PREZI environment to learn about these phenomena, to make guesses or to create hypotheses, and to conduct small experiments to test them. Additional help for guidance and self-assessment is offered by video clips of example experiments (Figure 6).

The structure of plant surfaces is also dealt with in this phase of the module. Research has revealed that a student hypothesis is regularly suggested, which proposes that most plain surfaces can be most easily cleaned by water. This was also a common misconception in science and engineering up until the 1970s. It took a very long time until Barthlott

and others suggested how self-cleaning surfaces in nature are structured and what technology needs to do to design surfaces mimicking the so-called lotus effect (Cerman, Barthlott & Nieder, 2005).

Leaf surfaces in plants with self-cleaning behavior use a combination of micro- and nano-structures. These structures are not plain, but rather have small pins on which crystals of wax are layered. This structure and the wax cause an extremely small area of contact between the dirt particles, the water drops, and the surface of the leaf. An idea for a model (Figure 7) of this phenomenon is initially presented to the students. The balloon represents the water droplets. The white paint on the surface reveals which of the two examples has the largest contact area between balloon and surface. The smaller the contact area, the easier it is for a water drop to pass over the surface. Since the interactions of the dirt particles and the plant surface are also weak, water easily can remove dirt from such surfaces. After this the students are encouraged to build their own model and dig deeper into the explanation.

Ergebnisse des Experiments



Fahre mit der Maus auf das Video und drücke die "Play"- Taste.

Versuch 1:

- B) Die Wasseroberfläche wölbt sich am Glasrand und läuft nicht sofort über.

Versuch 2:

- A) Die Büroklammer schwimmt auf der Wasseroberfläche.
- Wasserläufer
- B) Die Büroklammer geht unter.



Fahre mit der Maus auf das Video und drücke die "Play"- Taste.

Figure 6. Integrating media, here videos, into the PREZI environment

In the final PREZI environment, students are asked to apply the information learned to situations in their own lives in the means of the socio-scientific character of the PROFILES teaching modules. Self-cleaning wall paint ("Lotusan") is presented to the students. The students can paint different materials with this color and inquire into its behavior. They can transfer their knowledge to formulate potential experiments, as well as use their theoretical knowledge to explain the behavior of the paint. (If the paint is not available, pictures of the experiment are offered instead.) Learners can also discuss and reflect upon whether this paint should be widely applied, where it might be of the greatest use, and to which extent the higher price tag of such a wall paint might be justified.

In the end, students can assess their learning success using an online test with 13 different items (a mix of single choice, multiple choice and sorting items).

Findings and reflections

In the open questionnaire, students often stated that the biggest difference compared to conventional science lessons was the high level of autonomy in learning. This coincided with the teachers' view. Students also mentioned the large number of experiments that they were able to conduct based on the computer learning environment. One student said: *"We didn't obtain our tasks from the teacher, instead we had to work on the whole topic and the experiments on our own."* Especially the self-directed work with the computer and the experiments were categorized by the students as the biggest benefit stemming from this manner of organizing the module. The Likert questionnaires confirmed the positive acceptance of the open and self-directed learning atmosphere. All of the learners largely agreed that the learning environment was well-structured and that the students had had no problems working within it.



Figure 7. Attempt to model the surfaces of leaves

Feedback showed that students viewed the learning environment as supportive and feasible. More than 90% supported the statement that PREZI was user-friendly. About 80% of the students supported the statement that the dynamic character of PREZI presentations makes the learning environment more modern in appearance. The combination of the computer learning environment, experiments, and paper handouts was judged to be good by 90% of the students. Only a few of the students supported a more teacher-centered pedagogy or preferred having all of the materials in written format. About 95% agreed that they had learned a lot with the aid of the learning environment.

However, the teacher feedback showed also that the teachers felt becoming familiar with PREZI technology was valuable. The teachers learned how to structure and use learning environments with the help of a modern and innovative computer technology and how to operate the technology to structure teaching-learning-modules following the PROFILES philosophy of inquiry learning embedded in socio-scientific contexts. Due to their contribution to the development, the teachers developed ownership and stated to intend using the module and related ones developed in PROFILES-Bremen in their classes now and in the future.

Conclusions

PREZI can be used as a valuable tool to create multimedia-based learning environments for inquiry-based science education. PREZI offers educators chances to create learning environments which allow for more guided teaching, but also

support more open approaches to learning. It has the potential to create a module that allows the learning to find his or her way between structured, guided and open inquiry. Its user-friendliness, its dynamic, modern appearance, and its ability to integrate a broad range of media and activities into one tool promoting autonomous learning was highly appreciated by both students and teachers alike. This case study supports similar findings reported by Krause, Kienast, Witteck and Eilks (2013).

As stated in the introduction, the benefits of using computers and ICT-based learning environments for learning are not self-evident. A suitable and feasible structure is necessary, including well-connected content matter and activities. Modern software tools fitting the learners' everyday life experiences in using digital media can also be beneficial. PREZI can offer a basis for providing such learning environments. However CPD is necessary to get teachers self-efficacy in applying respective technologies.

The close cooperation of science educators and practicing teachers, supported by pre-tests and student feedback, led to evidence for changed teaching practice according to the PROFILES philosophy. The PAR model for science education proved once again that it has potential for constructing user-friendly, feasible learning scenarios and materials. It also contributed to the PROFILES CPD and gave a feeling of ownership of the teaching module developed under their participation. And, although it was not the initial focus of this case study, the science educators and

the participating teachers also learned a great deal about PREZI technology, particularly how to use it and how to incorporate it into educational ends.

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**SECTION 3:
CASE STUDIES ON PROFILES TEACHER
TRAINING (CPD) AND OWNERSHIP**



Case Studies on PROFILES Teacher Training (CPD) and Ownership

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Since teachers' continuous long-term professional development (CPD) is essential for school science teaching to become more meaningful, more inquiry-based, more educationally effective, and better aligned with the 21st century science and its related socio-scientific issues, it comes as no surprise that this is the focus of the PROFILES project. The professional development (CPD) workshops conducted in the partners' countries were based on the rationale of PROFILES (**P**rofessional **R**eflection **O**riented **F**ocus on **I**nquiry-based **L**earning and **E**ducation through **S**cience), which aims at promoting inquiry-based science education (IBSE) by enhancing the science teachers' self-efficacy and sense of ownership via a 3-stage model recognizing the importance of motivation and a familiar socio-scientific approach. This clearly indicated a multi-faceted CPD coverage, encompassing, by design, new ideas for teachers and which can be approached by building on teachers' needs.

What are the characteristics of a CPD programme? A theoretical background

Effective CPD needs to provide an opportunity for teachers to reflect on and learn about how new practices can evolve or be modified from existing classroom practice (Harison, Hofstein, Eylon & Simon, 2006). Teachers need to familiarize themselves with new ideas and also understand the implications for themselves as teachers and for their students in the classroom before they adopt and adapt them. Of major importance for PROFILES is that if the new approach differs greatly from teachers' previous practice, they need to reshape their own beliefs regarding science teaching and learning. This involves reconsidering core-principles and issues (educational theory in PROFILES) as well as contextualizing them in developing practices and approaches (education through science ideas in PROFILES). The challenge appears when teachers return to their schools, where the ideas that were developed during the PROFILES CPD sessions probably conducted outside the

supportive climate of the teachers' meetings are considered as a component of the CPD sessions, e.g., Action Research (Mamlok-Naaman & Eilks, 2012). It is then that the intervention aspect of CPD is put into operation before reflection on PROFILES, and on ways to sustain the PROFILES' goals, which can provide a further key component of the CPD programme. Not surprisingly, it has been recognized that conventional methods of conducting CPD have usually suffered from being too short and/or occasional to foster changes in teachers' classroom practice (Loucks-Horsley, Hewson, Love & Stiles, 1998). PROFILES refers to previous research that highlights important features that characterize effective CPD programmes (Loucks-Horsley, Hewson, Love & Stiles, 1998), such as:

- engaging teachers in collaborative long-term inquiries into teaching practice and student learning;
- introducing these inquiries into problem-based contexts that consider content as central and integrate them with pedagogical issues;
- enabling teachers to approach teaching-learning issues, embedded in real classroom contexts, through reflections and discussions of each other's teaching and/or examination of students' work;
- focusing on the specific content or curriculum teachers will be implementing so that teachers will be given time to determine what and how they need to adapt regarding their current teaching methods.

The PROFILES CPD model

The key goals of the PROFILES CPD model (Figure 1) are to develop teachers professionally, based on the teacher as a *learner*, as an *effective teacher*, as a *reflective practitioner* and eventually, in some cases, as a *leader*. These stages are not distinct. They are developed in parallel with the goal of enhancing teachers' professional abilities regarding effective teaching and hence meaningful student learning

through the PROFILES programme (modules). The 1st stage, namely, the teacher as a learner, aims at enhancing the teachers' CK (content knowledge – in this case the science content, possibly important when recognizing the interdisciplinary nature of PROFILES teaching); the 2nd stage aims at enhancing the teachers' PCK (pedagogical content knowledge – a major focus of the CPD programme); the 3rd stage aims at enhancing the teachers' self-efficacy towards the PROFILES ideas and approaches by encouraging reflective practices both by the teachers enacting their practice and by others commenting on the classroom operation), whereas the 4th stage – the teacher as leader – is intended to encourage teachers to accept PROFILES as their own and seek evidence related to a sense of ownership of PROFILES, as reflected by their classroom operations.

Loucks-Horsley, Stiles and Hewson (1996) suggested six key principles for creating effective CPD experiences that should be provided for science teachers within PROFILES. These principles are as follows:

1. Provide teachers with opportunities to develop the necessary knowledge and skills and to broaden their teaching approaches, so that they can create better learning opportunities for students (The 1st and 2nd

stages in the PROFILES model).

2. CPD experiences are driven by a clear, well-defined image of effective classroom learning and teaching. Among other factors, they emphasize inquiry-based learning, students' investigations and discovery, and application of knowledge (stage 2 in the PROFILES model).
3. Use instructional (pedagogical) methods to promote learning for adults to mirror the methods that will be used later by their students (stage 2 in the model).
4. Provide conditions that foster learning in a community of practice (promotion of collegiality and collaboration). Also provide support for other teachers. In addition, CPD is viewed as a lifelong process that is part of school norms and culture (stages 2 and 3 in the model).
5. Include assessment. CPD programmes must continually be assessed and reviewed regarding engagement, satisfaction, etc. (stages 2 and 3 in the model).
6. Prepare and support science teachers to serve (at least some of them) in leadership roles if they are inclined to do so. The meaning of leadership in this context is highly aligned with the claim made by Fullan (1991) regarding: "*The ability of a person to bring about changes among teachers and teaching.*" (For more information about the

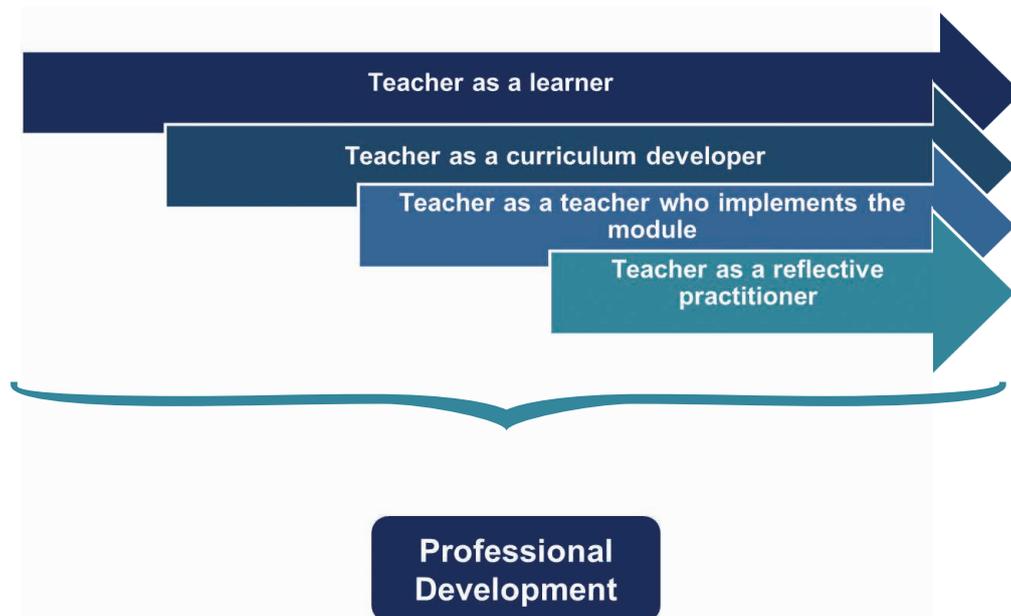


Figure 1. A description of the various stages that exist in the PROFILES CPD model.

development of leading chemistry teachers, see: Hofstein, Carmi & Ben-Zvi, R. 2003; stage 4 in the PROFILES CPD model.)

Clearly, the first three principles are related to the first two stages mentioned above, namely, the *teacher as a learner* and the *teacher as a teacher*, whereas the other three are highly related to the teacher as a reflective person who strives to enhance self-efficacy and ownership. It is suggested that the CPD model (implemented in the PROFILES project), designed according to these principles, has high potential to develop teachers' self-efficacy and ownership through the CPD programme. It provides teachers with a background according to their needs and guides teachers to prepare for implementing the CPD programme in the classroom. For this purpose, teachers utilize PROFILES modules, either adaptations of existing modules from a previous project (PARSEL), or when the teachers feel sufficiently self-confident in handling the PROFILES approach, they will develop their own materials and address self-perceived issues and constraints by researching various components (or pedagogical interventions) in their own classrooms. PROFILES regards these activities as taking major steps toward developing self-efficacy and a sense of ownership.

The CPD section consists of eight contributions (from six contributors). These contributions provide the reader of book 2 with an overview regarding the models used to attain the main goals of PROFILES through intensive and comprehensive CPD initiatives. In general, usually the contributors, professional development providers, and teachers decided (throughout the CPD) to develop their own modules and not to adopt ready-made modules from (for example) those developed in the context of the PARSEL project. It is suggested that using this approach, namely, the *teacher as a curriculum developer* (of teaching resources) had a significant impact on the teachers' self-efficacy and thereafter their sense of ownership.

The group from Finland described in their contribution a case study regarding the professional development (PD) of two physics teachers. Initially in order to familiarize themselves with the PROFILES

goals, they decided to implement and adopt a module from the PARSEL project. Thereafter, they planned four new learning environments for their school and successfully taught according to the PROFILES 3-stage model.

The contributors from Portugal reported on leading teachers (trained in the 1st CPD cycle) who were involved as leading teachers in the 2nd cycle. A unique approach for assessing the CPD was used by this group, namely, using SWOT analysis in one of their case studies.

The Slovenian article describes the implementation of *action research* as a tool to enhance teachers' PCK and also their self-efficacy in using PROFILES learning materials.

The development of a sense of ownership is the main focus of the contributions from Berlin (Free University) and Israel (the Weizmann Institute of Science). The contributors from Berlin (the 1st article) describe a CPD in-service programme for science teachers who worked cooperatively in a PROFILES-based CPD initiative termed "ProNawi" (an acronym standing for "Projektgruppe Naturwissenschaften" – they focus on the teachers' work and cooperation within this project, the modules they created, and the level of ownership the teachers developed.

The contribution from Israel details the various levels of teacher enhancements (e.g., the teachers as practitioners) that eventually led some of them in their development towards attaining a sense of ownership; some of them became leading teachers in guiding additional CPD programmes.

The Czech group describes a case-study related to the development of teachers' creativity through CPD. The main objective of the case-study is to describe and analyze the roles of creativity in the multidimensional development of teachers' professional competence through PROFILES.

The group from Poland reported on the PROFILES' CPD as a vehicle for developing teachers' professional skills aligned with the key goals of the project (e.g. IBSE, decision-making, and education through science). The leaders of the project implemented

the strategy of “needs assessment” in order to obtain information on teachers’ perceptions and opinions regarding the importance of professional skills. These it is suggested could serve as future guidelines for long term CPD experiences similar to those implemented in PROFILES.

Only one contribution was conducted among the pre-service teachers, namely, from the Berlin group. Evidence for the development of self-efficacy and ownership in pre-service teachers and towards conceptualizing the PROFILES philosophy and appreciating the PROFILES approach is detailed in the article.

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3.1 Teachers' Ownership: The Case in Mertala School

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Abstract

Two physics and chemistry teachers from a lower secondary school in Eastern Finland, participated in the first PROFILES teacher training programme in 2011–2012. During their training period, they further modified one of the PARSEL modules according to the PROFILES learning environment. After this first experiment, they planned four new learning environments for their school and successfully taught according to the PROFILES 3-stage model. In addition, to suit their own needs, they modified two PROFILES learning environments designed earlier by other teachers or teacher students. Having completed the teacher training programme, they immediately started to train their colleagues. The aim of this study was to clarify these two physics and chemistry teachers' ownership of the PROFILES teaching idea by exploring their experiences through interviews, and to get a more complete picture of this ownership; their three colleagues were also interviewed.

Introduction

Ownership is closely related to teachers' professional identities, though in somewhat different ways (Blonder, Kipnis, Mamlok-Naaman & Hofstein, 2008; Fullan, 2001). Ownership is understood in this study as the physics and chemistry teachers' mental or psychological state regarding their personal innovation of PROFILES. Ownership can be developed when a teacher contributes actively the innovation. Feeling a degree of ownership towards an innovation is assumed to lead to a successful integration of the innovation into the teacher's working routines, and a continuation of the process of change in the future. Teachers who feel a high degree of ownership towards the innovation express their identification with it and communicate with others about it. A feeling of ownership might therefore be seen as a way of expressing one's identity as a teacher, in terms of what one found important and what one identified with (see Blonder et al., 2008; Ketelaar, Beijgaard, den Brok & Boshuizen, 2012; Ogborn, 2002). Innovations could be successful when teachers feel a personal sense of ownership towards the innovation and do not feel that it had simply been imposed on them (Ogborn, 2002; Simon, Campbell, Johnson & Stylianidou, 2011).

Educational innovations frequently need to be introduced into teachers' daily teaching practices. An educational innovation could have a strong impact on a teacher's professional identity (Day,

Kington, Stobart & Sammons, 2006). Professional development (PD) is related to the teacher's identity; this means that while actively engaged in one's working life, it is a continual process of learning to enrich and enhance oneself and to meet with the current demands of the information-based age. In this sense, teachers' professional development means increasing teaching techniques, broadening subject knowledge, creating responsibility and establishing commitment (see Appleton, 2008; Hoque, Alam & Abdullah, 2011).

Continuous professional development (CPD) is also widely acknowledged to be important in the pursuit of improvements in teaching and learning. The core of CPD is the enhancement of pedagogical content knowledge and teachers' reflection on their beliefs and classroom actions (Chang, 2009; Fraser, 2011; Kennedy, 2011; Scherz, Bialer & Eylon, 2008; Valdman, Holbrook & Rannikmäe, 2012).

The aim of this study is to describe how two Finnish science teachers experienced, in their own teaching, ownership towards the PROFILES approach.

Methodology of research

This case study focused on the clarification of two teachers' ownership within the framework of the PROFILES 3-stage approach. The teachers worked at a comprehensive school, which included a primary school (grades 1 to 6) and a lower secondary school

(grades 7 to 9). The school also had a preparatory class for immigrant students, intended for children in the first year after moving to the area. The school focused on the arts, and music classes began in the third grade. The school had approximately 600 students and 50 teachers, seven of whom were physics and chemistry teachers.

Ownership was assessed through the learning environments that were used, modified or planned, and through perceptions, ideas and experiences of the scenario, inquiry and decision-making stages found in semi-structured interviews. In addition to the two leading teachers who participated in the PROFILES training in 2011–2012, three of their colleagues were also interviewed. All the teachers were physics and chemistry teachers. Each interview took about 45–60 minutes. The interviews were conducted after the academic year that followed the PROFILES training period; they were all carried out under similar conditions on the same day, two of the teachers interviewed together and one teacher alone. There were two interviewers. The interviews focused on the teachers' experiences regarding the whole of the PROFILES project, the aims, materials and strategies of physics and chemistry teaching.

The semi-structured interview was planned to determine teachers' perceptions, ideas and experiences in the following areas:

- What was the meaning of the 3-stage based model teaching?
- What were teachers' feelings before starting to explore the learning environments?
- What were teachers' feelings during and after PROFILES teaching?
- What sort of impression did teachers get regarding students' reactions to the learning environments?
- Would teachers recommend PROFILES teaching to their colleagues in the future?
- Would teachers use this kind of material in future?

The interviews were transcribed and analyzed. Analysis focused on the teachers' perspectives regarding PROFILES, the learning environment adaptation process and their ideas of ownership.

Inductive data analysis consisted of scoring and grouping descriptions from the teachers' interviews.

Results of research

Learning environments

During her PROFILES training period, Amy first modified 'Corrosion' from the PARSEL modules, and used it in the 8th grade. She also used the 'CSI' learning environment (from now on referred to as modules) modified from the PARSEL modules by a teacher student at the University of Eastern Finland. After these two, she started to modify her own modules, first 'Water', related to the pond near the school, and then an 'Energy' unit.

Mary also used the 'CSI' module and the 'Water' module planned for their school. In addition, she also created her own 'Energy' module and 'Specific heat capacity' module, all of which she used in her classes.

Both Amy and Mary were able to create modules according to the 3-stage approach. After their training period in May 2012, they presented the PROFILES approach to their colleagues, both at the primary as well as the lower secondary level. The following term, together with other teachers, they planned the learning environment 'Nutrition'.

All of the lower secondary school students in the grade 9 had used the 'Energy' module and 'Nutrition' module in the term 2012–2013. Some of the 8th graders studied the 'Water' module, as well as 'CSI'. Some of the 7th graders studied the 'Specific heat capacity' module.

The modules are described in Tables 1 and 2.

Teachers' ideas about the scenario stage

Physics and chemistry teachers highlighted the purpose of the scenario and considered it important that the scenario stimulated students' interest and motivated the study of physics and chemistry content. A good scenario was seen as making science lessons more interesting and enjoyable

for the students. All of the teachers said that the scenario phase was challenging with regard to finding such a relevant and meaningful scenario that would be related to the students' lives.

For example, Mary commented:

"The most important thing is the scenario. How to find one that is good and interesting..."

Teacher	Teacher experience	Number of modules used	Grade			
			6 th	7 th	8 th	9 th
Amy	More than 20 years	6	Specific heat capacity	Specific heat capacity	Water CSI	Energy Nutrition
Mary	10–20 years	5		Specific heat capacity	Water CSI	Energy Nutrition
Karin	More than 20 years	5		Specific heat capacity	Water CSI	Energy Nutrition
Bill	Less than 10	2				Energy Nutrition
Jane	Less than 10	2				Energy Nutrition

Table 1. Participants and PROFILES modules

Theme of the module	The main idea of the scenario phase	The main idea of the inquiry phase	The main idea of the decision-making phase
Energy I	What form of energy will be supported by the EU during the next 20 years? Article on the internet	Numerical tasks Laboratory work; electromagnetism, induction and transformer Homework: finding the principle of a generator and information on some EU country's form of energy related to the role as a representative of an EU country which students had; Text books	Drama; energy conference, in which the decision about the use of a form of energy to be supported
Energy II	What form of energy will be produced in the EU in 2020? Article in newspaper	Literature inquiry in small groups concerning different forms of energy: environmental issues, waste issues, raw material issues and future issues	Group decision-making about a future form of energy
Nutrition	Nutrition needed by fictive persons Fictive stories	Laboratory work concerning fats, carbon hydrates and proteins found in exercise books Homework; Textbooks	Drama; role play giving recommendations about nutrition
Water	Water inquiry Story about the pond and field work	Field work: water from the pond Laboratory work: temperature, acidity, smell, colour, conductivity, oxygen concentration, oxygen consumption, iron, nitrate, phosphate, aluminium and ammonium concentrations Homework; Textbooks Co-operation with the Vocational Institute	Written portfolio and short presentation; a common decision on the quality of the water in the pond and the plan to purify it
Friction	Traffic accident: who is to blame?	Numerical tasks Homework	Written work Role play simulating a courtroom Decision about the guilty party
Specific heat capacity	Text discussing everyday situations and supported by pictures	Numerical tasks Laboratory work concerning the heating of water and a piece of iron Homework; Textbooks	Written work Decisions related to everyday situations in the scenario

Table 2. Descriptions of the PROFILES modules which were used in the School

All the scenarios used at the school included open-ended problems without clear-cut solutions. For example, the ‘Water’ module included multiple plausible solutions in which the students had the opportunity to be involved and present arguments based on their pre-knowledge. In Mary’s opinion, the scenario for the ‘Water’ module was not good.

“The idea about the condition of the lake is good in our ‘Water’ module, but our scenario is too open; what is the condition of the lake? Is it possible to drink the water? Is it possible to swim in it? Perhaps we need for example, a story about people who live near the lake. Or is it possible to write a story about a scientist who wants to analyze the condition of the lake? We discussed it, but as yet we have not found any solution. We will still try to find a good scenario (...).”

Mary and the other physics and chemistry teachers discussed the problem and were willing to improve the scenario.

Each teacher had the possibility to construct her/his own scenario for the learning modules used in the school. One physics and chemistry teacher (Mary) said that she had used a newspaper in the module ‘Energy’. There was an article about a famous Finnish sportsman who was thinking about how to choose his energy system for his new house. He said in the newspaper that it was very hard to make a decision. Mary said that she wanted to change the scenario and modify it according to the students’ interests. The first attempt to construct an interesting scenario had been difficult, but the following ones would be easier.

“I used a newspaper article in the module ‘Energy’. But it was not interesting to the students. (...).”

In the Nutrition project, all of the physics and chemistry teachers used scenarios that included plausible stories about people who had nutrition problems and raised questions about healthy food. Karin considered that a good scenario was linked to the needs of students’ daily lives.

“(...) the idea of people who had many problems was interesting. It was so interesting to read the story about Reiska Truckman. How he eats and how much he eats (...).”

Teachers’ ideas about the inquiry stage

The teachers said that through conducting inquiry work and problem-solving tasks in the inquiry stage, the students constructed a common understanding about the content that they had studied. They produced questions and collected and analyzed data. Students also undertook individual work with textbooks; for example, solving numerical tasks and value judgments. Laboratory work and field work was also used in the inquiry stage. Mary said:

“For example, during the ‘Water’ project, the students undertake the fieldwork; the lake is located near the school.”

Karin indicated:

“During the ‘Nutrition’ project, our students solve numerical tasks and do their laboratory work, for example, a demonstration of starch.”

Especially in the inquiry stage, the physics and chemistry teachers used well-known inquiries and modified them into their instruction. It has to be noted that as the inquiry-method has been included in Finnish teacher training for a long time, it is a common method of teaching in Finnish schools. Mary said:

“(...) it was useful to find that there is a lot of good material suitable for the PROFILES modules. Although there have been good ideas before the PROFILES training, it is easy to see that the idea of the PROFILES three-stage model helps to make the tasks better and more student-orientated for the weaker students too. Also with the aid of PROFILES, it is possible to get a more complete picture of the topic.”

Teachers gave some tasks for homework. Mary and Amy said that at the beginning of the lesson, students had the possibility to discuss ideas and questions concerning their homework with the

teacher and other students. All of the physics and chemistry teachers highlighted the role of students' homework, saying that most of the students did their homework very well and were motivated. PROFILES modules are especially suitable for weaker students.

Amy spoke about the role of the inquiry phase:

"The inquiry stage included collaborative work in which the role of student-student interaction is central. Students construct their own understanding about topics and use social software tools for inquiry and collaboration."

According to all of the teachers interviewed, ICT provided tools for connecting students, teachers and educational administration. Teachers spoke about the possibilities of using iPads as well as Facebook. They had tried to use iPads during their field work in the module 'Water', but there had been some technical problems. Bill said:

"We had thought to use iPads during the field work, but it was not possible because the software connection to the iPad did not work outside the school area."

Teachers said that in general they used student-centered teaching approaches that developed problem-solving and decision-making skills. In PROFILES teaching, all teachers agreed there was an increase in students' achievement in the problem-solving and decision-making area.

Teachers' ideas about the decision-making stage

Physics and chemistry teachers stated that PROFILES training helped them to understand the role of the decision-making stage. Students put into practice new knowledge learnt in the previous stages and assessed multiple viewpoints regarding the subjects; they engaged in reasoning, argumentation, decision-making and position taking.

Teachers highlighted that they used drama in the decision-making stage to enhance and extend

speaking and listening skills, develop problem-solving skills, enhance students' applications of science to different situations, and provide guidance on active and participatory learning. Drama could combine elements of art, music and sport and develop students' creativity and fitness, as well as their emotional and aesthetic awareness. It attracted students who were more orientated towards languages and the arts because it stimulated their imagination and creativity. Additionally, it could help teachers to start applying small changes in their teaching as well as providing new ideas for teachers who have already started implementing similar activities in their classes. According to the teachers, creative drama promoted a positive classroom environment, improved social interactions and self-esteem. All students enjoyed creative drama and the way it was presented pedagogically, affected how it was received by the students.

Co-operation between teachers and society

Teachers described their school as already being innovative before the PROFILES project. For example, this year (2013) students participated in the competition, 'The Finnish Contest for Young Scientists' and they came third. Teachers highlighted the fact that the physics and chemistry PROFILES modules also included the main ideas of environmental education: skills and knowledge that were necessary for students to participate in society and think critically.

The teachers have formed peer-supporting groups to work together and exchange information; this was seen as an encouraging factor. Teachers shared a common philosophy, worked together, and developed materials for their classes. They highlighted that participation in the school's PROFILES projects had been entirely voluntary for each teacher and everyone was free to use a scenario of his/her own choice.

During their discussions, teachers recognized that the PROFILES modules were worthwhile and that they understood the purpose of studying according to them. Students were motivated by the modules but the teachers considered them to be time

consuming. The PROFILES approach helped the teacher to discover a way out of traditional teacher-centered classrooms that comprised of lectures, demonstrations, a few experiments, paper- and pencil assignments, and tests. Teachers highlighted that the major goal of science education was scientific literacy that leads to scientific knowledge and the acquisition of higher-level thinking and problem-solving skills.

The school was active in making contact with sectors of society. Classes visited factories, companies, Vocational institutes and also met policy makers. The teachers invited a journalist from the local newspaper to visit the school during the day of interviews. They wanted to present their work to stakeholders and point out that they based their teaching on learning theories; also to highlight that their instruction was always thoroughly planned, taking into account locality, inquiries and education for citizenship. By taking stakeholders and policy makers into account, they would be assured of resources for science education; small groups, equipment, field trips and visits.

Evaluation and assessment

The physics and chemistry teachers highlighted the role of evaluation and assessment in the PROFILES modules. For example, Amy and Karin said that students' presentations and home assignments were assessed. A successful scenario enabled science teaching to be less fact-oriented and the PROFILES modules included many evaluation assessment tools. Amy stated:

“Effective learning occurs when students construct their understanding through active learning and by building on their prior knowledge.”

In addition to the students' scientific skills, the teachers also assessed affective skills such as cooperative work, empathy, communication, listening and reasoning.

Continuous professional development

Mary said that after the PROFILES training programme, she understood the role of reflection. After her lessons she made notes about the things that were good and not so good, as well as how to change the modules. Karin also highlighted the role of reflection. The teachers had many opportunities to reflect on their practices, discuss with other teachers the value and methodology of using the teaching modules, as well as how students' assessment could be undertaken. For example, Amy said:

“Compared with instruction before PROFILES, nowadays we have few science lessons using the pencil-and-paper method in which students are required to read a selected text and answer questions on it.”

“We no longer study small details, instead we use larger entities.”

Discussion and conclusions

Two physics and chemistry teachers who participated in the PROFILES training programme, modified some PARSEL modules and developed new ones with their peers. All of the interviewed teachers felt a high degree of ownership towards PROFILES (see e.g. Blonder et al., 2008; Ketelaar et al., 2012; Ogborn, 2002). All of the interviewed teachers highlighted the 3-stage model that included teaching and learning by inquiry and included a lot of laboratory and field work. In the decision-making stage, they had used drama. All this helped them to contribute to students' intrinsic motivation and to achieve the learning outcomes specified by the curriculum. These results are in accordance with the results of the study of Valdman et al. (2012).

The physics and chemistry teachers produced high quality PROFILES modules. For example, the 'Water' module included open inquiry. Students did a lot of laboratory work, analyzed the condition of the water by co-operating with the Vocational school through using their equipment. Next year, teachers

have planned to write to the local newspaper about the lake and its condition. This aim is associated with pointing out participation in society, one of the main aims of sustainable development and environmental education. Teachers also considered it important to be in co-operation with policy makers, as well as researchers.

Teachers' ownership was important; it directed them to follow developments and motivated working as a team (see e.g. Fraser, 2011; Kennedy, 2011). The physics and chemistry teachers were eager to involve other teachers in the school's PROFILES projects. For example, next year the home economics teacher said she would also join in. Through collaboration, the teachers continued to develop other school practices, for example special theme days and competitions. They applied to the Regional Council for funding for the theme days and succeeded in getting it; the Finnish PROFILES project supported their application.

The physics and chemistry teachers mentioned that in ICT, for example, Facebook could be used to facilitate partnership and enable the collaboration of students, teachers and local communities on concrete, sustainable, development tasks and issues. With the aid of different drama exercises and discussions in the decision-making phase, it was possible to give a model on how to participate and act responsibly in real society.

It was highlighted that the teacher is a guide and promoter of students' knowledge building, also that PROFILES raised the popularity and relevance of science teaching by enhancing students' scientific and technological literacy, and by identifying suitable teaching and learning materials based on relevant context-based educational approaches.

Referring to Pintó, Couso and Gutierrez (2004), our *“teacher training proposal aimed to help teachers reflect on the transformations that they unavoidably underwent when putting an innovation into practice, according to their own knowledge, beliefs, and context of the work. Through analysis of their own activity, teachers reflected on their transformations from teaching facts, to teaching the skills and knowledge needed in future life and the implications of these for students' learning. This was an important first step for*

teachers, to help them recognize their transformative role in the innovation process; this could aid them in the future to address innovations in a more critical and detailed way.” Professional development was the development of habits of learning that were far more likely to be powerful if they presented themselves day after day (Fullan, 2001). Teachers were willing to discuss innovations, to reflect on their practice and discourse, to interact with others and to learn in this process. They were able to change their practice and to adopt innovations with a greater sense of control and ownership after having the opportunity to experience the success of the PROFILES approach.

Educational innovation in schools, such as PROFILES, was time consuming. Inquiry-based learning also needed resources, for example both equipment and teacher resources. In spite of these challenges, the teaching profession deserved respect and teachers' interactions with students were highly appreciated. In the teachers' opinion, the PROFILES modules were especially useful with low-achieving students.

The school building and environment in question provided a place for good learning and teaching activities. The school served not only the students and teachers but also the social, cultural and ecological need of the parents and local community. Not only these two of the school's physics and chemistry teachers, but also the other three, could be considered as learners, teachers, reflective practitioners as well as leaders.

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3.2 Outcomes from Implementing a PROFILES Continuous Professional Development Programme in Portugal: Reflections and Indicators

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Abstract

One of the mainstays of the PROFILES project is the implementation of a Continuous Professional Development (CPD) programme supporting science teachers to implement PROFILES ideas in the classroom using PROFILES designed teaching-learning modules promoting inquiry-based science education and a recognition of the need for education of students through the teaching of science. In the 2nd version of the CPD programme, teachers are engaged in the creation or modification of modules related to the PROFILES 3-stage format. To guide this, an additional small group of teachers, successful in the 1st CPD programme, acted as leading teachers to help guide the module developments based on their prior experiences. These ‘lead’ teachers were able to clarify a range of doubts held by the teachers in their initial developments, adding to the success of the 2nd round CPD. Following the CPD, a SWOT analysis was undertaken with the teachers and teacher comments solicited related to their CPD discussions and classroom experiences. The SWOT outcomes are given and their implications.

Introduction

PROFILES promotes, as one can understand by its acronym, approaches based on Inquiry-based Science Education (the IL in its acronym). According to Branch and Oberg (2004), “*inquiry-based learning is a process whereby students are involved in their learning, formulate questions, investigate widely and then build new understanding, meanings and knowledge.*” The emphasis on the learning acquired by students can involve students in answering questions, develop a solution to a given problem based on evidence, or support a socio-scientific argument which takes the IL into ES (education through science) learning. IBSE thus promotes learning through the use of creativity and scientific problem-solving and can lead to stimulating social-scientific decision-making, when the science acquired is applied to a societal setting. This is one of the strategies that guide the teaching and learning, as promoted by PROFILES.

In PROFILES, teachers were involved in three major pedagogical areas: the CPD based on a teacher needs analysis; intervention using modules in the classroom setting, and determining student gains in terms of increased motivation. This article concentrates on the CPD and the modules developed.

Continuous Professional Development (CPD)

To better appreciate the goals of PROFILES and to further the professionalism of teachers, PROFILES provides the opportunity for teachers to participate in a needs-driven continuous professional development programme. The intended outcome is not only a more motivated teacher teaching more motivated students, but teachers recognising that as a major goal of education is improving the educational future of each student, this must apply to the teaching of science subjects. Based on this intention, and the continuous guidance for teachers during the CPD workshops and the intervention by the teachers in their classroom, a major goal was to promote self-efficacy in teachers related to the PROFILES ideas and approach. This is based on two main principles associated with the development of self-efficacy:

1. Stimulate and promote teachers’ skills to reflect on ways to promote science teaching in order to increase the scientific literacy of students (Holbrook & Rannikmäe, 2007).
2. Enthuse teachers with a sense of mission, so that they will be able to initiate students’ intrinsic motivation as well as undertake motivational teaching, despite restrictions inherent to the teaching-learning process (Laugsksch, 2000).

Description of the CPD in Porto

A major goal of the PROFILES project was the implementation of a carefully developed CPD for science teachers (Bolte et al., 2012). The CPD ran in Porto was divided into six classroom sessions, complemented with additional blended learning, thus combining face-to-face instruction with computer mediated instruction. In the face to face sessions, teachers were involved in activities such as synchronous discussion sessions, especially designed for the promotion of social interaction, as well as asynchronous discussion sessions. Both types of sessions showed good results when topic-related postings were used (Im & Lee, 2003). The main focus was two-fold: promoting relevant and meaningful IBSE teaching and on strengthening the teaching of science while incorporating a historical perspective. Face-to-face presentations by teachers were included and these provided ample opportunities for reflection on teachers' experiences regarding the adaptation, development

and implementation of PROFILES modules in the classroom setting. Teaching activities related to effective student-centred, classroom learning within an IBSE frame, initiated in a context-based environment, were promoted and the PROFILES philosophy and approach were amplified and discussed. Table 1 illustrates the developments intended in each session of the 2nd CPD.

Evidence for teachers' change during the CPD

PROFILES' goals are not solely limited to teacher professional development from a set programme of lectures and workshops. The CPD by PROFILES-Porto also strives to:

- (a) establish a conscious dialogue and interaction between teachers;
- (b) develop teacher networks;
- (c) broaden teacher approaches, reactions and reflections about different methodological strategies.

Session	Coverage
1	Teachers gained an initial introduction to the PROFILES project and by means of groupwork enhanced their learning about the concept of IBSE and associated teaching methodologies (Branch & Oberg, 2004). The teachers also completed a PROFILES designed, "teacher needs" questionnaire intended to drive the future CPD inputs and reflected on PARSEL type modules.
2	Based on comments made in the questionnaire, an action research focus was adopted to explore areas of concern and how they could be addressed so as to promote self-efficacy in the teachers, Major discussion were held on the ideas associated with motivation, particularly with respect to student intrinsic motivation, the PROFILES 3-stage model, based on the need for relevant of science learning using a context-based approach and the interpretation of the ES in PROFILES leading to inclusion of socio-scientific decision-making in science teaching. A list of several digital and educational resources was made available to teachers which helped to focus future module developments on just one application (Burke, Greenbowe & Windschitl, 1998).
3-5	The teachers were engaged in the construction of new modules (some available online on " http://www.profiles.org.pt/?page_id=70 "). In this 2 nd CPD version a range of very interesting new modules were developed, with different methodology/practices aided by a focus on the knowledge/experience shared by the "lead" teachers. These modules were tried out in the classroom setting and future discussion workshops were held related to presentations by the teachers and the sharing of each other's experiences and the range of constraints met.

Table 1. Developments intended in each session of the 2nd CPD

These goals were ever present in all parts of CPD, especially in the last session, in the overall evaluation of the CPD and in the launching of new proposals. Initially, in striving to establish these goals, a dialogue and interaction was established among teachers which then extended to teacher networks at the local, regional and even national levels. But, in the long run, European networks are envisaged so that teachers of different nationalities can share, propagate and upgrade their opinions and perceptions about science teaching.

In the CPD programme, evidence of teacher change came from teacher acceptance and reflection through:

- Face-to-face sessions in large groups in order to develop knowledge, skills and to broaden their teaching approaches, so that they were able to create better learning opportunities for students.
- Teacher's ability to enhance the conditions to learn in a community of practice.
- Interest and willingness of teachers to serve in leadership roles (for some of them).
- Evaluative activities indicating teacher engagement, interest and satisfaction.

We are confident that the activities in the CPD initiated meaningful developments towards a sense of ownership in the teachers regarding philosophical and teacher approach ideas. This is supported by insights that indicate the beginnings of developments towards a sense of PROFILES ownership, namely:

- (a) The teachers being able to decide and justify the changes and amendments to the original modules, bearing in mind the curricula and social Portuguese context and thus strive to enrich these modules with digital resources – simulations, videos, animations, games and web-quests – along with pedagogic dynamics for using web 2.0 tools.
- (b) Teachers proudly telling their colleagues and students that they are actively participating in the PROFILES project, developing new teaching-learning modules.
- (c) Teachers willingly disseminating the project

and their modules to other teachers.

- (d) Teachers making a self-determined effort to bring materials from home, and/or from school, in order to undertake “hands-on” experiments to incorporate in the IBSE section of modules.
- (e) The teachers' developing a meaningful perception that the approach to the topic or issue taught is relevant for his/her classroom.
- (f) The willingness and ability of teachers to put forward evidence of classroom success and to share this with other teachers.

The approach to creating modules

In the second version of the CPD, Portuguese teachers were engaged in the rearranging or creation of new modules. Three key goals for the adaptation/development of PROFILES modules were put forward as:

1. relevance of the topic taught (in the eyes of students);
2. student active involvement (not only in undertaking experimental activities but in the thinking processes involved at the various stages in the 3-stage model, and
3. enhancement of scientific literacy in terms of scientific problem-solving, socio-scientific decision-making and higher order reasoning skill (Holbrook, 2012).

During the 2nd CPD cycle, teachers made several presentations of their module development at intermediate stages. These reflective sessions, about the evolution of the modules and how the 3-stage model was meaningful incorporated, were very useful. The interactions provided new ideas from the larger group, which, in some cases, even granted solutions to specific constraints. There was real interaction and reflection between colleagues, trying to reach solutions to questions raised and this entailed several decision-making procedures in the development of the module (some in the intermediate steps, others in the final stages of developing the modules). The interactive sessions continued after interventions in the classroom using the modules were carried out.

Teachers found the working on the application of

new modules really thrilling and were very proud to be able to produce new educational materials incorporating inquiry-based science education in a meaningful way within the PROFILES modules, and that this was possible for students of different grade levels.

It is noteworthy that all titles are developed as questions. This is in line with the PROFILES philosophy in which the context-based teaching derives from a familiar issue or concern.

The first module is an obvious area of interest for students as Porto is a major home of the development of wine and even more so the world famous Port wine. While the wine trade provides the setting, the science learning (via the IBSE aspect) enabled students to conceptualise the production and value of alcohol, not only as a drink but also as an important solvent and starting point for the development of other valuable chemicals. The issue on distinguish green or mature wine is intended to initiate a discussion on when the grape is ready for harvest and how the alcohol content, pH etc. can be identified. And because this is Porto, the value of picking the grape at the appropriate time must be a further serious consideration.

All students are familiar with Popeye – the sailor man. But trying to be as strong as Popeye underwater is an intriguing and thus motivational approach to the teaching of buoyancy.

Starting science teaching from a familiar and enjoyable setting for students in an excellent context-based approach and what better that to

make use of disco settings. But the enjoyment comes with some risks and this module provides the opportunity to recognise these and determine whether the risk is high or low based on their science learning. The module thus allows students to explore the electromagnetic spectrum, how different wavelengths of visible light interact and the meaning of primary and secondary colours.

The last module is drawing students attention to the simple fact that all matter is made of chemicals, whether it is edible, used to create technological wonders or provide danger to the general public if allowed to go uncontrolled. By concentrating on the food aspect the module interrelate chemistry with biological learning and can focus on the learning about proteins, carbohydrates and fats in a motivational manner.

SWOT analysis

A SWOT analysis was the major focus for this case study. The SWOT analysis technique was created by the *Harvard Business School* during the 1960s and was originally used in industrial assessment. However, nowadays, we have recognized several different applications in a range of distinguished areas. Maiteny & Ison (2000) considered SWOT to be a useful evaluation instrument, especially in cases with content that promoted interdisciplinary fields. They also suggested that: *“the overall SWOT analysis could be an initial attempt to explore the relevance of courses to students’ everyday personal, social and working lives. A SWOT analysis could also aim to identify ‘stakeholder’ views about how to respond to*

Modules' title	Portuguese grade level	Students' ages (average)/years
<i>“Green or mature wine? Should distinguishing them have any extra value?”</i>	11 th	17
<i>“Should I be as strong as ‘Popeye’ underwater?”</i>	9 th	15
<i>“The changing colors of clothes at the disco – should this be permitted?”</i>	8 th	14
<i>“Should it be necessary for chemistry to be part of your breakfast?”</i>	7 th	13

Table 2. Modules created in the 2nd version of the PROFILES CPD and its correspondence to school grade and students age

changing needs, markets, and new communication technologies.” Another great advantage was in applications on ‘systems movements,’ where SWOT analysis was employed in different areas: environment; development and the ‘holistic movement’.

The SWOT acronym means the union of the following four key-characters:

- **Strengths** – strong points coming from this formative experience.
- **Weaknesses** – weak points coming from this formative experience.
- **Opportunities** – external elements of the course itself. They can be sustained by the final result of this course (for example, student motivation, curiosity, responsiveness to STS approach and other previous courses).
- **Threats** – external elements of the training itself. They may have contributed to jeopardize the success / the increase use of formative experience (for example, lack of time, lack of students’ interest, difficulties in translation) (Maiteny & Ison, 2000).

A SWOT analysis was carried out by soliciting comments from the teachers involved in the CPD programme and provided interesting evidence and information about the implementation, developing and application of the modules. The feedback received was used to interpret the effectiveness of the CPD and to give indications about the teachers’ current level of self-efficacy related to PROFILES.

Information about the classroom implementation of the modules

Bearing in mind that our CPD aimed to focus on the central ideas of the PROFILES project, the intention was to guide teachers to make the teaching of school science more meaningful in specific cultural contexts, via IBSE, while promoting self-efficiency among teachers and a sense of teacher ownership. These components given in Table 2, were derived from through teachers’ insights, particularly in the strengths and opportunities’ columns. For an explicit understanding of the analysis of the Portuguese programme, each key element was carefully explained, as indicated in Table 2. This covered (a) meaningfulness in a specific cultural context, (b) involvement of IBSE, (c) promoting self-efficacy and (d) initiating steps towards teacher ownership.

Strengths	Weaknesses
<ul style="list-style-type: none"> • After explaining to students they were integrated into a European project (project PROFILES), they became immediately motivated because they felt that PROFILES was something very important. 	<ul style="list-style-type: none"> • To apply this teaching methodology with greater frequency and, at the same time, meet the syllabus, would take more time than academic classes available in a normal curricular structure. We conclude that, unlike the syllabus, PROFILES assumes that the curriculum includes education through science learning.

Strengths	Weaknesses
<ul style="list-style-type: none"> • The successful student learning is mainly related to the degree of student involvement in the construction of knowledge. This approach allows the development of different skills, such as identifying problems, devising strategies, selecting and organizing information, structuring knowledge, developing the ability of reasoning and critical thinking, all of them attained through guided questions. • With the application of a module, lessons were more interactive for the students during the learning process. The use of PROFILES modules also increased the students' interest in science and facilitated the development of multiple skills. After a short period of time, students could already evaluate what might happen with other materials / similar experiments. • Through the experiments students easily reached the same conclusions and the same consolidation of the underlying content. It is noteworthy that, in general, all students wanted to perform experiments to confirm the results for themselves. • It stimulated dialogue, teamwork, cooperation and shared responsibility, allowing for creative interaction between the teacher, students and technology/society. The effective involvement of the students implied an active method, making them the "key players" in the discovery of knowledge, both in real experiments and in computer simulations. 	<ul style="list-style-type: none"> • The adaptation of the planning module to the current period of regular school arrangements where the action occurred. • Tough time management, conciliating moments working together. • Difficulties, given the range of the topic, focusing only on the main topic (keywords) in question. • Initially, it was somewhat difficult to know what kind of activities should be applied to answer the initial motivating question. Then we started to plan the first activities and others came out through a snowball effect, but sometimes with no guiding order. • Some students, who were less interested in the subject and in school in general, were not actively involved in the learning process. As PROFILES indicated, experimentation by itself was not necessarily motivational, but the teacher could bring other valid ideas from the CPD and group discussions.

Opportunities	Threats
<ul style="list-style-type: none"> • Schedule group work within lessons. • Improve student intrinsic motivation. • The current society is strongly influenced by scientific and technological development. Thus, citizens must have an education in several areas, being able to demonstrate agility, communication skills and lifelong learning. In this sense, this new methodology contributes to the formation of active students who are motivated in the study of sciences, who are directly involved in the teaching / learning process, obtaining responses to the issues of everyday life. • It boosts the formation of critical and responsible students who will be more able to participate actively in the life of society, watching the scientific and technological development. • Most students were motivated, especially in carrying out various tasks, for example, a task involving a color blindness test, which involved clinical diagnosis. • The preparation of a poster, even though being a difficult task, was achieved with the help of students and teachers. The final poster encompassed information which is important to convey to the school community and society. 	<ul style="list-style-type: none"> • Despite the great advantages of group work, we found that students at this age are not yet adequately prepared for a real team effort (presumably due to a lack of development in this direction in earlier schooling). Moreover, they had great difficulty in articulating themselves outside school hours and conducting the research work asked of them. • The classes are highly heterogeneous, comprising very interested students, with a strong curiosity and desire to learn, but also a considerable range of completely uninterested students, to whom the school gives nothing! • The initial familiar, socio-scientific approach needed to focus more on combatting initial inertia. • The preparation for other classes withdrew space / mental readiness for commitment in the training action, which generally meant taking much more time to teach the same unit • Finding appropriate materials to carry out activities, theoretically planned in advance. • The preparation of a poster proved to be a difficult task for these students, needing the help of the teacher as students showed little autonomy.

Table 3. SWOT analysis of PROFILES implementation based on teacher quotes, some involving their students

Conclusion

The SWOT analysis revealed that

1. There is much potential to raise student motivation through relevant context-based approaches and paying more attention to IBSE and education through science learning. Students wanting to participate and learn are important keys.
2. Such context-based approaches are socio-scientific and thus relate to both scientific aspects and to the social factors with which the science interacts within society. Nevertheless they are only useful if seen to be relevant and motivation for students. Unfortunately, the science without the society link makes the science heavily academic and perceived to be irrelevant, or it is fun but with very little learning.
3. In using a context-based approach, student involvement is increased, although, of course, this requires more teaching time.
4. In adopting a more student-centred approach, a number of constraints need to be tackled, such as handling of teaching time, guiding students to become more self-determined, self-directed and self-evaluative (and student helping student through meaningful teamwork)
5. PROFILES teaching requires a re-evaluation of what exactly is the curriculum intentions, especially in relation to cross-curriculum aspect such as collaborative team work, promotion of creative thinking, positive attitudes towards the learning and encouraging student reflection on their learning to enhance the acquisition of conceptual science (the last point being a particular cause for concern in many classrooms).

Further teacher comments

As evidence of teacher development we provide important testimonials that substantiate the previous indicators and give us interesting proposals to the future (some of these reflections were discussed in the CPD workgroup sessions, solving most problems are mentioned earlier):

- i. *“Learn to give new perspectives and new appearances to curricula materials, in order to try to raise curiosity. It was suggested as an appropriate didactic approach. It was concluded that a context, when poorly addressed, even if it initially could promote students’ interest through relating to daily experiences, can be an annoying topic.”*
- ii. *“The quality and effectiveness of teaching and the whole educational process is dependent on the involvement of teachers and on the skills that they try to develop in students as they strive for real consolidation of learning.”*
- iii. *“After the initial presentation of the problem, followed by a discussion, the purpose of the next step is to introduce possible ways to solve the problem and simultaneously introduce new challenges. To clarify the initial research in students’ work we need to promote a research-oriented method (Webquest).”*
- iv. *“We think that the method according to which students are guided, through planning and conducting experiments, reading graphs, undertaking mathematical calculations, viewing videos and simulations to answer the initial question is very positive, because it instils in students a love of science and an stimulus for discovery in problem-solving.”*
- v. *“The importance of ownership of ideas and approaches in these modules, in the application of science education, promotes changes in the practice of science education.”*
- vi. *“We propose that a group for science teachers should be created on Facebook for greater dissemination. We also think that it is possible to achieve teams of two or three teachers from different subjects. These groups may develop materials that could be tried out by colleagues from the same vocational area group. We should also exchange ideas with other colleagues in other scientific areas and use Google Drive to create new collaborative documents with further sharing.”*

Further considerations

The ultimate target for the teachers is that they can achieve teacher ownership of PROFILES. Teacher ownership may be understood as the teachers' acceptance, participation and active exploration of ways to provide evidence and promote the PROFILES philosophy, such as through the adaptation and development of teaching-learning materials, as well as the application of diverse pedagogical dynamics, e.g. education through science (Holbrook & Rannikmäe, 2007) and stimulating an active students' role (EC, 2007). However, teacher ownership surpasses simple implementation of existing materials. Teachers with teacher ownership put their personal touch to the production of materials, like his/her own motivational experiences and different methodological strategies, according to the specific students' grade level and the teachers' meaningful conceptualisation of the PROFILES philosophy and approach (Hofstein & Even, 2001; Borko, 2004; Holbrook & Rannikmäe, 2010). This is certainly one of the assumptions of the SWOT analysis and one of the major conclusions of the case study.

Noting the strengths indicated in this article, future plans are to provide and disseminate this important information: qualitative analysis of the feedback given by teachers from both editions of CPD; positive testimonials from the teachers' evaluation, identification of the main advantages of this approach; the disadvantages found, alongside with the submission of proposals of several improvements for future editions (Morais, Paiva & Barros, 2012).

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3.3 A PROFILES Model of Science Teachers' Professional Development, a Slovenian Perspective of Implementation of Action Research

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Abstract

Teachers' continuous professional development (CPD) is an important aspect of an effective science education. In this chapter the Slovenian perspective of the PROFILES (Professional Reflected Oriented Focus on Inquiry-based Learning and Education through Science) as a model of teachers' professional development in the context of the action research is presented. Detailed description of CPD PROFILES programme implemented in two rounds (school year 2011/12 and 12/13) is presented.

Introduction

Teachers' professional development is a lifelong process in which teachers constantly acquire new knowledge, develop new skills and competences and they move towards a better quality of teaching performance and other professional work in the school. This process includes teachers' individual, professional and social dimension, and it also means teachers' progressing towards the direction of critical, independent, responsible decision-making and acting (Vogrinc & Valenčič Zuljan, 2009). "Teacher development is the professional growth a teacher achieves as a result of gaining increased experience and examining his or her teaching systematically" (Glatthorn, 1995, p. 41). Effective teachers' professional programme needs to provide an opportunity for teacher reflection and learning about how new practices can be evolved or moulded from existing classroom practice. Teachers need to familiarise themselves with new ideas and also understand the implications for themselves as teachers and for their learners in the classroom before they adopt and adapt them (Harrison, Hofstein, Eylon & Simon, 2008).

Teachers' professional development is a complex process; its success is the responsibility of all institutions related to the education of education practitioners: faculties which educate future education practitioners, education institutions where education practitioners are employed, and suitable national institutions that take care of the education system. However, a key element of teacher's professional development is his/her willingness for in-depth learning and knowledge

of scientific achievements pertinent to his/her professional work, coupled with critical evaluation and considerate integration of new findings into pedagogical work.

Professional development includes formal experiences (such as attending workshops and professional courses) and informal experiences (such as reading professional publications, watching television documentaries related to an academic discipline, etc.). This perspective is, in a way, new to teaching. For years the only form of professional development was in-service training, usually consisting of workshops or short-term courses that would offer teachers new information on a particular aspect of their work. Only in the last decades has the professional development of teachers been considered a long-term process; a continuous professional development (CPD) that includes regular opportunities and experiences planned systematically to promote growth and development in the profession (Villegas-Reimers, 2003). Effective CPD programmes have some important features: they engage teachers in collaborative long-term inquiries into teaching practice and student learning; these inquiries are situating into problem-based contexts that place content as central and integrated with pedagogical issues; they enable teachers to see such issues as embedded in real classroom contexts through reflections and discussions of each others' teaching and/or examination of students' work; focusing on the specific content or curriculum teachers will be implementing such that teachers are given time to work out what and how they need to adapt what they already do (Harrison, Hofstein, Eylon &

Simon, 2008). It is important to emphasize that the PROFILES project undertakes a so-called “bottom-up” approach in the CPD programme that can be identified as a project-based model of teachers' long term in-service professional development (Blonder, Mamlok-Naaman & Hofstein, 2008; Hofstein, Mamlok-Naaman, Rauch & Namsone, 2012).

The PROFILES CPD programme in Slovenia

The PROFILES project contributes a great amount of time to teachers' professional development in the perspective of the long-term education (WP 4, 5 and 6). This means that teachers should participate in their in-service education for at least one school year where they are engaged in collaborative development of learning materials (PROFILES learning modules) with other teachers and members of the national PROFILES team (consultants). The consultants advise teachers in developing the innovative teaching approaches according to the PROFILES philosophy following the bottom-up approach. In each group of teachers in the second round of the project one of the leading teacher is also included, who already went through the PROFILES training in the first round. Teachers are grouped according to their professional science orientation. All groups of teachers have to develop or adapt three PROFILES modules which have specific 3-stage PROFILES structure. The Slovenian project team has also upgraded the learning modules for students' independent group work (teachers only guide students in the process of collaborative learning) by following the principals of active learning. This approach was applied in the first round of the PROFILES professional development, but in the second round some teachers have the opportunity to choose and adapt one PARSEL module, one PROFILES module from the first round and they also have to develop one new PROFILES module by themselves (all modules developed in Slovenia can be accessed on-line <http://www2.pef.uni-lj.si/kemija/profiles/moduli.html>). Developed modules were then implemented in the school and some specific variables regarding students' achievements were measured. Teachers also prepared portfolios where they documented their engagement in the

PROFILES project. All teachers' activities in the PROFILES project were conducted in the frame of the action research, which represents one of the important factors in teachers' professional development, in particular when it is designed as a collaborative process involving teachers and researchers. Specific teachers' training and implementation of the modules were considered as a cycles in the action research model. Stages of this model are presented in Figure 1.

We assume that the effectiveness of teaching in schools would be substantially improved if teaching were a research-based profession and if educational practitioners were to play a central role in carrying out educational research. Teachers' involvement in research should also stimulate ownership of the innovation (PROFILES teaching strategies) because researching his/her own practice can directly influence his/her further work due to direct evidence of students' achievements, which are the fundamental goal of teaching.

Practitioner and action research

The idea of teachers conducting research on educational practice came from the work of the 1973–1976 Ford Teaching Project in the United Kingdom, under the direction of John Elliott and Clem Adelman. This project involved teachers in collaborative action research into their own practices. Its notion of the “self-monitoring teacher” was based on Lawrence Stenhouse's (1975) views of the teacher as a researcher and as an “extended professional”. Stenhouse's view of educational research implies doing research as an integral part of the role of the teacher, just as a teacher who uses research into their subject as a basis for teaching implies that s(he) does research into the subject through their teaching. Stenhouse has actually introduced teacher/practitioner research as a concept for the professional development of teachers. According to Schön (1991), practitioners should: (1) participate in research of their own practice and (2) develop educational theories that directly reflect actual educational practice. Action research, as presented below, provides an appropriate means for realizing these objectives.

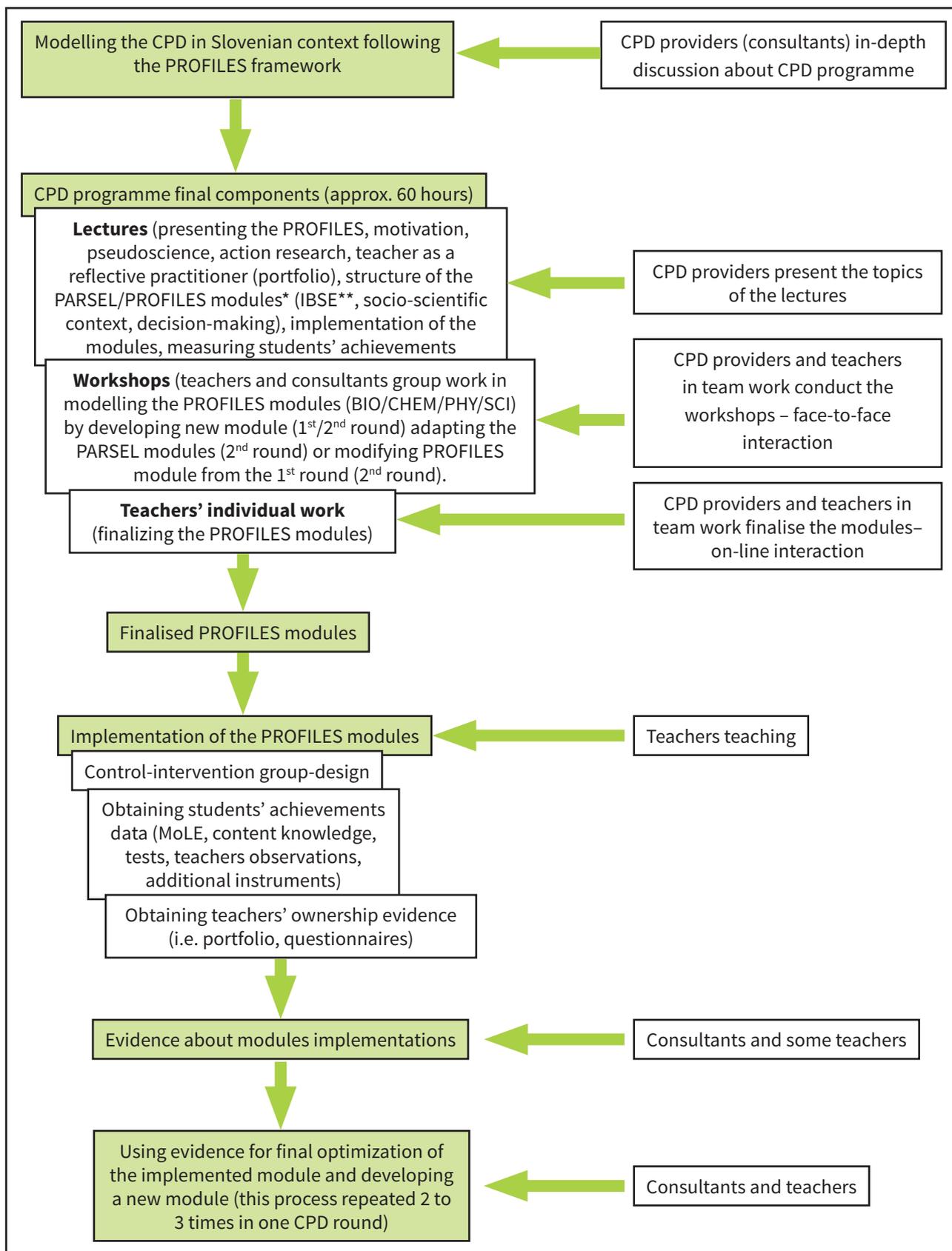


Figure 1. Structure of the CPD PROFILES programme in Slovenia; * PARSEL module »No smoke without a fire – (Un)Desirable combustion« and PROFILES module »How to prevent car accidents in winter?« developed in Slovenia were used for presenting the structure of the modules to the teachers; **IBSE – Inquiry-based Science Education

There is ample evidence that practitioner research can be a powerful factor in the lives of the teacher-researchers: teacher researcher report learning more about their students, about their schools, and about themselves; they use this knowledge to change their practice, to feel more professional, to engage “authentically” with the profession of teaching in a new way (for more on this see Berger, Boles & Troen, 2005). As Wilson (2000, p. 303) explains of his own teacher research efforts,

“The question is not so much ‘How can I teach better?’ but rather ‘How can I organise my thinking about what is happening in my classroom to enable me to gain a deeper insight into the learning process and to maximise the effectiveness of the learning experiences I prepare for and share with my students?’”

This is why in the project PROFILES attention has been shifted from questions about implementing innovations proposed from outside to questions about implementing changes in collaboration with teachers.

As basically illustrated on Figure 1 PROFILES teachers and consultants (members of the national PROFILES group from university) work in team to develop an innovating teaching approach following the PROFILES framework. CPD PROFILES programme comprises three major activities: (1) lectures where members of the national PROFILES group present the basic aspects of the PROFILES, (2) developing PROFILES teaching modules in group work (workshops) and (3) implementing PROFILES modules into the science teaching.

Teachers had to design and implement four precisely structured documents (Front page, Instructions for students, Instructions for teachers comprising additional teaching information and assessment tools (i.e. pre- and post-content knowledge test; classroom activities observation rubric). The design of each PROFILES module had to undergo several steps. Firstly, an initial draft had to be created in cooperation between the teachers and the consultants. Each step in the PROFILES module construction by the group of teachers was revised by the consultant. In the second round of

CPD programme each group of teachers also had one leading teacher – teacher who participated in the first round of the PROFILES CPD programme and also implemented the PROFILES modules in the first year of the project. The leading teacher instructed the novice teachers (those who were involved in the PROFILES CPD for the first time) and helped them in modules design and implementation in the classroom environment. The consultants revised all PROFILES modules giving the teachers adequate feedback where necessary, focusing on both the content and the teaching methods included in the module. Specific focus was made on the 3-stage PROFILES model (socio-scientific context, IBSE, and decision-making). In the process of module optimization, each teacher in the group had an opportunity to take part in a common discussion. After the optimization process teachers went to their schools and try to implement the developed modules. Teachers came to the CPD meetings reflecting their observations and views about implementation of the modules in the classroom settings. They also suggested to other teachers what was good and what went wrong according to their opinion during the module first implementation in the science class.

The phase of implementation of the PROFILES modules and gathering the data about students' achievements and teachers' observations about students using the modules can be understood as some form of practitioner research specifically focused on action research (Vogrinc & Valenčič Zuljan, 2009; Burmeister & Eilks, 2013) that was used in Slovenian context when planning PROFILES CPD.

Action research in Slovenian PROFILES context

Slovenian PROFILES team decided to engage teachers into the action research during their CPD PROFILES programme. According to the action research characteristics described above, we decided that Slovenian science teachers would benefit most from profiles CPD programme if they are actively engaged into their education. Figure 3 shows the model of Slovenian action research in

the context of CPD programme and followed by the teachers and consultants. Each group of teachers followed the model according to their abilities to perform research. It is important to emphasise that the majority of PROFILES teachers in both rounds were not familiar with action research, so they had to get used to teaching, researching and following their and students' work. It is also important to emphasise that Slovenian science teachers are quite familiar with IBSE and using context in science

education for initial boost of interest, and this helped them to design the modules easier. They had some problems with the last level of the 3-stage PROFILES module, because they usually do not use decision-making very often in science education, especially because they are usually focused on content knowledge and not so much on the wider educational component of the school science (i.e. education through science as an important aspect of PROFILES).

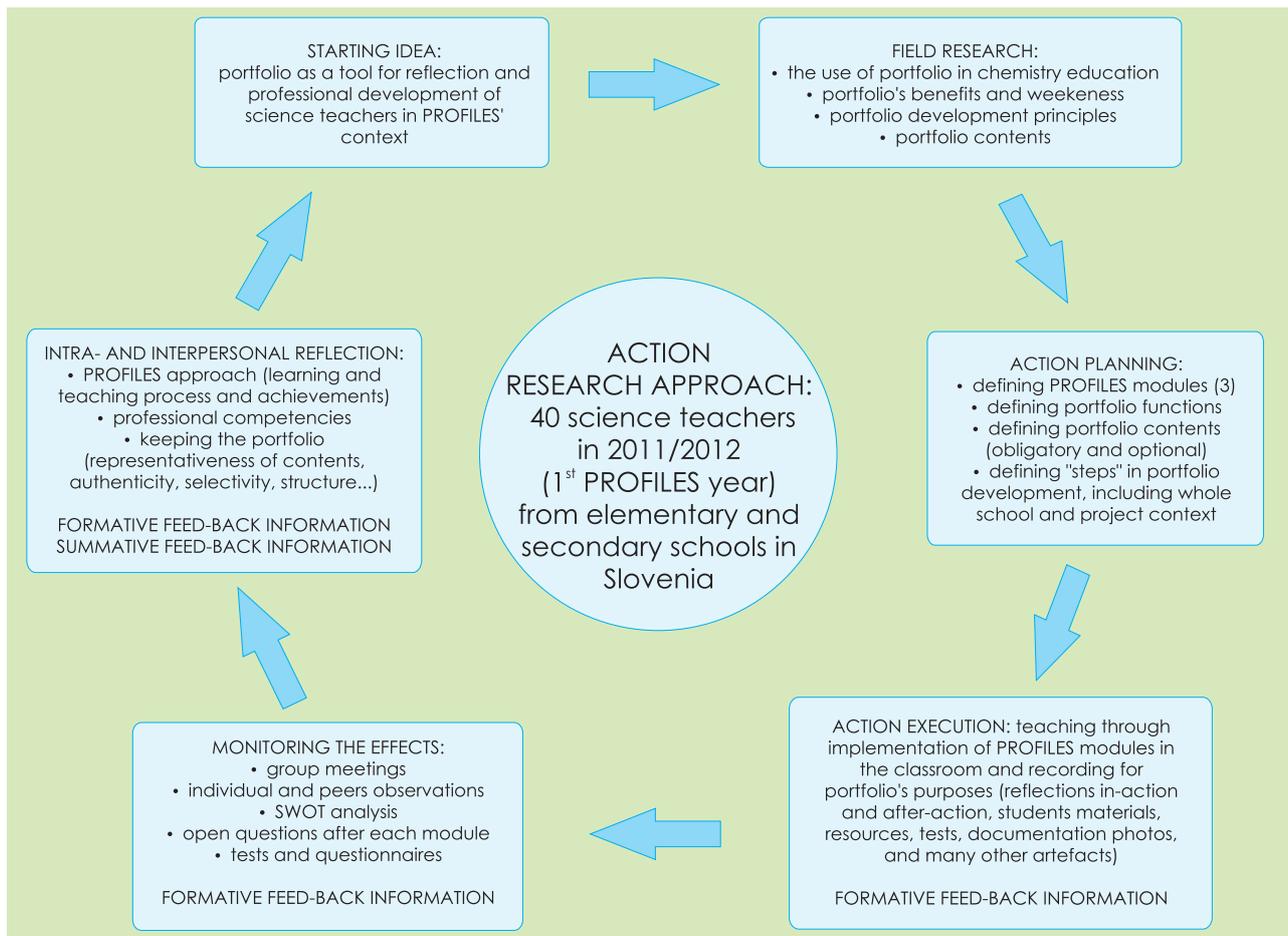


Figure 2. A model of CPD programme implemented in the PROFILES framework in Slovenia in the first and second round of the project (Juriševič, Devetak & Vogrinc, 2012).

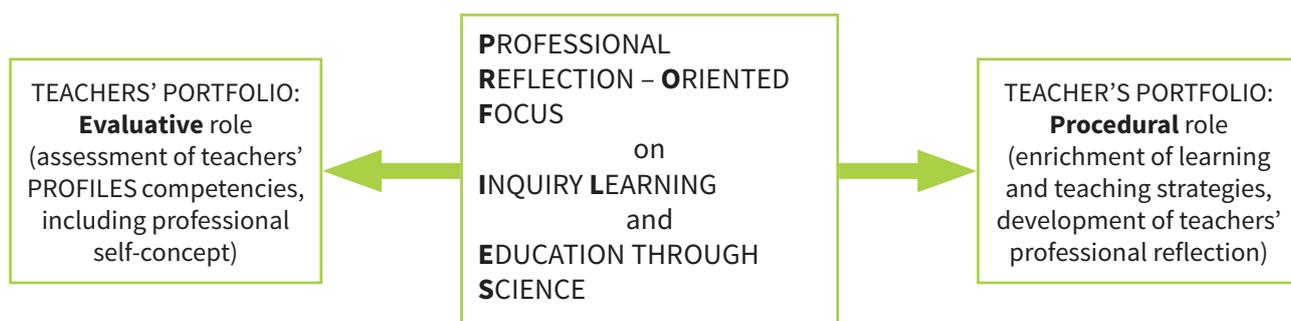


Figure 3. Identifying teachers' ownership by using portfolio in the CPD PROFILES programme in Slovenia (Juriševič et al., 2012).

Action research strategies used in the CPD programme can encourage teachers to more efficiently develop their ownership about PROFILES innovative teaching and learning science. We decided that portfolio can be used as a tool to follow teachers' professional development during PROFILES CPD. Teachers held written records of the specific observation, perception, hesitation, positive experiences or conclusion about different phases of the project. The portfolio serves two purposes (Figure 3).

The first is procedural, developing science teachers' reflection, encouraging their professional development and self-concept, and improving the quality of learning and teaching. The second is evaluative, with the portfolio functioning as a tool for science teachers to present their pedagogical competences and knowledge of the new professional experiences related to the project goals, through a process of action research following the main principles of the PROFILES approach (Devetak, et al., 2012). The last activity of the teachers' action research process is also publication of the research results. Some teachers and their consultants participated at the first PROFILES conference with the poster presentation in Berlin (Šket, Petrica Ponikvar, Klopčič, Mesojedec & Ferk Savec, 2012) and also at national science and mathematics teachers' conferences where they disseminated their work among other non-PROFILES teachers with oral presentations and workshops (i.e. Šket, Ferk Savec & Devetak, 2012; Devetak, 2013; Devetak & Ferk Savec, 2013) and also poster presentations.

Conclusion

In action research the final result as well as research process is important. Throughout this process a teacher can improve his/her professional standpoint and teaching (e.g. determines which teaching methods are more appropriate for children with special needs, which strategies of applying discipline are more effective, etc.), and acquire knowledge in research work. Action research trains teachers to perform independent studies, motivates them and trains them to read and critically judge

other studies dealing with similar issues. Teachers with experience in own research work are usually more qualified to transfer the findings of other studies into their own practice. Action research can thus be defined as one of the important factors of a teachers' professional development and to increase the effectiveness of teaching. Practitioner research is often seen as a significant form of teacher professional development; however, practitioner research undertaken with academic researchers is also a significant form of academic professional development. Seen as such, academics can learn a great deal which contributes to the broader goal of improving their own practice (Groudwater-Smith & Mockler, 2006).

PROFILES CPD programme undoubtedly contributed to the teachers' awareness of what a practitioner research is and how it can be used for their continuous professional development in their scientific and didactical way.

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3.4 Crossing Borders in Science Teaching – PROFILES Teachers on their Way to the European Science on Stage Festival 2013 and towards Teacher Ownership

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Abstract

One of the PROFILES key objectives is to support science teachers in their effort to improve their professionalism. Continuous professional development (CPD) courses offered in the PROFILES project should help to raise teachers' self-efficacy and to identify evidence of ownership (Bolte, Holbrook & Rauch, 2012). In this contribution we report about a group of in-service science teachers who worked cooperatively in a PROFILES based CPD initiative named "ProNawi" (acronym for "Projektgruppe Naturwissenschaften" – in English "project team science"). We will focus on the teachers' work and cooperation within this project, the modules they created and the level of ownership the teachers developed. A special emphasis of this report builds the story how the ProNawi teachers engagement led to the situation that some of the teachers finally came on "stage" and attended the European Science on Stage festival to present their modules developed during the PROFILES CPD courses.

How everything started...

ProNawi is a group of interested and experienced in-service teachers who teach science to pupils of 5th and 6th grade at Berlin schools, who are willing to further develop and improve their science lessons, and who participate in the CPD programme of the PROFILES group at Freie Universität Berlin (Streller & Bolte, 2012).

The starting point of ProNawi was a one day teacher training course with practical workshops which was conducted at Freie Universität Berlin, where the teachers met the first time. After this course some of the participants raised the question if there would be an opportunity to meet again and to work on questions and problems regarding their own teaching. They intended to develop and improve their teaching in cooperation with colleagues from school practice and education research. The first CDP course was founded.

The design of the CPD course ProNawi followed a) the recommendations about professional development we find in the literature and b) the PROFILES principles. Loucks-Horsley et al. (2010) recommend for successful professional development processes to consider the following guidelines for designing CPD courses.

Useful guidelines for professional development are to “

1. provide opportunities for active engagement, experiences, discussions, reflection to challenge existing ideas and construct new ones,

2. situate the learning in contexts teachers find familiar,
3. make useful connections and resolve dissonances between teachers existing ideas and new ones,
4. use formative assessment to elicit prior knowledge, and
5. provide time and support.” (Loucks-Horsley et al., 2010, p. 57).

These guidelines are strongly connected with the “Four Stage CDP Model” which underlies the PROFILES approach for designing CDP courses (Hofstein et al., 2012). In this model it is suggested firstly to develop the **teacher as learner** and as practitioner in their classroom (**teacher as teacher**). The “goal should be to equip the teachers with the relevant content knowledge and the aligned pedagogical content knowledge” (Hofstein et al., 2012). The participating teachers teach parallel and afterwards the CPD in school and so they use the new knowledge in real situations. A general principle for the designing CPD courses is that “teachers and teacher students benefit from learning experiences that are based on the same principles that they are expected to implement with students” (Loucks-Horsley et al. 2010, p. 170). This principle we consider in each of our CPD meetings.

The teacher as learner and teacher are the two initial and basic components in the Four Stage CDP Model. This is particularly important because learning does not stop after study or a CPD course

but continues lifelong. Being a lifelong learner is a precondition for development processes (Mamlouk-Naaman et al. 2013).

At the third stage in the model – **teacher as a reflective practitioner** – the teacher starts to develop a sense of ownership. This development is fundamental to become a leader. In the fourth stage – **teacher as a leader** – we can state that the teacher developed ownership. The development of ownership among science teachers during the PROFILES workshops is the key goal because only then it is likely that the teachers take the leadership role. *“Through the development of their own expertise in leading adult learning, teacher leaders also increase their own sense of professionalism and empowerment”* (Loucks-Horsley et al. 2010, p. 15).

The Four Stage CPD Model (Hofstein et al., 2012) and the guidelines for professional development (Loucks-Horsley et al. 2010) are the basis for our CPD course ProNawi.

The implementation of ProNawi

The frame of the course was negotiated with the teachers during the first meeting. We agreed to meet for one academic year once a month on a Friday afternoon. The ten participating teachers wanted to improve their professional skills; mainly their scientific content knowledge (because most of the participant had to teach science although they had not studied a science subject) and pedagogical content knowledge as well as skills in inquiry-based teaching and learning. In this academic year the ProNawi-teachers came together more than nine times to work cooperatively on issues they estimated as important for them and their practice.

The teachers started to work on the development of their competence in the area of ‘scientific inquiry’ and on other important scientific concepts relevant for their profession (see Table 1 in Streller & Bolte, 2012, p. 69). When the group came together for the supposed final meeting, nearly all of the group members wanted to follow up with this cooperation they experienced as successful. This was the starting point of the second ProNawi year.

	Main contents – primary topic: Developing modules
Sept.	Clarification of general conditions, wishes, expectations; goal: planning science lesson sequences together – context: fairy tales – topic: everyday substances
Oct.	Starting to work on and adapting the module “Cinderella”
Nov.	Selecting appropriate fairy tales – should provide a scientific question
Dec.	Developing modules: Hansel and Gretel
Jan.	Developing modules: Hansel and Gretel
Feb.	Developing modules: The emperor’s new clothes
March	Developing modules: The emperor’s new clothes
April	Developing modules: The frog king
May	Developing modules: The frog king
June	Developing modules: The frog king
Dec.	Reflection meeting: Discussions experiences with implementation

Table 1. Overview of ProNawi meetings in school year 2010/11

In the first meeting of the second ProNawi year the teachers once more discussed and negotiated their special professional needs, and at the end of this meeting they agreed that the second ProNawi year should aim at creating flexible lesson sequences (PROFILES modules) based on their current knowledge and skills about inquiry-based learning which the group had developed during the first ProNawi year. The teachers wished to apply and to implement their new inquiry skills by adapting and developing modules in their classes. A special emphasize was put on the concept of inquiry-based learning, on everyday life relevance and on including possibilities to differentiate. This is of special importance because the heterogeneity is a serious problem for teachers at Berlin schools. Furthermore, the ProNawi teachers expressed their wish to develop modules and materials which are really new, unusual and unconventional. While they were looking for good ideas which fit to their concerns the teachers finally found the module “Cinderella – separation of substances” (developed by Streller, 2009), and started to adapt the module. By adapting the module which has a scientific focus embedded in the context of a fairy tale, the idea

was born to develop more “fairy tale science”. The development and implementation of modules were the focus of the second ProNawi year (Table 1).

“Once upon a time...” – Fairy tales in science lessons

In the modules “Once upon a time...” fairy tales forms the context and are the starting point (the scenario; see Holbrook & Rannikmäe, 2012) for inquiry-based learning in science lessons. The aim of the modules is to engage pupils in the topic “everyday substances”, which is typical for elementary science education (grades 5 or 6 at German schools), from a new, unusual perspective. The teachers choose fairy tales as a context because fairy tales, stories and fables are on the one hand familiar to children and on the other full of scientific aspects. Four fairy tales by the Brothers Grimm and Hans-Christian Andersen turned out to be particularly adequate for the topic “everyday substances”, but there are certainly more fairy tales and fables a teacher could use. Based on these fairy tales, the teachers designed new modules.

Hansel and Gretel **Focus: Substance Properties**
 Intention: Students discover substance properties with the model “witch’s cottage” by simulating different influences on the house in the forest. This lesson is suitable to introduce the whole topic “everyday substances”.

The Frog Prince **Focus: Density**
 Intention: Students discover density as a property of substances by comparing materials with a model based on the phenomenon “king’s daughter playing with a golden ball” and understand the concept of density through generalization. This example can also be used to introduce or consolidate a simple particle model.

The Emperor’s New Clothes **Focus: Thermal conductivity**
 Intention: Students discover thermal conductivity as a property of substances by experimenting with isolation. They conclude that the substance with the best isolation properties is the worst heat conductor.

Cinderella **Focus: Separation of substances**
 Intention: Students are introduced to separation methods by separating a nonsensical, fairy tale mixture of ashes and lentils. They can relate the choice of separation method to the property of substances.

Figure 3. Overview of contents and intentions of the modules “Once upon a time ...”

All of modules and the corresponding material are directed at children of ages 10–12 of every type of school and learning stage. The following figure shows an overview of the developed and adapted modules.

All modules follow a similar pattern:

1. The starting point (scenario) is a **fairy tale**, which can be read out as a whole or in parts. Pictures can be used for illustration: The pupils can draw a picture or color the attached picture while listening.
2. The pupils discover the **scientific issues** in the fairy tale and pose one or several **questions**.
3. They develop ideas and **hypotheses** to test these questions and **plan experiments**.
4. They conduct the **experiments** or model experiments **independently** or with supporting worksheets.
5. Finally, they present, compare and discuss their **results** and check if the original **question** can be **answered**.

The ProNawi teachers preferred to divide the ‘PROFILES 3-Stage Model’ for creating PROFILES type modules (Holbrook & Rannikmäe, 2012) into at least five stages to structure their sequence of inquiry-based lessons. All members of ProNawi developed in cooperation with other group members the fairy tales modules (Table 1).

In each module children were lead to focus on aspects and phenomena described in the story in a manner they have not faced like this before – in this scientific way – and it is likely that the children were intrinsically motivated to deal with the offered topics (Bolte, Streller & Hofstein, 2013). These scenarios to which the pupils were exposed so often before do really have a strong motivational potential, because the pupils realize something strange – or to keep it in a more educational sophisticated term: the pupils became aware of a ‘cognitive conflict’, and this conflict they wanted to solve and they wished to know if the things mentioned in the story could be true or realistic. The mentioned phenomena or problems (e.g. the princess playing with a golden ball, or Cinderella picking lentils out of ashes) the pupils got aware of, led them to observe the phenomena scientifically, and the questions which emerge by this enhanced the pupils interest to investigate now the question raised and to answer it by means of scientific inquiry. At the end the pupils were able to assess whether the princess could to able to through a golden ball in the air easily or to understand that if Cinderella would had known more about science she would not have needed the birds to select the materials. The pupils were finally able to decide properly and by a scientifically based assessment the questions of concern.

Example: The Frog Prince – Focus: Density

After reading out the fairy tale, the teacher reveals three golden balls of the same size (acrylic balls, \varnothing 12 cm, filled with 20 cotton balls, walnuts and stones respectively, sprayed with gold color), which are placed on the teacher’s desk. This action should demonstrate the phenomenon “the king’s daughter playing with a golden ball” and capture the pupils’ attention. The question should be obvious: With which ball did the king’s daughter play? (Alternatively: Which of these balls is the golden ball of the king’s daughter?) The children carefully lift the balls and give estimates. On this basis, they pose the scientific question: Why do the three balls have different weights when they look the same?

Possible pupil answers (hypotheses) are: The balls are filled differently. They are hollow or not hollow. The balls consist of parts with different weights.

Then, the children suggest an approach to test these hypotheses. Alternatively, this supportive task can be given: Compare the balls! (Find as many similarities and differences between the balls as possible!)

Option A: small groups

In small groups, pupils receive three acrylic balls of the same size (\varnothing 6 cm) filled with wooden beads, cotton balls and stones as a model for particles. It is important that the number of filling items is the same in each ball and the weight is different. (For differentiation, the number of model particles can be varied between 20 and 60 items per ball to make it suitable for faster and slower pupils.)

Option B: big groups

The pupils use the big acrylic balls from the beginning of the lesson. For this purpose, the balls must be opened.

They write down the results of the comparison on a work sheet.

Now, the concept of density is introduced. By working with the model, the children have already understood that the same amounts (volume) of different substances can have different masses. This property is called density. It is a (further) property of substances and is defined as mass per volume.

The children find other examples for objects of the same size, but different materials, and determine their mass. Subsequently, pupils can calculate density in exercises of different levels with material we have developed.

At the end of the sequence, pupils recall the fairy tale and consider how difficult it would be for the king's daughter to play with her ball. The pupils place the ball they assumed was the golden ball into a bucket. How heavy a ball of this size (12 cm) would be if it was made of gold can be shown with a second bucket, which is covered by a cloth and filled with stones to demonstrate the mass of a ball of gold: 17.5 kg!

Experiences with the lesson building blocks sent by a ProNawi member to the group:

"(...) I need to make a quick report. With my class (grade 6), I have done the sequence of the Frog King for the first time. I was surprised how positive the responses to the fairy tale were. Most children didn't even know it. The models were very successful. The children were impressed by counting the content of the balls and also by the 17 kg bucket (I used a bit less) with the stones. The working sheets were used without problems. I have the feeling they understood the particle model in its basics. Several times I was asked for other fairy tales with scientific content. Luckily, I have quite a few to offer. ... My colleagues have admired our models. I will present our work in the next [school] conference."



Preparing the model for the module "The frog king" during ProNawi meeting; Children test the weight of the golden balls

Box 1. Short description of the module "The frog king" developed by ProNawi

In December 2011 the ProNawi team came together for their 'supposed' final meeting of the second year. This meeting was to discuss the implementation of the fairy tale modules in class and to share experiences and relevant information. One teacher informed the group that there is a call published inviting teachers to get involved in a special network of science teachers called "Science on Stage". Within this call teachers were invited to send a proposal offering innovative and extraordinary science teaching initiatives, materials and/or approaches implemented already

in science classrooms which show the potential to enhance science educational practice. The best contributions reviewed by a peer jury would get invited to the German Science on Stage festival to disseminate their work among other science teachers. The ProNawi teachers spontaneously agreed to take up the fruitful cooperation once more and to start working on the proposal for Science on Stage festival in Germany. At the end, in May 2012 the group sent their proposal to the Science on Stage jury and waited excitedly on the jury's feedback.

ProNawi on Stage

In May 2012, ProNawi working on the project “Once upon a time... fairy tales in science lessons” – successfully applied for the participation in the national Science on Stage Festival in Berlin. In the course of the national Science on Stage selection process the Berlin PROFILES group ProNawi was able to convince the Science on Stage jury which included teachers and teaching methodologists of their ideas. Therefore, the ProNawi team was invited to present their “good-practice”-ideas for science lessons to the audience of the European Science on Stage Festival as a member of the German delegation.

Science on Stage is a network of teachers of all kinds of schools, who teach science and technology subjects. It offers a platform for a national-, Europe- and World-wide exchange of ideas and concepts for science education. One focus of Science on Stage is on connecting teachers, who present successfully implemented ideas for science lessons to their colleagues and have the opportunity to further inspire one another at project stalls, in workshops, presentations and on stage. This exchange of ideas takes place at national and European festivals. The motto of the European Festival 2013 was **Crossing Borders in Science Teaching**. (www.science-on-stage.eu)



Figure 1. ProNawi at Science on Stage Germany (3 teachers missing);



Figure 2. Interested guest at the ProNawi stall during the open day of “Science on Stage” (Germany) in September 2012



Figure 4. ProNawi teachers introducing their ideas and PROFILES type modules materials and the educational theory the modules based on at the European “Science on Stage” Festival in April 2013

From the 25th until the 28th of April 2013, the European Science on Stage festival took place in Słubice (Poland) and Frankfurt/Oder (Germany). On this European Science on Stage festival, 450 teachers from 25 different countries took part. Six members of ProNawi presented the project “Once upon a time... Fairy tales in science lessons” to the participants and to the general public. On Saturday, the 27th of April 2013 – the open day of the festival – more than 150 interested teachers visited the festival, informed themselves about the projects

and talked to the presenters. The ProNawi group presented a poster and various self-developed materials during the science fair.

Development of ownership

The ability of teachers to reflect their own practice is the beginning of taking ownership (Hofstein et al., 2012). Some indicators are relevant to proof if one developed a sense of ownership. To these indicators belong the dissemination of modules to other teachers and the willingness to serve as leaders. Teachers who developed a high level of ownership may develop the ability to become leading teachers (Hofstein et al., 2012).

Taking the activities of the ProNawi teachers into consideration – either if we take a look to the activities in Berlin or in Stübice, in our opinion it becomes obvious that the ProNawi teachers who shared their experiences with other colleagues and who disseminated insights and products of their work – such as the modules and materials they developed and tried out as well as the findings regarding their pupils' gains they evaluated – in a conference like this are acting as a disseminator and thus developed more and more leadership characteristic.

In the frame of the ProNawi project the teachers have not only developed their fairy tale modules but also tried out the teaching and learning materials with their classes. Surely, in this period they were acting – as they usually do – as *teachers*, but attending the next ProNawi meeting and discussing the experience they had by implementing the modules the participants were also acting as *reflective practitioners*. Facing the interaction among and the support the teachers provide to each other, we can assume that *these teachers showed an increase of ownership* for innovative and student centered approaches to a more inquiry-based science education.

The ProNawi group showed a *high level of ownership* hence they had now started to network and tried to disseminate their ideas and work on a national level in order to convince other teachers in Germany to follow the philosophy of their science teaching and to use the module they developed.

Outlook

Since the fairy tale modules enjoyed great popularity and many visitors were interested in these ideas, some ProNawi teachers offered to organize and conduct CPD workshops for interested colleagues. Furthermore, the ProNawi group is now going after the publication of the fairy tale modules, to allow an even wider public access to the units and materials (Erb & Streller, 2014). The 'supposed final meeting' of the ProNawi initiative has not happened yet, and we are sure that more activities will follow. However, the experiences regarding the ProNawi CPD activities and the follow up emerging from this initiative can be seen as indicators for evidence regarding the professional development of the ProNawi teachers, a continuous professional development in the direction of taking step by step more and more ownership. All in all the teachers of the ProNawi group became innovative disseminators for a better science educational practice; either regarding their own lessons, science lessons in their schools as well as for other teachers on a local, regional, national and finally international level by disseminating their examples of an innovative science educational practice.

The members of the ProNawi group are: *Nadine Chasté – Manja Erb – Ilona Grote-Großklaus – Detlef Knebel – Pirko Krause – Claudia Frühinsfeld – Christine Prem-Vogt – Cornelia Radusch – Stefanie Schmiereck – Sabine Streller.*

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3.5 From a CPD Workshop to the Development of Self-efficacy and Ownership among PROFILES Teachers: The Israeli Experience

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Abstract

This article explores the importance of the CPD to develop self-efficacy and ownership among science teachers who were involved in two CPD cycles during the years 2010–2013. In this manuscript we discuss in-depth the various activities and developmental stages (phases) that the teachers underwent during the CPD workshops. Finally, we discuss the issue of development of teachers' self-efficacy and ownership to attain the goal of developing leadership among few of the participating teachers.

Introduction

- An important component of the PROFILES project is the continuous professional development (CPD) offered to teachers. Its purpose is to enable teachers to become conversant with the PROFILES philosophy and teaching approaches, particularly where teachers indicate that they feel there is a need. The PROFILES project advocates a more student-centered approach to teaching, building on a familiar, relevant context and interrelating the science learning with the impact the science has on the decision-making process within the society (PROFILES document, 2010). The project thus introduces a number of features: Promoting students' intrinsic motivation, such as an initial scenario,
- Involving students in inquiry-based investigations, and
- Consolidating the science by interrelating the science gained with social factors such as economics, environmental concerns, ethical issues and social factors in undertaking socio-scientific decision-making developing argumentation skills.

This vision led to the PROFILES model for CPD based on 4 major pillars: teacher as learner (to enable further learning in science so that teachers could better cope with an interdisciplinary approach), teacher as teacher (to enhance the professional content knowledge (PCK, see Shulman, 1986) and familiarize teachers on the PROFILES philosophy

and approach), teacher as reflective practitioner (strengthening the teacher's self-efficacy by reflecting on their interventional teaching using PROFILES type modules) and teacher as leader (preparing those teacher who wish to show evidence of going beyond the self-efficacy stage and illustrating true ownership of PROFILES ideas).

The CPD

Two cycles of CPD, in two separate year groups, were conducted (as in-service), each with about 25 upper secondary school science teachers. In total, the duration of each of the programmes was 84 hours. 25% of this was conducted in the summer preceding the academic year in each case. The remainder of the programme was conducted throughout the year either, face-to-face or as online activities.

During each of the academic years, the course emphasis was on the following activities related to the teachers PD. The teachers:

- Learned about the rationale of PROFILES, the importance of IBSE, the meaning and interpretations of relevance, and they learned about modules developed in previous projects (e.g., PARSEL: selecting one of the modules for further investigation).
- Studied in-depth issues related to high-order learning skills including IBSE, decision-making, and other subjects.
- Created a scientific background related to

the module they had selected for further in-depth investigation.

The intensive summer course (3 days) served mainly as a vehicle for motivating the teachers to commit themselves to the PROFILES programme. Most teachers, in groups, felt the need to build on their learning in the CPD to develop new modules and not to use those that were recommended by the project in the internet (e.g. PARSEL modules www.parsel.eu). Indeed, the professional development providers were encouraged by this because it clearly indicated teachers' intensive involvement in the development aligned with the professional development model: *"the teacher as a curriculum developer"*. This has potential to enhance teachers' self-efficacy and later provide an approach to gaining evidence for teacher ownership of PROFILES ideas. Here is a quote from one of the participants:

"I felt right from the beginning that our group is going to attain the philosophy of PROFILES. In the induction course during the summer we had an opportunity to investigate the scenario of the module. This was done in an unusual and very interesting way. We had to be creative in preparing the poster (for the initial presentation). The preparation involved all the group members and included both hands on as well as minds on activities." (Boaz, 2011 writing about his personal reflection related to the development and implementation of the "sunscreen protection" module).

During the CPD workshop about 45% of the meetings were conducted online and the remaining 55% face to face. Teachers were involved intensively in the development of the learning materials the teachers acted as these materials were implemented in schools which gave the teachers the opportunity to reflect on their experiences: *The teacher as a reflective practitioner*. Note that the CPD programme served as a platform for feedback from peers and the CPD providers (for details about activities see Figure 1). Clearly, the development of the module (original) became the corner stone of the PROFILES CPD. There is no doubt that this had a significant impact on the teachers' feelings of self-efficacy and the development (later on of

sense of ownership). For most of the teachers this was the first time that they were exposed to such experiences.

The guidance, encouragement, and support of the CPD providers and peers were essential for the teachers' success (See a quote from one of the participants):

"During the development of the module we learned to think in creative ways to overcome the difficulties and even attain the best. It is important to note that the development process is not simple. It often requires conceptual approaches, often discouraging and sometimes painful. But the result is the "baby" of the group and carries great pride and a sense "Wow I can do it." I felt that this process allows me as a teacher to experience the ability to create some change, even if it is a small one."

The development of the modules involved several stages that were based on collaborative efforts with peers and CPD providers:

- Choosing the theme of the module in alignment with the abilities and interests of their classroom student population.
- Collecting correct and valid scientific backgrounds.
- Designing pedagogical interventions aligned with content and context.

All these stages fully represented PROFILES key issues and pedagogies, namely, relevance, inquiry interventions, and decision-making. Nevertheless, there were important benchmarks in the development of the modules: the design of the first-scenario, the design of the inquiry-based activity, which should lead to the decision-making process and maintaining the timing that was given by the CPD providers.

All the modules that were developed were original, namely, they were not adapted from other projects, e.g., modules that were developed in the context of the PARSEL project (for more details relating to the modules that were translated to English, see: <http://stwww.weizmann.ac.il/g-chem/profiles/chomarim5.html>).

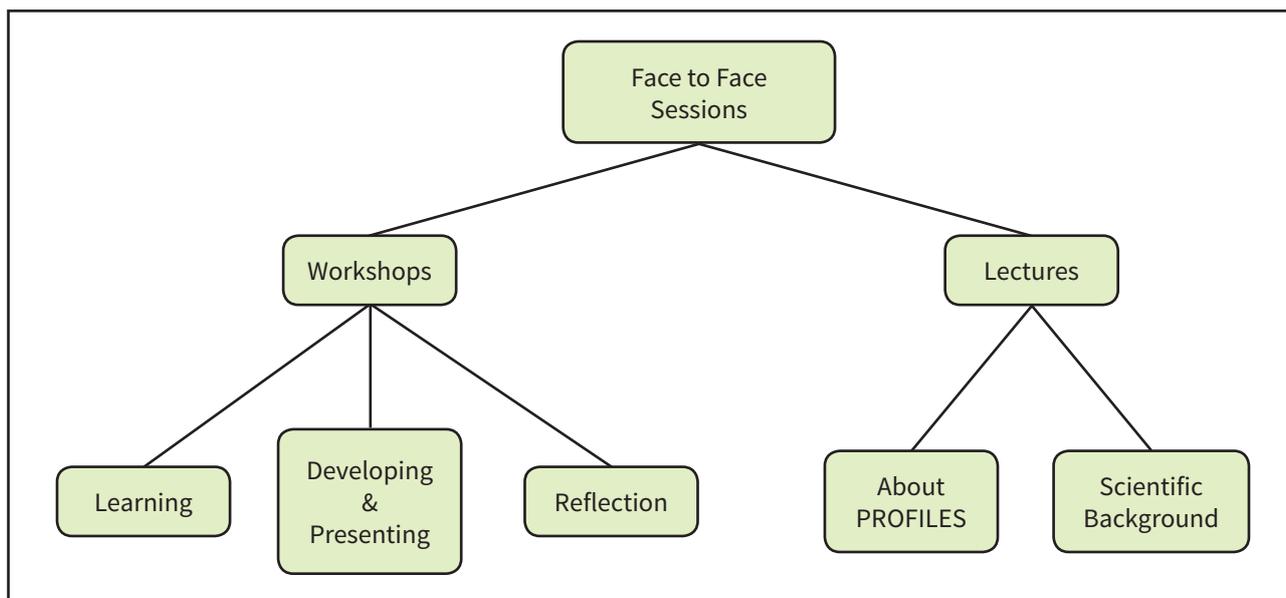


Figure 1. Schematic structure of the CPD programme during the PROFILES CPD programme

Among the modules that were developed are the following:

- Biodiesel: The use of alternative source of energy
- Sun screen ointment. Which one to use.
- To drink or NOT to drink: The quality of drinking water
- Energy drink: Is it healthy?

Implementation of the modules in the science classrooms

Following the developmental phase, the teachers tried out the modules in their respective classrooms. Clearly, this is the phase in which teachers acted as teachers to implement the CPD ideas and as reflective practitioners. This phase is, in the teachers' eyes, the most important phase since through implementation they found out how the module actually applies the PROFILES philosophy and approach.

To gain more information regarding the implementation, teachers were observed, they completed questionnaires and also took part in interviews. All teachers were excited about undertaking the implementation in class; they claimed that they had experienced something new, different from teaching undertaken in other previous classes. One of the teachers wrote:

"Today I started to implement the module of biodiesel in the classroom. (...) I told you: in one class I taught the biodiesel module and in another one the toothpaste module. It went well – I am very excited about it. It seems to me that the biodiesel worked better and provoked interesting discussions and ideas, since I designed that module(...). In classes the students took the task very seriously – something I was really afraid of (...) and another thing – indeed the weak students were interested and worked in a different way." (Liora, 2012).

Teacher reflection

Following the classroom implementation, the teachers were asked to reflect on their experiences. Three methods were used for the teacher reflections:

1. Teachers completed a semi-structured questionnaire. The questionnaire included questions such as: What did I like most about this activity? I encountered some difficulties during this activity... How did I cope with these difficulties? How did the activity contribute to the students' comprehension or understanding of the content? If I will conduct this activity again, I will make the following changes...
2. Each teacher conducted an open-ended

(narrative oriented) presentation in front of all the CPD participants, reflecting on experiences. This usually involved telling a “story” by a representative of the group accompanied by a Power Point presentation that included evidence from their class.

- Final reflection in which the participants were asked to write a reflective essay regarding their perceptions, feelings, difficulties, and accomplishments (see an example in Appendix 1).

Using these three methods for reflection enabled us to collect evidence regarding the teachers’ professional development and it emphasizes the need for long-term workshops that include implementation in class and reflecting in order to improve the teachers’ activity and their performance in class.

The development of teachers’ self-efficacy and later on – a sense of ownership regarding PROFILES

One of the key and unique products of the PROFILES CPD workshop is the development of feelings of self-efficacy implementing the project among most of the participating teachers. Self-efficacy means that the teachers feels the can and want to use PROJECT ideas and that these are not imposed on them (Ogborn, 2002). The relationship between the CPD, the development of self-efficacy and ownership, and its related scientific content and pedagogy is illustrated in Figure 2. In this schematic description of WP5 (CPD), a model of the four fronts of teachers’ development is presented. Whereas the first two fronts are usually developed throughout the CPD programme by most of the teachers, the fourth front will be developed by

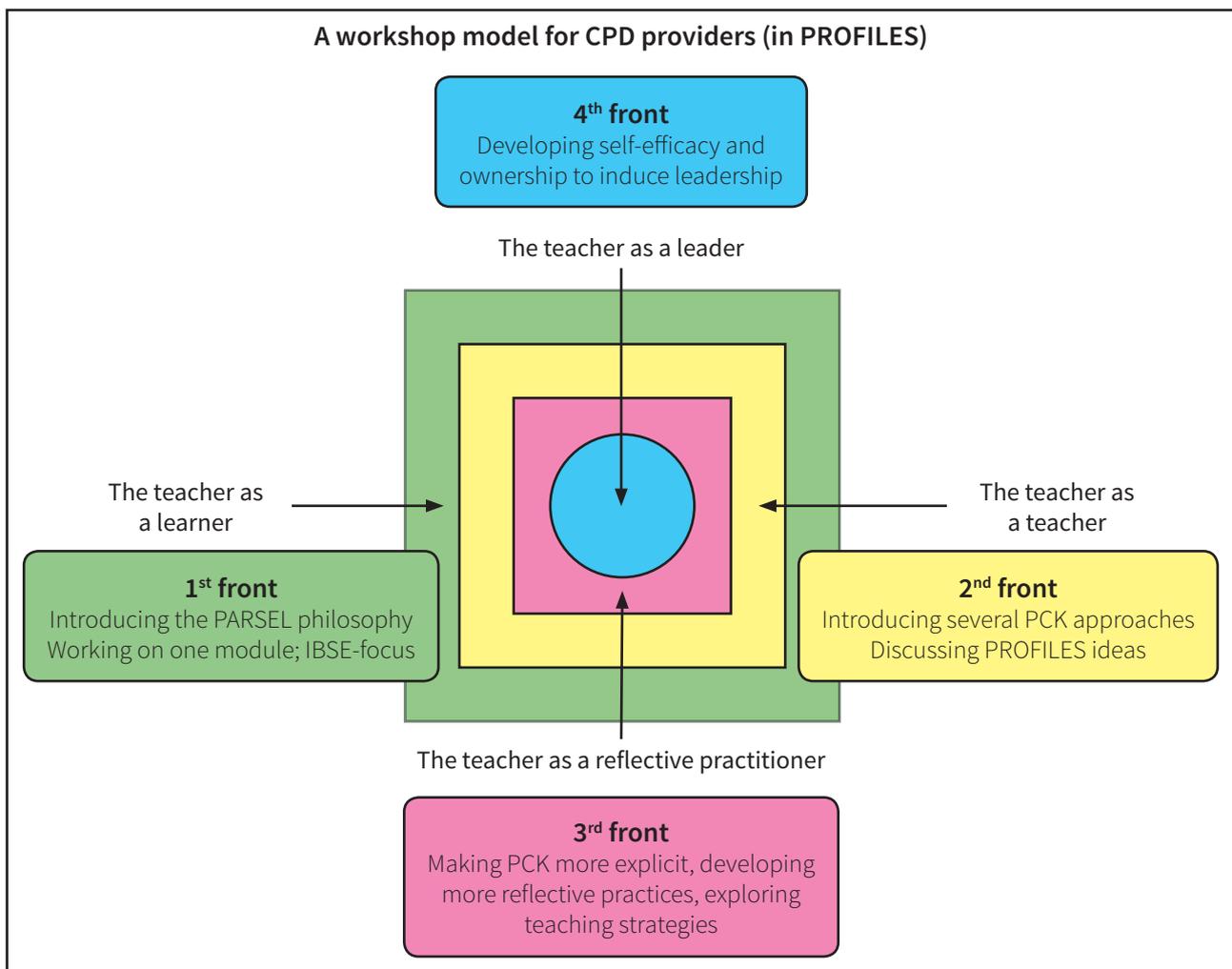


Figure 2. The various fronts of the PROFILES CPD model (based on: Hofstein, A., Mamlok-Naaman, R., Katchevitch, D., Rauch, F. & Namsone, D., 2012, p. 57).

about 5%–20% of the teachers. These are teachers who demonstrate a developed sense of ownership regarding the PROFILES (see also Hofstein, Mamlok-Naaman, Katchevitch, Rauch & Namsone (2012). It is suggested, that it is very difficult to differentiate between self-efficacy and ownership. These two characteristics are linked to each other. However, based on our findings, it is clear to us that teachers will gain a sense of ownership provided they initially developed self-efficacy.

What are the characteristics of teachers' self-efficacy and ownership (in the context of PROFILES)?

In addition to the ability of teachers to reflect on their practice, we (the Weizmann Institute of Science team) have observed and identified other variables that indicate the development of self-efficacy, namely:

- Teachers' willingness to involve and actually involve other teachers in school in their practice.
- Involving the principal in the project (stakeholders).
- Teachers' willingness to identify socio-scientific issues (to be developed) that have local characteristics (e.g., an environmental-type issue) and to seek a relevant issue.
- Identifying themselves with the rationale of the project (development and implementation).
- Identifying oneself with the newsletter (published on the web).
- Teachers telling their students that they were involved in the development or adaptation of the module as a part of an international project.
- The dissemination of the project or module to other teachers.
- Teachers making an attempt to bring items (artifacts) that eventually will provide evidence of their classroom behavior and practice.
- When teachers perceive that the topic or issue taught is relevant to their classroom (the nature of the students).
- When teachers are willing to develop their

own module and not accept those imposed on them.

- When teachers decide to make changes, alternations, and amendments to the original module. The willingness and ability of teachers to bring evidence of their accomplishments.
- The teachers' willingness to serve as leaders in the 2nd year CPD programme (the 2012–2013 academic years).

Methods that were used to assess the development of self-efficacy and ownership among PROFILES teachers

In order to determine the degree of self-efficacy among teachers, data were collected using different instruments:

A questionnaire consisting of Likert-type items organized as a bi-polar semantic differential scale

The questionnaire was developed bottom-up, based on categories that arose from teachers' discourse in the previous CPD programme (2011–12). Teachers were asked to complete the sentence "I feel confident in my involvement in PROFILES because_____". Teachers' claims were sorted, categorized, and were the basis for formulating the items in the questionnaire. All together, the questionnaire consists of 29 items in 6 categories:

- (1) Empathy with the rationale,
- (2) Promotion of the teacher's image among peers,
- (3) Promotion of the teacher's image in class,
- (4) Willingness to continue,
- (5) Sharing and disseminating,
- (6) Professional development.

The questionnaire was administered twice: at the end of the three-day summer session and at the end of the CPD workshop. The questionnaire was used as a tool to assess the self-efficacy profile of each teacher who participated in the PROFILES CPD workshop and of the whole group at two different points of time. For reliability the Cronbach α statistic was calculated as an indicator of internal consistency of the values in the various categories.

These ranged from 0.6 to 0.9 (see Table 1). Further research is needed to obtain more valid information regarding the instrument’s validity and usability.

Scale	α Cronbach reliability	Sample item
Empathy with the rationale	0.60	The goals of the project are in alignment with my beliefs
Promotion of the teacher’s image among peers	0.57	The project improved my relations with other science teachers in school.
Promotion of the teacher’s image in class	0.71	The implementation of the module improved my status in the class.
Willingness to continue	0.90	I want to develop another module.
Sharing and disseminating	0.67	I will recommend other teachers to participate in the project.
Professional development	0.86	The development of the module empowered me.

Table 1. The self-efficacy instrument scales, a sample item, and α Cronbach reliability coefficients.

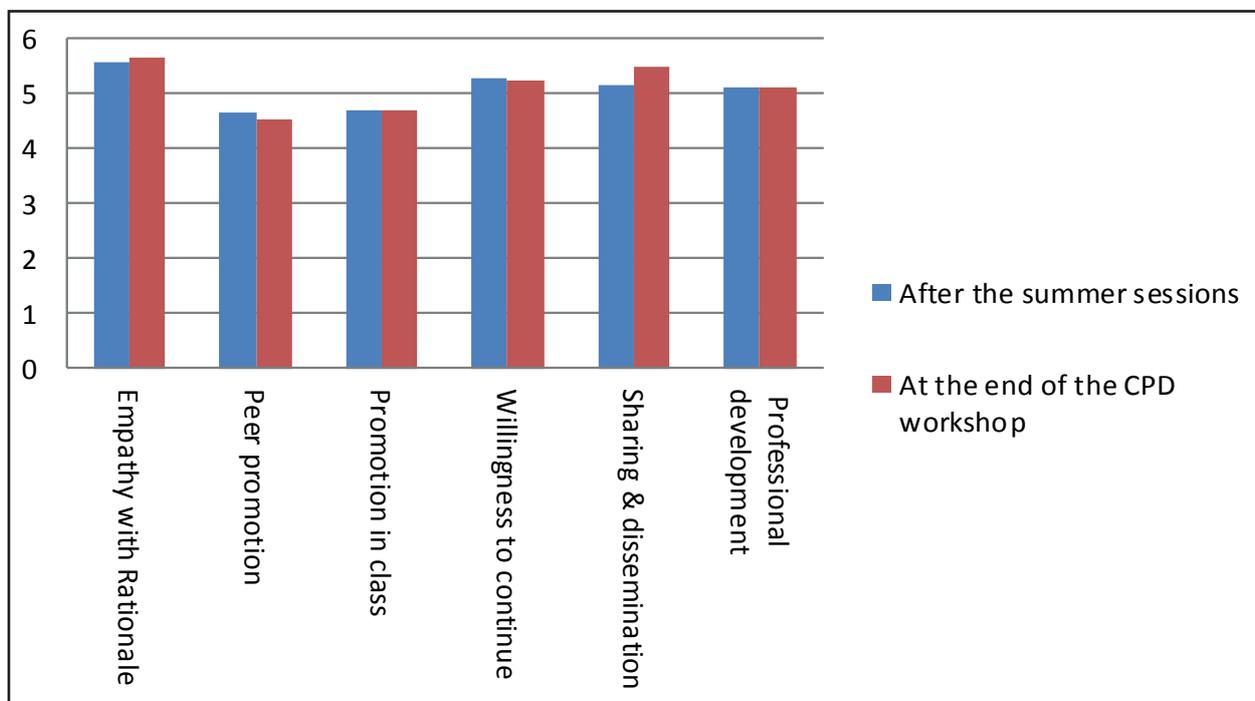


Figure 3. The self-efficacy and ownership characteristics of the whole group after the summer sessions and at the end of the CPD workshop (N=23).

Findings

The analysis of the questionnaire is presented in Figures 3–5. As seen in Figure 3, the level of self-efficacy was high at the end of the summer sessions, the high level was maintained at the end of the CPD workshop, and no significant differences were found between the two snapshots. The empathy

with the PROFILES rationale was relatively high; maybe that is the reason for teachers' willingness to continue and to share and disseminate the project.

Figures 4-5 show examples of a schematic presentation of the various self-efficacy components (characteristics) taken from two teachers who participated in the CPD programme.

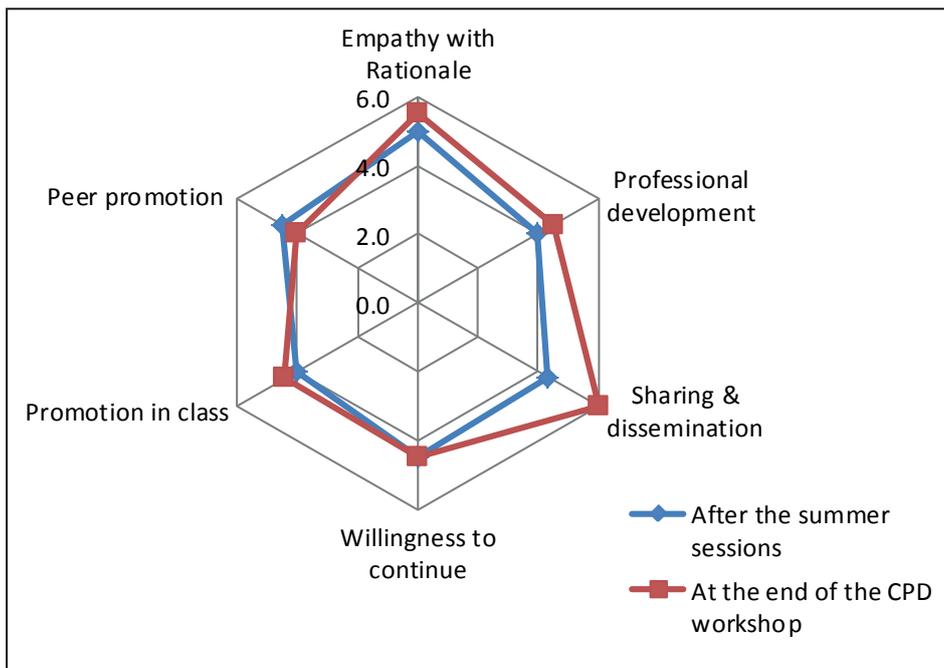


Figure 4. Schematic presentation of self-efficacy and ownership by Na (pseudonym of one of the teachers) after the summer sessions and at the end of the CPD workshop

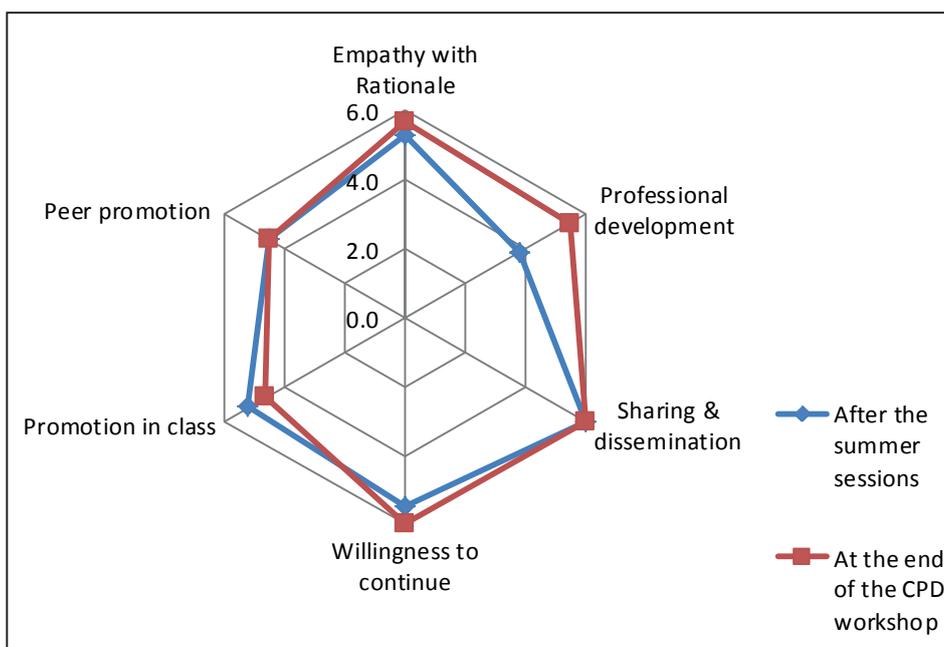


Figure 5. Schematic presentation of self-efficacy and ownership by Sh (pseudonym of one of the teachers) after the summer sessions and at the end of the CPD workshop

The method used (Excel) is fondly called the *Radar Chart*. It is suggested that it can be used for diagnostic purposes. However, more research is needed, in order to obtain more valid information regarding the instrument's validity and usability. From these schematic representations, it can be seen that the practitioners exhibit a high sense of self-efficacy and that the change during the year is expressed differently.

It can be seen that Na. has a high sense of self-efficacy towards PROFILES, but her willingness for sharing and dissemination increased during the CPD workshop. It can be assumed that this is based on her empathy with the rationale.

Sh's profile shows the highest score in three characteristics of self-efficacy and the greatest change lies in the perception regarding her professional development. Sh is now taking part in the third round of the CPD workshop as a teacher leader.

In addition to the questionnaire designed for assessing quantitatively the various components of the teacher self-efficacy, we also obtained information from reflective essays (see above). For example, information was solicited regarding the issue of disseminating the content and pedagogy of PROFILES to more teachers, either in their school or in other regions.

One of the teachers wrote:

"The next assignment in which I want to be involved is to disseminate the module (that we developed in the CPD workshop) among other teachers in other schools."

Regarding the willingness of some teachers to continue to be involved in further PROFILES initiatives, one teacher wrote:

"When we heard that another CPD cycle was initiated, I decided to go for another round to have an opportunity to be involved in the development and implementation of another module."

Regarding identifying oneself with the PROFILES approach and philosophy, one teacher wrote:

"I believe that teaching chemistry using IBSE as a central pedagogical approach is the best approach to teach my chemistry students. The combination of teaching relevant ideas (topics) using the inquiry method and involving the students in the process of decision-making is very motivating and eventually will influence the students to enroll in more advanced chemistry studies."

Information (quotes) was also obtained for the other self-efficacy components. However, it is beyond the scope of this manuscript to include them all.

Summary

We set out to determine the degree of self-efficacy gained through the CPD programme among the teachers. Two components are essential for this: the teacher as a teacher using PROFILES ideas and the teacher as a reflective practitioner implementing PROFILES ideas. The first truly involves the teacher in the project and the second aids the teacher in understanding the importance of her/his involvement. *"What I enjoyed most was implementing the biodiesel module, for a very simple reason – I could say 'This is mine, I am part of it.' I'm excited at the start-up and I felt butterflies in my stomach (...). because after working so much here I reached the final stage where I implement my module – this is the most important part – to see whether the students enjoyed the activity, whether it will go smoothly; will they feel excited that the module has been developed for them?"* (Liora, 2012).

We believe that some of the activities that we initiated catalyzed further developments through which teachers provided evidence of real ownership of the PROFILES philosophy and approach:

- Encouraging teachers to present their modules at the national conference of chemistry teachers and sharing with their peers their reflection following the presentation.

- Encouraging teachers to write articles to the journal for chemistry teachers in Israel.
- Encouraging teachers to become partners in writing the newsletter, and referring to all the modules in the newsletter including pictures of the teachers.
- Providing a forum for teachers and sharing their modules and get feedback from peers

Recommendations

1. During or after the CPD, teachers should develop their own modules using teamwork.
2. The modules should be in alignment with the curriculum in order to raise the probability that more teachers will implement the developed module.
3. Teachers should participate in a task dealing with distributing and promoting their module among fellow teachers.
4. Teachers should present the project and its intentions in their school including the school board.

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Appendix 1

The following will serve as an example of a teacher reflection: The reflection of B.H. upon the development of the module: “Sun Screen Ointment”. B.H. is a chemistry teacher who was involved in the academic year 2011–2012 in the 1st PROFILES CPD. He wrote a reflective essay (written in his own words):

“I came to the course (CPD) on PROFILES with little knowledge about its goals and content although I had some information about the professional development providers.

For me, as a teacher, my values are: involvement, collaborations, and creativity. I sincerely believe that values are the driving forces that shape our behavior in many areas. I was glad to hear that the PROFILES project will provide me with experiences to develop as professional teacher (as well as my peers). From my experience in the CPD, I can say that my active and personal involvement in the project enabled me to develop as an active participant and as a result to develop me personally to become a leading teacher.

The 1st meetings in the summer course, was enthusiastic based on three reasons:

- 1. I had an opportunity to meet with colleagues who were involved with me in another long-term CPD.*
- 2. I met new teachers with new ideas.*
- 3. I felt that the tutors are making their utmost to provide support and interesting pedagogical interventions.*

All these motivated me to become highly involved (also in the future) in the PROFILES project.

The Selection of the topic (Sun screen ointment) was a direct result from the lecture on the importance of relevance in science education that was presented by the science education department staff. I and my group (while thinking about the topic) were convinced that it has potential to implement the philosophy and theoretical background of PROFILES namely: inquiry, relevance, decision-making, etc. We started the development of the module by

planning and developing the framework of relevant posters. This activity enabled the active involvement of the whole group. To include, both “hands on as well as minds on”. Personally I believe that this is a vital stage in such developments.

The group’s collaboration throughout the year that included many communication skills (argumentation, communication, providing feedback to each other, etc.) was enjoyable and interesting experience for all the group members. Half way the academic year I started to implement the module in my own classroom (in school). This followed the implementation of the module in another school (by another member of the group) I had the opportunity to be involved in this implementation. My impression was that the implementation of the module was very relevant to the students both regarding the varied type of pedagogical interventions as-well-as its educational effectiveness.

For me, the challenge was the writing of the learning material it underwent several cycles of rewriting and changing. Surely, my experience with teaching gave me ideas as to how to change the content and structure of the module.

In addition, preparing the abstract and poster for the Berlin’s PROFILES meeting was an easy task following the experience I accumulated throughout the CPD programme (the academic year). To sum-up, I am very satisfied with the results to include the high level of the module and its alignment with the PROFILES goals.

The next assignment is to disseminate the module to more teachers in more schools.”

3.6 Science Teacher-Leader: Role of Creativity in the Multidimensional Development of a Teacher's Professional Competence

Eva Trnova, Nadezda Kopecka & Josef Trna – Masaryk University, Czech Republic

Abstract

This paper is a retrospective case study giving a descriptive and explanatory analysis associated with one person: a PROFILES teacher-leader. The case study of a “teacher-leader” is the case-object of the inquiry that provides an analytical frame. The case-subject with whom the study is conducted and who illuminates and explicates the case is one of the teacher-participants of a CPD programme in the PROFILES project. The main objective of the case-study is to describe and analyse the inclusion of creativity in the multidimensional development of teacher professional competences through IBSE. This is effected, based on the creativity of one teacher-participant, initially in CPD in the PROFILES project and then developing into a teacher-leader. General conclusions are supported by specific examples and demonstrations of curricular materials.

Introduction

A fundamental problem for Czech teachers is “burnout” based on several factors. These include:

- Exhaustion of learned and well-tried teaching methods from undergraduate training
- Change of students learning styles (arrival of the “Net” generation, etc.)
- Reduction of intrinsic (internal) and extrinsic (external) motivation of teachers

Our hypothesis, based on our experience and research, is that teacher creativity is an important element that can minimize burnout. Our case study teacher reached the point where she could no longer figure out how to motivate students. She recognised that unfortunately, students are often overloaded with modern teaching technology, based on ICT and this is often inappropriately included in instruction. Yet it was desirable to attract students through something new and perhaps surprising. A paradigm shift in the approach to teaching was needed and with this a change of conception of science education itself.

Conceptions of science education

Support for a change in the paradigm of perceiving science education came from studies carried out within the PROFILES project. We applied the Curricular Delphi Study on Science Education (Osborne et al, 2001; Bolte, 2008) that was

specifically developed within the PROFILES (2013) project. For example, a Delphi study served as the main research instrument in this respect and cluster analysis within a second round of the study resulted in three different conception of science education. These are amplified below:

Concept A: Conceptualising the sciences in current, social, globally relevant and occupational contexts, relevant to both educational and out-of-school settings

This refers to an engagement with the sciences within the frame of current, social, globally relevant, occupational and both educational and out-of-school contexts, enhancing emotional personality development and basic skills. The impressions a person gets through engaging with topics and associated science-related questions, from his or her environment, influence both the person's sensibility and his or her attitudes towards the sciences. Dealing with scientific issues or phenomena in out-of-school, or social and public contexts respectively also facilitates conscious experiences of scientific phenomena, scientifically precise observation and cognitive ability. Moreover, basic and professionally relevant skills such as finding, interpreting and communicating information can be enhanced in this way. Suggestions for this kind of engagement and education are, amongst others, provided, for example, by current issues or media coverage. Dealing with the history of the sciences especially, reveals how findings and methods of the sciences enable, enhance and bring forward research in the natural sciences. This shows, moreover, how historical science-related developments are still linked

to applications in industry and technology, how these applications changed the world and how they influence our professional and everyday life.

Concept B: Conceptualising intellectual education in interdisciplinary scientific contexts

Concept B refers to an engagement with the sciences, their terminology, their methods, their basic concepts, their interdisciplinary relations, their findings and their perspectives, which enhance individual intellectual personality development. In concept B, dealing with the sciences serves not only the acquisition of science-related basic knowledge, but also helps in the understanding of fundamental findings and the process of gaining knowledge in the sciences. Moreover, dealing with questions and topics of the sciences helps to comprehend and follow (empirically and experimentally) scientific research methods, facilitates analytical abilities and fosters the ability to take differentiated perspectives. In addition, an engagement with current scientific research reveals not only how findings and methods of the sciences enable, enhance and support both scientific research and its applications, but also how scientific research is interconnected in an interdisciplinary manner.

Concept C: Conceptualising general science-related education and facilitation of interest in the contexts of nature, everyday life and the living environment

Concept C refers to a science-related engagement with everyday life and living environment issues that takes up and promotes students' interests, enhancing general personality development and education. Dealing with topics from the natural and technological living environment shows how scientific research, scientific applications and scientific phenomena influence both public and personal life. Another important aspect of this concept is engaging with different values and perspectives as well as reflecting on both personal and public deliberations and a course of action. Moreover, this concept refers to facilitating the motivation for scientific inquiry beyond school, including aspects such as realizing and shaping one's own interests. Dealing with scientific issues and phenomena within the contexts of social and public fields such as technological developments, their consequences and issues about safety and risks enhances, in particular, the students' own abilities to judge and both critically reflect and rationally account for their own actions.

Czech teachers tended towards a slight predominance for option C. Option A was chosen as the second option and option B was supported the least. These results confirm a change in the Czech teachers thinking about the teaching of science. Earlier research has shown that Czech teachers preferred the view that school science subjects need to copy the structure of science and students should be "little natural scientists." This earlier view of teaching science is related to option B and is also related to the classical way of teaching, which preferred an 'active teacher' to an 'active student.' With the change in the concept of science education comes the need to change the way of teaching and 'energize' students in the new vision. This demands greater teacher competence and this in turn is dependent on teacher creativity.

Teacher creativity

It is difficult to define creativity. The field of creativity as it exists today emerged largely as a result of the pioneering efforts of Guilford (1950) and Torrance (1962; 1974; Torrance & Presbury, 1984). Unfortunately, most researchers develop their own definitions of creativity. As our case study concerns a Czech teacher, we quote definitions of Czech experts on creativity, reflecting how creativity is perceived in the Czech Republic. In the pedagogical dictionary by Czech authors (Průcha, Walterová & Mareš, 1998, p. 264), creativity is defined as "*a mental ability based on cognition and motivation, where an important role is played by inspiration, imagination and intuition. It is called into play in finding solutions that are not only correct, but also new, unusual and unexpected.*" Related to the multidimensional development of teacher professional competences the definition of creativity by Žák (2004) can be considered the most comprehensive. He defines creativity as:

- (1) Ability to
 - (a) imagine/invent something which does not mean creating something from nothing;
 - (b) generate ideas, solutions, pieces of work, using combinations, changes, replications of existing ideas.

- (2) Individual approach characterized by:
- (a) agreement, acceptance of changes and news;
 - (b) willingness to play with ideas and thoughts;
 - (c) flexibility in perspective.
- (3) Process characterized as:
- (a) hard work;
 - (b) continuous mental activity to generate solutions;
 - (c) space for improvisation;
 - (d) order.

According to Sternberg (1999), Amabile (1996) and Gryskiewicz (1982), a creative teacher is necessary to develop students' creativity. Students must feel that they are expected to be creative (Barbot, Besançon & Lubart, 2011). Unfortunately, creativity is often perceived as disturbing by society, and especially by uncreative teachers, and can therefore be suppressed (Csikszentmihalyi, 1988). Teacher creativity is one of the core teaching factors. Quality development of teacher competences cannot exist without creativity. Our hypothesis is that high quality CPD is needed to develop teacher creativity.

The importance of creativity for education is evident from the interest of the OECD in this issue. Taddei (2009) in preparing a study for the OECD stated that a rapidly changing and less predictable environment leads to the tendency to change jobs repeatedly and learn something new. He emphasizes a great deal of creativity and self-initiative is appropriate to do that. But school educational systems continue to prepare students for a rather static world. He criticizes that they do not prepare students to work together to solve interdisciplinary problems, but they mostly lead students towards rivalry among classmates in one subject. Instead of developing critical thinking, students rarely get the opportunity to argue about the teachers' opinions. Robinson (2009) goes even further and criticizes the way students are educated. He claims that schools destroy creativity and fights for a radical review of school systems. And Beaussart, Andrews & Kaufman (2012) point out creativity is suppressed by directive management, stereotypes and tendency to conformity, which are unfortunately common in today's schools. According to our experience, inclusion of PROFILES

modules in instruction helps to develop creativity of teachers and students.

The implementation of CPD depends on the professionalism and personality of the instructor, who must be creative and be able to motivate teachers positively. It is ideal if the CPD is led and implemented by educators and teachers-methodologists who have these qualities. In the opinion of our case study teacher, it is important for an instructor to

“have charisma, based on high expertise that continues to improve. Such a person can motivate others to work on something they do not trust in the beginning. She mentioned creativity as an important quality that allows the bringing of flexible solutions to problems within CPD.”

As creativity is a crucial factor in the multidimensional development of teacher professional competences, we examine the role of creativity in a number of partial dimensions in the development of teacher professional competences.

Teacher creativity and PROFILES project

The PROFILES project provides teachers with opportunities to use and develop creativity, and develops teachers' basic knowledge of IBSE methods (Bolte et al, 2012). It offers models and patterns, but forces students to think and create independently (Bloomberg, 1967). It shows teachers how to develop students' creativity by integrating this in the instruction and giving students space to develop creativity. It enables students to think about issues and look for ways to discover phenomena around them and find laws related to their interrelationships.

In the opinion of our case study teacher,

“teacher creativity is the ability to make a ‘boring’ curriculum unusual by interesting, humorous elements, enabling an innovative approach to problems so that students become involved in the action. Students feel they would like to help with inventing various experiments, contests and other

activities which can make instruction special and enjoyable. Teacher creativity is associated with a given occasion. Each lesson is different and each class reacts differently but this still makes me, the case study teacher said, reach the same goal – to explain the subject matter comprehensibly and accessibly.”

Also in the opinion of our case study teacher, the PROFILES project is focused on the development of teacher creativity,

“mostly because it forces teachers to undertake individual production of teaching materials and finding new methods. Teachers learn e.g. how to find an interesting topic and how to choose suitable learning activities for it.”

Some examples of multidimensional teacher creativity

Creating a scenario

Important IBSE element in the PROFILES project is a scenario – a story which introduces the context from which the content can be taught. According to our teacher, a teacher must be able to identify an interesting, motivational situation and ask appropriate questions leading students to the desired goal. The teacher learns how to process information efficiently and how to lead students in search of relevant information. Worksheets prepared for students by the teacher are a tool that helps them to sort ideas and leads them to desired outcomes. Therefore, creation of worksheets and a scenario are important elements of the CPD.

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

Purpose of toothpaste	INGREDIENTS IDENTIFIED FROM THE TOOTHPASTE PACKAGING
<i>Whitening toothpaste</i>	
<i>Toothpaste with baking soda</i>	
<i>Toothpaste for gingivitis</i>	
<i>Children’s toothpaste</i>	
<i>Toothpaste for smokers</i>	
<i>Toothpaste for adults</i>	
<i>Toothpaste counteracting smell from the mouth</i>	

Figure 1. An example of a worksheet.

An example of a scenario related to dental caries for students, aged 12–13:

Peter receives money for a snack, but instead he buys sweets. His friend, John, advises him against this because of problems with dental decay. However, Peter makes sure that every morning and evening he cleans his teeth using quality toothpaste. His teeth have only white stains, suggesting there was nothing to worry about. On the contrary, Peter thinks that John will have problems of dental decay, because of drinking a lot of Coca-Cola and orange juice. Who's right?

Creating a worksheet

The teacher should be able to guide students unobtrusively along the right track to a solution (Gardner, 1993; Treffinger, Renzulli & Feldhusen, 1971). Appropriately asked questions make students think and associate known, heard and seen information. This is related to the creation of worksheets. The worksheets should have an adequate level of IBSE so that students don't work with worksheets as a "cookbook" without thinking. It is important to ensure a strong link to the scenario – a strong motivational story, which is the source of heuristic questions and a trigger for students' creative thinking. We present worksheets of the module "Chemistry for beautiful smile" which is dealing with relevance of toothpastes to protect against dental caries (for structured inquiry in IBSE).

Teacher creativity and interdisciplinarity

We present the opinions of our teacher:

"When teaching science subjects at primary schools, I personally consider it appropriate that the teacher has a good knowledge of science. It seems to me that because I experience teaching the science subjects except geography and also science at primary school, I have an ample relevant background and experience. I coordinate instruction with my colleagues – teachers complement each other so that students are more easily guided to create the required interdisciplinary links and connections. A creative teacher can identify a key concept

to create an interdisciplinary link for students. Furthermore, when such a teacher offers students an appropriate combination of topics, they are able to discover relations and connections quite quickly. A creative teacher should therefore be familiar with the curriculum content of related subjects and encourage his/her colleagues to cooperate."

Through teacher cooperation, duplication of topics to promote the education learning covered in each subject can be reduced and redundant content be limited, which strengthens the multidisciplinary perspective of issues, as recommended by Taddei (2009) for the development of creativity. Because reduction of curriculum, as opposed to student needs driven, teaching is also important, Johansson (2004) recommends balancing depth and breadth of knowledge to striving for maximum creative potential. Nowadays, when every subject field has accumulated a large amount of information, but the capacity of the human brain to absorb such knowledge is limited, it is necessary to prioritise the learning expectations. According to researchers such as Johansson, redundant information decreases creativity. Similar to undertaking research, staffed by teams of specialists in various fields, it is possible to increase the scope of knowledge by forming groups with different interests working on a joint project and also drawing upon relevant information sources.

Teamwork itself encourages the development of creativity; therefore properly guided group instruction applied in the PROFILES modules and is of great significance for creativity development.

The effect of teacher creativity on multidimensional development of teacher professional competences in utilizing IBSE

The CPD offered in the PROFILES project (2013) has the potential to provide a strong incentive to change the view of teachers related to the value of teacher creativity in the multidimensional development of professional competences in stimulating relevant and motivational IBSE.

Teacher creativity and a PROFILES module related to “Carbon nature of life”

The creativity of teachers takes on a complex, multi-faceted shape in the development of entirely new PROFILES modules. Our case student teacher-participant in the PROFILES project showed creativity by creating a new module dealing with the biogenic elements “Carbon nature of life”. This module is presented here. Creating a new module is a comprehensive expression of teacher creativity. Innovative components of PROFILES modules used in CPD are integrated here.

Our teacher created a new module called “Carbon nature of life”, which plays a strong cross-curricular role. The newly created module “Carbon nature of life” can incorporate or be modified for all science subjects, and it can be used repeatedly at different grade levels. Modification of this educational content can be used throughout the secondary level of science education.

The potential subject content components of the learning (from which IBSE can be developed) can be:

- Geography: brief development of planet Earth, world’s coal reserves;
- Biology and Geology: photosynthesis, development of the Earth, coal formation;
- Chemistry: properties of selected compounds and elements, introduction to organic chemistry or

natural compounds;
Physics: properties of substances, measurement of physical quantities, energy resources, heat engines.

The module has a typical structure of a PROFILES module (see Table 1).

Teacher creativity and the scenario for the module on “Carbon nature of life”

An essential element of PROFILES modules is a motivating scenario. The training element is a relative novelty in the national curriculum of the Czech Republic. Creation and modification of a scenario requires a well-developed level of creativity. Our teacher-participant in the PROFILES project created a good professional competence for modifying motivating scenarios, including creating her original ones, in a short time.

The scenario as a brief and interesting story is often based on everyday experience and knowledge of students and in this sense is socio-scientific. The story of a scenario should be strongly motivational and should lead students to the asking of IBSE questions.

The module on “Carbon nature of life” contains a number of interesting, simple, visual experiments that are useful in instruction. The worksheet is

Module materials	
Scenario	<i>An interesting motivational story which introduces the issue of the subject matter which is the substance of the inquiry learning</i>
Student activities	<i>The guidelines for independent work of students in groups</i>
Methodology for teachers	<i>Materials for teachers including theoretical background and experiments</i>
Evaluation tips for individual tasks	<i>Assessment of students work</i>
Worksheet	<i>Worksheets help students to record their observation, reasons and answers. It includes a motivational entrance text. More importantly the worksheet guides the learning whether this is drawing on prior experience, seeking student ideas, procedures, controlling variables, suggesting degree of repeating experiments.</i>
Notes	<i>Additional information (for the teacher to use) If the teacher is wishing to be truly creative then the worksheets can be given here, so that the teachers has the opportunity to modify or substitute</i>

Table 1. The typical structure of a PROFILES module.

intended to be modified depending on the year and the subject. What is important is the selected level of the follow-up IBSE and the presumed prior knowledge and experience of students. Our example shows a modification for chemistry in grade 9 (students aged 14–15).

The Scenario for the Module on “Carbon nature of life”:

Part 1: 350 million years ago

It's warm, maybe hot and the air smells damp. Why not? We are in marshes and wetlands and there are huge Equisetaceae and Lycopodiophyta around us. The trees are not small at all. They have grown to 20 m, and some are probably 10 m more. The tree trunk has a diameter of more than 1 m. Giant dragonflies fly among the trees. If there was a man, he would be scared of a plane hurtling at him. This Meganeura has the wingspan of about 75 cm and the body length of about 250 cm. But it is no time to look at Meganeura. Suddenly, the wind rises and brings storm clouds. It starts thundering and becomes overcast. It starts pouring with rain. The water falls from the sky and the wind blows. It looks like a hurricane. Suddenly, trees start falling down. They fall into the swamp and start slowly sinking. Suddenly, the storm fades as quickly as it came.

Part 2: Some 20 years ago in the coal region near the city of Ostrava (town in coal region in the Czech Republic).

Coal miners work in a deep mine. They break off smaller and larger pieces. Suddenly they break off a piece with a nicely visible leaf. Where did it come from? Is this the magic of dwarves?

Part 3: Yesterday in our kitchen

I feel like eating something nice. What will I prepare? Maybe I like to have cocoa. I pour a little milk into a saucepan and heat it on an electric stove. Ring, ring. Who is calling? Well, Eva. “How are you?” We keep talking. Suddenly I smell burnt milk. I hang up and hurry to the kitchen. What a mess! When my mother comes home, she will tell me off – I have to wash everything quickly!

Teacher creativity and follow up IBSE experimentation within the module related to “Carbon nature of life”

In PROFILES, stage 2 relates to inquiry-based science learning. But this needs to stem from the motivational scenario introduced in stage 1 (which also determined the student's prior learning) for students. This suggests a link is needed so that the intrinsic motivation of students carries across from stage 1 to stage 2. If stage 1 concluded by students recognising the needed science to learn (to better understand the issues related to the scenario) and posing the inquiry question, the key initial aspect of inquiry learning is established. This is the scientific question component of IBSE. Once in place, of course, the inquiry-based experimentation can follow.



Figure 2. Neuropteris, retrieved from <http://cs.wikipedia.org/wiki/Soubor:Neuropteris.JPG> [25.02.2014]

The planning and carrying out of experimentation is an important part of IBSE. During the

implementation of CPD, the creativity of our teacher-participant in the PROFILES project resulted in the modification and creation of appropriate, student learning experiments for the PROFILES modules. It is recognised that IBSE experimentation in PROFILES modules needs to be appropriately presented and within the learning challenge appropriate and acceptable to students.

According to our teacher,

“experiments should be based on practical experience, or should illustrate real processes in a simplified version. The course of an experiment must be clear to students and linked with the practice and students’ experience. Experiments should be directly connected with the scenario.”

IBSE Activities within stage 2 of the module on “Carbon nature of life”:

The IBSE question for investigation stemming from the scenario can be in the following form:

If plants are the basis of coal and as plants were composed of a range of substances made up by combining elements of carbon, oxygen and hydrogen, then are these elements present in coal compounds, or in compounds derived from coal such as paraffin?

This can be broken down into subparts as follows:

- Is there evidence of carbon, oxygen and hydrogen in the compound paraffin (a derivative of coal)?

Procedure: What is our prediction (hypothesis)? How can we find out? What are your suggestions?

Of the many possibilities, the following is interesting. Students put a burning tea light in a beaker (any size that holds the tea light will do). After a while students cover the beaker with a Petri dish. When the tea light douses, the students are guided to observe the sides of the beaker as the tea light out. The students are then guided to pour limewater into the beaker and shake it. Write down the results of observations, explain them and then make appropriate inferences related to the initial

question posed. Students can take a picture of the reaction.

Students’ prior knowledge is needed here. Students should recognise that cloudiness on the sides of the beaker is connected with water vapour and that the cloudiness of the limewater is connected with the presence of carbon dioxide.

- Is carbon present in coal or substances that can lead to the making of coal e.g. wood?

Procedure:

Based on, for example, wood, students can again give their prediction (explaining why they predict the way they do), but the challenge is how to find out. This is now a real test of students’ ingenuity.

One possibility is: Students put dry sawdust in a test tube, close it with a stopper into which a glass tube has been inserted. To the second test tube students add limewater and the apparatus is appropriately assembled. Students heat the sawdust and observe what happens in both test tubes. Students disassemble the apparatus and on observing drops of a clear liquid on the side of the test tube with the sawdust, the students carefully wipe the side of the test tube with a swab that has been coated with powdered anhydrous copper sulfate (CuSO_4). The students also observe the change in the second test tube and write down the reactions and explain them.

Students’ prior knowledge in this case relates to the realisation that ‘suck back’ will occur if the apparatus is left to cool without being disassembled. The students should have experience that heating the air in a test tube will cause it to expand and thus bubble through the liquid in the second test tube. On cooling, the air contracts, sucking in the liquid from the second test tube and making the testing of the liquid formed in the first tube by the reaction no longer possible.

- Is carbon present in organic materials, detectable in the same way?

Procedure: Pick up the porcelain with forceps and put it in a candle flame for a few minutes. On

removing the porcelain from the flame, examine its surface. Pour separately sugar, flour in to a test tube, and also a small piece of plastic can be heated on a used 'beer' bottle top (only if a digester is available!). Put the test tube in the flame and heat it. Examine changes in the individual test tubes.

Teacher creativity and an IBSE worksheet for the module on "Carbon nature of life"

Each level of IBSE (confirmation, structured, guided, or open) requires different levels of teacher leadership in students' activities. The first and second levels of IBSE is based on appropriately modified instructions for students (in the open level inquiry students provide all instructions). These instructions may take the form of worksheets, which our teacher-participant in the PROFILES CPD creatively modified according to the individual educational needs of students.

Such worksheets can take on different shapes and content, depending on their form, which may interrelate with the textbook, workbook or additional worksheets. Our teacher used worksheets of the following structure:

A general worksheet structure (including a scenario):

1. Scenario
2. Questions directly based on the scenario
3. Science questions for investigation identified by teacher or by students (depending on the level IBSE) and a simplified procedure for recording experiments and observations adopted
4. Finally, additional questions can be given, guiding students to summarizing how they performed the activities and the learning outcomes they had gained

The development of a PROFILES teacher-leader

Our case study presents aspects of the development from a teacher-learner to a teacher-leader. Creativity plays a decisive role in this development. As our case study documents, all creativity elements mentioned by Guilford (1950) are developed:

- Resourcefulness – the ability to create a wide flow of ideas: The teacher-leader herself demonstrated her development from self-efficacy from the CPD to teacher ownership of the PROFILES ideas by the evidence of creating a new module and preparing for and

Worksheet questions based on scenario and experiments		
1.	<i>Is it possible to find the piece of coal with a visible leaf? Which natural process is responsible for the things on the picture number one?</i>	<i>Yes, it is the result of natural process - carbonisation.</i>
2.	<i>What was the appearance of the saucepan from the short story „Yesterday...“? To what colour has the milk changed? What was the reason for this change?</i>	<i>Saucepan was change into brown to black. This change was caused scorching of milk. Carbon in the milk was reduced to its elemental form.</i>
3.	<i>Is it possible to consider described experiments as an evidence of the presence of carbon in organic materials?</i>	<i>Yes, it is possible; carbon had to be a part of compounds from which it has been separated.</i>
4.	<i>Is it possible to consider described experiments as an evidence of the presence of carbon in organic materials?</i>	<i>Yes, it is possible; carbon had to be a part of compounds from which it has been separated.</i>
5.	<i>How is possible to prove the presence of oxygen in organic substances? What simple compound containing oxygen can help to prove it?</i>	<i>The appearance of the water is an evidence of presence of oxygen.</i>

Table 2. Worksheet questions

meaningfully leading a CPD programme for teachers.

- Readiness, perceptiveness – the ability to modify ideas or jump from one idea to another: The teacher-leader was able to exhibit sufficient ownership of PROFILES ideas changing the form of experiments and worksheets according to changing conditions when testing out the new module.
- Originality – unusualness of ideas – a key element of PROFILES in striving towards intrinsic motivation of students: The teacher-leader created a completely original, yet related to the underlying philosophy, PROFILES module.
- Imagination – production of ideas that are not obvious at first sight: The module on “Carbon natural of life” is evidence of teacher-leader’s imagination, because it is very difficult to include this topic in a module connected with daily life, while addressing the knowledge and skills required and the Czech curriculum and the intrinsic motivation of students asked for in PROFILES.
- Endeavour – creativity is not only inspirational, but also hard work. If current ideas are not enough, coming up with new ideas or approaches is important.

The PROFILES project demands nothing less for a teacher-leader. It is not enough to work industrially; it is necessary to try out new solutions, reflect and evaluate in an action research cycle until the goal is reached. The teacher-leader in her effort to create a new module not only worked intensively, but also tried different ways, leading to the creation of a high quality module. Similarly, as a leader of a group of teachers, she did not use a tested strategy, but used an original one of her own which amply fitted the actual situation.

Barriers to teacher creativity

As our teacher confirmed, during her preparation for the role of teacher-leader she learned to overcome barriers that suppress creativity. She realized the barriers when cooperating with other colleagues and this action research approach enabled her to

overcome them.

Our teacher realized the barriers during her CPD and in our opinion they are typical within the Czech education system (and probably other systems which PROFILES is trying to address as well):

- Traditions – passive acceptance of old habits and transfer of stereotyped thought processes. Old and tested practices are often used. This barrier is perfectly described by often used statements:

“We have been teaching this for twenty years, and it has always been enough for students to understand.”

However, this may lead to a failure to address educational problems arising due to changes in learning styles of students, etc. This barrier may limit future teachers before they have the opportunity to apply creative approach to work, because they keep experience from their own students’ period consciously or unconsciously.

- Stereotypical perception – the inability to view a problem from different perspectives and in different ways can lead to the use of well-established teaching methods, because they are considered the most appropriate. The teacher uses these well-established methods for all students and fails to recognise the importance of intrinsic motivation of students.
- Prejudice against the new – the reluctance and fear of trying new methods, which can lead to loss of motivation to learn new procedures.
- Emotional barriers – fear of errors that can mean the loss of students’ recognition, fear of failure, which may lead to decrease or loss of the career position. Emotional barriers are often based on inadequately increased desire for safety, security and order, increased reluctance to improvise etc. This group of barriers, however, includes the tendency or inclination of opposite nature: excessive or uncontrolled enthusiasm,

which can lead to unpremeditated and inappropriate introduction of new teaching methods and result in undesirable outcomes. The subsequent failure can lead to teacher's demotivation and return to old traditional methods.

- Organizational barriers – school management which requires observance of well-established teaching methods and does not support students' and teachers' creativity, colleagues' unwillingness to cooperate on innovative teaching, inadequate school facilities, etc.

Conclusion

This case study explores causation in order to identify important CPD factors and present these in the spirit of the PROFILES philosophy. The multidimensional case study illustrates many of the processes in the development of a teacher-leader. In this case study, we identified great creative teacher development, which is very important for students, because creativity is one of the most important factors in their lifelong learning and future success. According to experts, however, only a creative teacher can educate a creative student.

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Appendix

1. A professional CV of our case-study teacher-leader:

A primary school teacher at a village school with almost twenty years of experience. Her specialization is mathematics and chemistry at higher primary school, at present she teaches also physics, ICT or art. She has experience in teaching biology.

2. Excerpts from the case-study diary:

“I started my PROFILES teacher career in the autumn of 2011, when I was invited to a seminar on IBSE, conducted in the Faculty of Education at Masaryk University.”

“I was interested in information from different researches, involving students aged 12–16 years. It concerned their way of thinking and school preparation and their approach to education. We started with the basic information and finally got to IBSE.”

“I was surprised that teachers in other European countries face the same or similar problems. I personally regarded the unwillingness to learn and reserved approach to education, increasingly observed in my students, as a consequence of changes in our country in 1989. Suddenly, the

teacher position and the role of school and education in general began to decline in our society. The unwillingness to work in foreign schools was news to me.”

“Finally, I realized that our children, as well as children throughout Europe, have access to the Internet and get the feeling that there is everything you need. Unfortunately, it is difficult to explain that there are things they should or must know.”

“We were offered Inquiry-based Science Education (IBSE) and related teacher training as one of the possibilities how to involve our students in the process of learning and show them the beauty of science and its laws that can be illustrated in simple, but interesting and entertaining ways. Moreover, we would not use purely academic information, but we would base teaching on students’ practice and experience or their knowledge from previous instruction.”

“I must admit that although it seemed interesting to me and I liked the four presented IBSE levels based on students’ skills and abilities, I did not believe it could work. I might have been too sceptical, but I felt my effort in instruction would have zero results.”

“At the Brno introductory seminar we discovered PARSEL modules. They are very interesting and our task was to decide which one we wanted to use in practice. Although we were divided into groups according to our specialization and preferred subjects, it was not easy for us.”

“Finally, our group of chemists decided on “Brushing up on Chemistry”. The module seemed to us more interesting and above all, enjoyable for students. It uses an activity that children should do every day at least twice – teeth cleaning and dental care. Moreover, working on this module should make students realize the importance of dental care and how they can protect their teeth from decay and themselves from unpleasant appointments with the dentist.”

“I started my preparation with some scepticism.



It was important to study the prepared materials thoroughly and think over the individual steps. Our lecturer Eva Trnova prepared further additional texts very carefully introducing the issue of dental caries and proper dental care. What was important for my own work was a text with an overview of various substances occurring in toothpaste. It was the basis for my own adjustment of the module.”

“I usually do not accept unchanged didactic or methodical materials. To be able to work naturally with “suitable” texts, I almost always perform minor adjustments and modifications. Because I am aware of literacy problems of our students, I like working with offered texts. They can be texts from textbooks, magazines, science books, or articles on the Internet. Students learn through tests how to focus on texts and find important and relevant information. Their findings need to be processed and for this purpose I prepared worksheets.”

“Suddenly, I found out that I was being entranced by IBSE. I buried myself in work, looking for ways how to prepare and present all the information and materials. Without realizing it, I started to learn.”

“I learned to think about motivating students and about making them reflect on a given topic and learn by themselves. It is probably the biggest benefit of participating in the PROFILES project for me.”

“As I understand the context of work in the PROFILES project, one of the CPD principles is the need to create independently and adapt the discussed curriculum creatively. It is important for teachers such as me to have theoretical, methodological information, motivation and a model. Then most of us are capable of working independently and creatively within the chosen method.”

3.7 Chemistry in Projects (ChiP) – An Evidence-based Continuous Professional Development Programme and its Evaluation Regarding Teacher Ownership and Students Gains

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Introduction

Within Work Package 5 (PROFILES, 2010; Bolte, Holbrook & Rauch, 2012), the PROFILES group at Freie Universität Berlin (FUB) is conducting different programmes of teachers' continuous professional development (CPD) courses for pre-service as well as for in-service science teachers (Streller & Bolte in progress). Most of the FUB CPD courses are founded on "evidence based approaches" (Harrison, Hofstein, Eylon & Simon, 2008; Taitelbaum, Mamlok-Naaman, Carmeli & Hofstein, 2008). Besides this, all FUB CPD courses are grounded on evidence based insights among others on those which we received through analyses of the "PROFILES Curricular Delphi Study on Science Education" (see WP3 in PROFILES, 2010; Schulte & Bolte, 2012).

In this contribution we introduce one of our CPD programmes and the impact of this educational offer

- (a) on the participants of our CPD programme and
- (b) on the pupils taught by the CPD participants in a PROFILES based project week.

The CPD programme we concentrate on is dedicated to pre-service science teachers. In this report we will show how this course – based on insights we received from the PROFILES Curricular Delphi Study on Science Education" (Schulte, & Bolte, 2012) – has an impact on pre-service teachers to take ownership for improved science teaching (see WP6 in PROFILES, 2010; Schneider and Bolte, 2012) and how pupils may benefit from the outcomes of the CPD courses (see WP7 in PROFILES, 2010; Bolte, 2006; Bolte & Streller, 2011; 2012).

Sources of evidence

The CPD course programme for pre-service teachers focused on is situated within the FUB Bachelor programme for becoming science (esp. chemistry and biology) teachers.

As briefly mentioned above we use as *one source of evidence* the analyses of the PROFILES Curricular Delphi Study on Science Education" (Schulte & Bolte, 2012). Especially the priority-praxis-differences identified in the Delphi-Study offer useful hints about the aspects which should be focused on more intensively in practical science education.

As *the second source of evidence* we are mainly focusing on outcomes from the participants of our CPD courses themselves, hence the participants give us information about their attitudes and concerns regarding the teaching of inquiry-based science lessons. To get systematic insights into their attitudes and concerns we are using the "Stages of Concern (SoC) Model" introduced by Hall and Hord (2011) and a specific SoC questionnaire which we adapted and piloted with regard to our research interest (Schneider & Bolte, 2012). This questionnaire was offered to the participants in a pre-post-test design and the analyses of this data are compared with data we received from a control group sample.

As *the third source of evidence* regarding 'better science lessons' we chose the pupils' assessments of how they perceived the "Motivational Learning Environment (MoLE)" in their science/chemistry classes (Bolte, 2006; Bolte & Streller, 2011; 2012). Furthermore, this investigation also serves as a factor for the evaluation of the impact of our CPD programme, because the MoLE assessment is based on the pupils' perceptions during the time they were taught in an inquiry-based way ("the PROFILES way") by the pre-service teachers who participated in this

PROFILES oriented CPD programme of the FUB. To investigate the ‘Students’ (Pupils’) Gains’ (see WP7 in PROFILES, 2010) we collected the data using the MoLE instrument in a pre-post-test design (Bolte & Streller, 2008; Bolte & Kirschenmann, 2009).

Framework of ChiP “Chemistry in Projects” and its evaluation

A main goal of all FUB CPD programmes in general and of the course sequence for Bachelor (BA) teacher students in particular was – and still is – to influence the participants’ professional attitudes towards the implementation of IBSE in and other best practice approaches for school practice in a positive manner, because in accordance to the theory of planned behavior (Ajzen, 1991) positive attitudes affect the probability of the IBSE implementation in school practice. In other words: Pre-service (or in-service) teachers, who are more concerned regarding IBSE and who have more positive attitudes towards inquiry-based teaching and learning can be labeled as professionals with the intention to take “ownership” (Ogborn, 2002; Pratt, 2001; Hofstein, Carmi & Ben-Zvi, 2003) for teaching in an IBSE oriented way. Hence professionals who are taking or show ownership for innovative practices or an innovative approach will probably teach their classes in this way. Therefore, enhancing “teacher ownership” regarding IBSE approaches in science education practice is one of the overarching goals of all PROFILES CPD programmes (see WP6 in PROFILES, 2010).

The IBSE related CPD programme of the FUB group is based on the PROFILES four stages CPD model as it is described in Hofstein et al. (2012; according Loucks-Horsely, 2010; Bolte, Holbrook & Rauch, 2012). On the basis of this model, the teacher students have to go through four different stages in the course of their professionalization. This process can be easily illustrated comparing it to four different roles or functions: In the course of their educational training, individuals which are concerned about their professional development act (1) as learners (“teacher as a learner”). The learned content is then tested by the students in their own lessons; here they take on the role (2) as

teachers (“teacher as teacher”). By critical reflecting of their lessons afterwards, the participants act and experience themselves as (3) reflective practitioners (“teacher as reflective practitioner”). If this reflection process results in a positive evaluation of these measures, then this leads to an attitude of “ownership”, and the (pre- or in-service) teacher is then going to share his/her experiences with other teachers. In those cases the person takes on the role of a “disseminator” or “promoter” – this role is labeled in the PROFILES context as: the “teacher as leader”(see Ogborn, 2002; Pratt, 2001; Hofstein, Carmi & Ben-Zvi, 2003).

Even if the “four stages CPD model” seems to be a hierarchical structured model the FUB PROFILES group is convinced that this is not the case. “Reflective teachers” are always acting as “teachers” and as “learners” while they teach and because they reflect their teaching they learn new things about their teaching and their classes. Therefore, the FUB PROFILES team recommends to term this model the “PROFILES four dimensional CPD model” because – as we will explain later – there are no different hierarchical stages (or levels) which are reached or not reached one after another by a (pre- or in-service) teacher.

To investigate the impact of the PROFILES CPD programmes at FUB on the development of professional attitudes and especially on “teacher ownership” we focus as mentioned above either on the “Theory of Planned Behavior” according to Ajzen (1991) and on the “Stages of Concern (SoC) Model” by Hall and Hord (2011).

The SoC theory and model itself is based on teacher professional development studies by Fuller (1969). Fuller (1969) proposed a four-dimensional concern-based model of professional development; with increasing experience in an educational programme, the teachers’ concerns pass through four dimensions: “Unrelated”, “Self”, “Task” and “Impact” (Fuller, 1969). “Unrelated” means that teachers have developed no or little concerns regarding the educational programme. “Self” refers to the impact the educational programme has on a person. “Task” covers the management of time and/or materials, and for the dimension “impact”

the focus is on collaboration and the impact of the educational programme on students.

Hall and Hord (2011) differentiate Fuller's four dimensional concerns model into seven "stages" and termed these stages "Stages of Concern" (see Figure 1).

Stage A: "Unconcerned" is identical with Fuller's dimension: "Unrelated". Fuller's dimension: "Self" is modified by Hall and Hord (2011) into two stages: Stage B: "Informational" and Stage C: "Personal". Stage B: "Informational" deals with knowledge about the educational programme, while the Stage C: "Personal" shows how the use of an educational programme will affect a person. Hall and Hord's Stage D: "Management" is identical with Fuller's dimension "Task" while Hall and Hord prefer and recommend to differentiate the Fuller's dimension "Impact" into three stages, namely in Stage E: "Consequence" which is focusing on the impact of the educational programme on students, Stage F: "Collaboration" which refers to coordination and cooperation with others (e.g. other colleagues), and Stage G: "Refocusing" which explores further benefits from the educational programme, including the possibility of improvement.

Overview of the CPD programme for Bachelor (BA) teacher students at FUB: What should the students learn, how should they teach and what should they focus on in their reflections?

The CPD programme we are introducing here is part of a science and chemistry education curriculum for Bachelor teacher students at FUB who decided to become chemistry teachers (8 Credit Point (CP) in total). This BA science and chemistry education programme consists of three courses. In the first course the teacher students take part in lectures

and seminars labeled as the "Introduction to Science and Chemistry Education" (2 CP). The second courses sequence is dedicated to the planning of science and/or chemistry lessons in general and organized by seminars and workshops (3 CP). The third part of this programme (3 CP) – we term "Chemistry in Projects (ChiP)" – is divided into three parts:

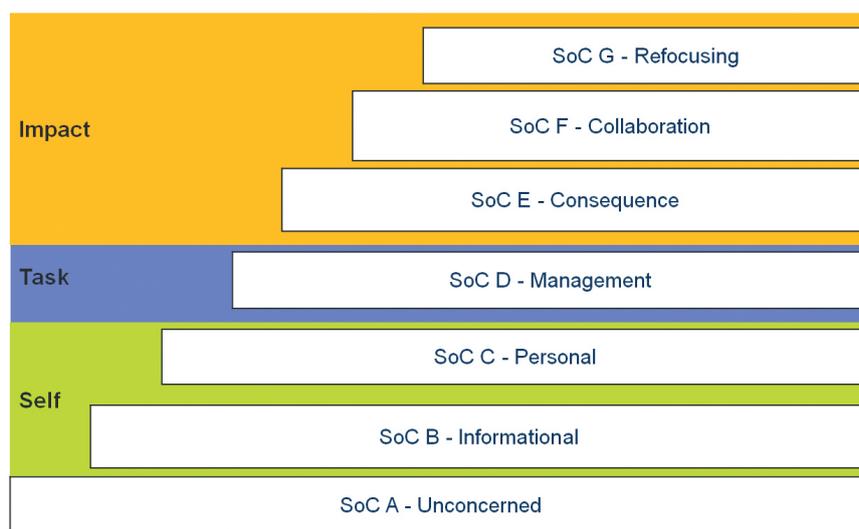


Figure 1. Stages of Concern model according to Fuller (1969) and Hall and Hord (2011)

In the first part the teacher students are introduced to the concept of inquiry-based science education (IBSE) which is mainly based on contemporary IBSE approaches and for sure on the philosophy of PROFILES (PROFILES, 2010; Bolte et al., 2012; AAAS, 2000; Bybee, 2004; National Research Council, 2000, Schmidkunz & Lindemann, 1992; 2003). They learn how to plan science lessons in general and lessons based on IBSE in particular. In this part the teacher students are acting 'as learners'. After this introduction they start planning 'their science lessons' by cooperating in groups of two or three – just 'as teachers' would do it. At the end of this period, the teacher students have to present the planned lessons to the other course members in a poster session and they are asked to discuss the lessons they planned. In this period the participants are acting 'as reflective practitioners'. In most of the cases the teacher students revise their first proposals in order to optimize the structure of the planned lessons (Loucks-Horsley et al., 2010, p. 206).

In the second part of this CPD course the teacher students meet a class of 7th or 8th grade in order to teach it in a specific project which takes a whole week (5 days and app. 35 hours per week). Now the pre-service teachers are acting ‘as teachers’. At the end of a project day the groups who taught the classes come together to reflect what they did with respect to their planned lessons and what they observed in the lessons of the other course members. Here, the participants are acting ‘as reflective practitioners’.



Picture 1. Teacher students as learners



Picture 2. Teacher-students as teachers

The third part of this CPD programme starts when the project week is over. Now, the participants have to write a report about their experiences while teaching their lessons and while observing the lessons of their course mates. This part ends with a one day seminar at the university. During this seminar the participants are reflecting and discussing the project week as a whole. They share their experiences and impressions regarding their own teaching and the teaching of the others they observed (Loucks-Horsley et al., 2010, p. 206). Once

again they are in the role of a ‘reflective practitioner’.

After this course nearly all of the participants change to the FUB Master programme for becoming science teachers. In the Master courses at FUB two more PROFILES based CPD programmes are offered for the teacher students. Within the Master programme we can observe that in some (but not all) cases even teacher students reach the attitudinal level of “taking ownership”, for example by creating and disseminating additional PROFILES type modules (Fischer, 2011; Fischer, Richter & Bolte, in progress) or by preparing and organizing workshops for teachers (Streller & Bolte in progress).

Questions of interest regarding our evaluation

In the context of this PROFILES CPD project – we call Chemistry in Projects (ChiP) – we focus on the questions:

- How can we describe pre-service science teachers’ IBSE-related attitudes and concerns and how do these attitudes and concerns change in the frame of the FUB’s CPD treatment programme?
- Is there evidence that the participants of our CPD course develop their professional skills in the direction of taking ownership for (better) IBSE teaching?
- How does the PROFILES based project week created and realized by the CPD participants correlate with the pupils’ assessment regarding the motivational learning environment they perceive in these PROFILES based science courses?

How we evaluated the impact of the evidence-based CPD programme ChiP

We evaluated the advantages and disadvantages of ChiP by focusing reflectively on two sources of evidence. As mentioned above we are analyzing the professional concerns and attitudes of the teacher students participating in our programme and how these concerns may change. Besides this we also investigate – whether and in which manner pupils might benefit from the pre-service teachers

professional development if the pupils are taught by the teacher students of our CPD course.

Method of analyzing pre-service teachers' professional concerns and their development

To evaluate this CPD programme for pre-service teachers we adapted an instrument to analyze (pre-service) teachers' profession-related attitudes and concerns about the implementation of IBSE in school practice. This instrument is based on the "Concerns-Based Adoption Model" of Hall and Hord (2011) and their work regarding the "Stages of Concern" (SoC).

For our analysis we adapted a German questionnaire version of SoC (according to Pant et al., 2008 and Hall & Hord, 2011). An adaption was necessary because the SoC questionnaires of Pant et al. (2008) and those of Hall & Hord (2011) neither focused on pre-service teacher students nor on IBSE. To ensure the scientific quality of our adaption, we created three additional items for three of the seven SoC scales (namely for scale B, C, and G; see Figure 1). Therefore, in our questionnaire version the stages A, D, E, and F are represented by five items and stages B, C and G by 6 items in our questionnaire version. According to Hall & Hord (2011), each item is combined with a rating scale from 1 "Not true of me now" to 7 "Very true of me now". Furthermore, if the content of an item is currently not relevant to a person at all, there is also the possibility to choose "0" as this is recommended by Hall and Hord (2011).

In the frame of a pilot-study we explored the reliability of our SoC scales (Schneider, Bolte 2012) and tried to reduce the number of items to 4 items for each scale. This way, we managed to reduce the number of items and ensure the reliability of our questionnaire version. Now, applying our modified SoC questionnaire renders information about the testees' attitudes and concerns – in our case towards the implementation of IBSE – by creating "SoC-profiles" as termed by Bitan-Friedlander, Dreyfus & Milgrom (2004).

For the evaluation of this CPD programme we chose

a pre-post- and a treatment-control group design using the adapted SoC questionnaire. This SoC questionnaire was given to the CPD participants before and after the CPD course while the CPD course itself served as the treatment. Students of the BA programme for becoming science teachers who did not participate in this CPD course yet build the sample of the control group.

Method of analyzing whether and to what degree the pupils gained benefit from the CPD programme

To find out whether and to which degree the pupils involved in the CPD programme benefited from this course an evaluation procedure has been used, which was also agreed on by the PROFILES consortium regarding the project evaluation within our engagement in WP7 "Student Gains" (WP7 in PROFILES 2010). This procedure also focuses on a pre-post-test data collection and on a treatment measure design. The treatment takes place through the participation of the pupils in the project week, which is organized and conducted by the pre-service teachers in the frame of the CPD programme.

The focus of our study is the investigation of how the 'Motivational Learning Environment (MoLE)' is experienced by the pupils a) in their regular classes (before the treatment) and b) in the PROFILES based project week (after the treatment). Therefore, we asked the pupils to evaluate the motivational degree of their chemistry lessons at school on the basis of the "Motivational Learning Environment" model (Bolte, 2004) before the project week (pre-test), because this way, we get to know how motivational the pupils experienced the learning environment in their regular chemistry lessons. At the end of the project week, the pupils are asked once more to evaluate the motivational learning environment; however, this time (post-test) we ask them to evaluate the project week instead of their regular classes.

The theoretical based and empirically sound MoLE model and the instrument for the analyses of motivational learning environments in science classes based on this model (Bolte, 2006; 2004)

are focusing on seven aspects (variables or MoLE dimensions); namely:

- Satisfaction,
- Comprehensibility,
- Subject orientation
- Relevance of the topics,
- Opportunities to participate,
- Class cooperation
- Willingness to participate.

Each MoLE dimension is only represented by two items. There is a seven-point-rating scale to assess the items coded from 7 (very positively assessed) to 1 (very negatively assessed); the code of “4” expresses a neither-nor-assessment. Prior investigations using the MoLE instrument showed that the MoLE questionnaire provides reliable and valid results (Bolte, 2006).

The comparison of the pre- and post-test-results help us to find out whether the treatment “participation in the PROFILES based project week” will lead to a more positive assessment of the motivational learning climate (even if this project week will be realized by professionally less experienced pre-service science teachers).

Impact of the FUB evidence-based CPD programme on the pre-service teachers professional concerns

The results, which are described in the following paragraph, are based on data, which we collected from 38 CPD course participants. It is worth to mention here that we only considered the data from participants, which took part in both, the pre- as well as the post-test data collection. The analyses of the control group are based on the data from 133 students; at the time of the data-collection these students had not participated in the BA CPD programme yet.

At the beginning of the academic term the treatment (blue line) and control group (grey dashed line) show a lesser degree of awareness considering IBSE compared to the findings at the end of the treatment (blue dashed line). Both groups wish to get more information about IBSE and search for cooperation to plan and conduct an IBSE-based learning environment and attractive science lessons. The pre-test results of the treatment group did not differ from that of the control group in a statistically significant manner. Regarding our treatment study, we can observe a development of the pre-service teacher students’ attitudes and concerns about the

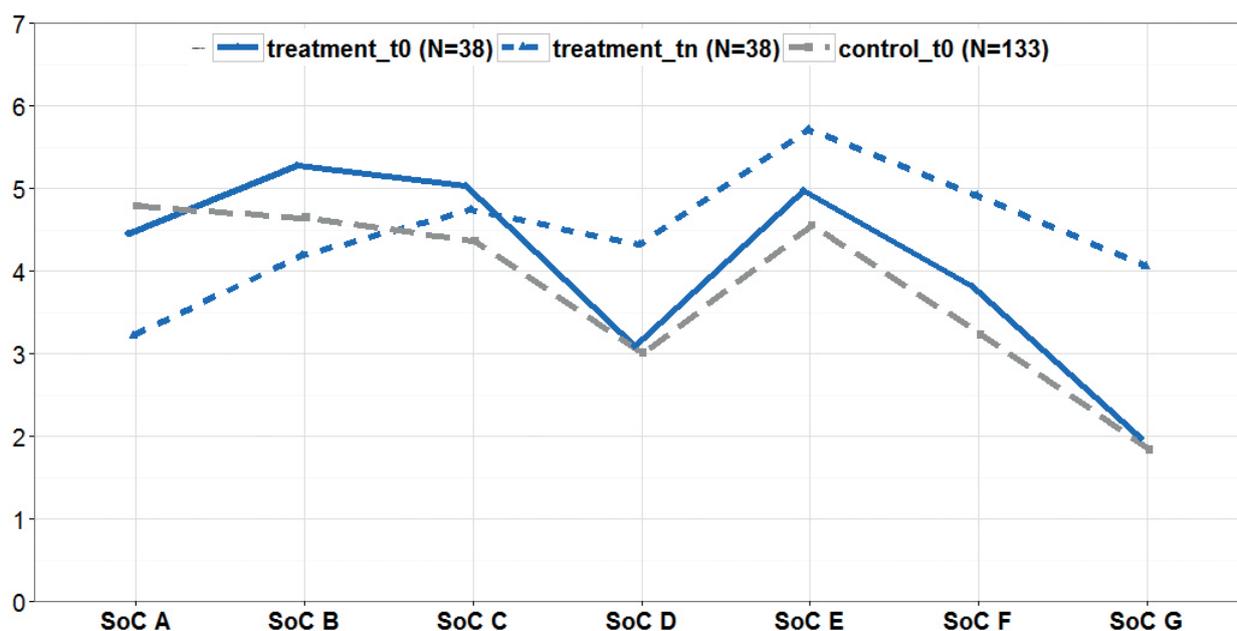


Figure 2. SoC profiles of the PROFILES treatment group and control group; SoC A - Unconcerned, SoC B - Informational, SoC C - Personal, SoC D - Management, SoC E - Consequence, SoC F - Collaboration and SoC G - Refocusing

implementation of IBSE, because we are able to identify according to Bitan-Friedlander et al. (2004) the typical SoC profile of a “cooperator” at the end of our treatment course.

A closer look shows that the participating pre-service teacher students are more aware about IBSE and have a stronger focus on management tasks at the end of the CDP course. Considering the SoC scales “Consequence”, “Collaboration” and “Refocusing”, the pre-service teacher students were also more concerned about these aspects at the end of our CPD treatment course. If we compare the post test findings of the treatment group (N=38) either with their pre-test results or with the findings of the control group sample (N=133), the positive development regarding the SoC scales: “Unconcerned”, “Informational” “Management”, “Collaboration” and “Refocusing” becomes obvious; the tests of significance show that the differences are statistically significant.

The pre-post analyses of the data as well as the comparison of the results of the treatment- and control-group show that according to the SoC profiles of Bitan-Friedlander, Dreyfus and Milgrom (2004) the pre-service teachers of our treatment group developed more ‘positive’ and more open-minded attitudes regarding IBSE towards the end of our CPD courses (see Figure 2). Hall and Hord (2011) pointed out that such results can be considered positive for the implementation of innovative educational programmes. Regarding the findings for management concerns, Hall and Hord (2011) state that a first step of using an innovation – in our case the IBSE approach – is present when management concerns are higher in post-test than pre-test analyses.

Impact of the FUB evidence-based CPD programme on the participating pupils

In the following paragraphs, the results of the FUB students’ gains data analyses which we got in the course of the intervention programme are focused on. When we wrote this contribution, in total 4 classes participated in the FUB programme so far (in the meantime 9 classes in total and more than 250

students have been involved in the FUB PROFILES based ‘Chemistry in Project CPD-treatment’). These classes came solely from public schools; the pupils of these schools are taught on the basis of the local curriculum. For the analyses we collected the data of 110 pupils (62 male and 48 female).

We find a positive impact of the inquiry-based science teaching of our pre-service teachers regarding the MoLE assessments of the participating pupils at the end of the project week (see Figure 3). Let us now try to explain these findings in detail:

Taking a look at the results of the data we collected before the treatment, we can see that nearly all MoLE variables are assessed more or less positive by the pupils; hence the variables are higher rated than 4.0. ‘Nearly all MoLE variables’ because only one variable – the variable “relevance” – was not assessed by the pupils in a positive manner; the mean of this variable is 3.5 in the pre-test-analyses.

Summing up, we can state that the motivational learning environment regarding the regular chemistry classes is assessed quite positively by the pupils. However, looking at the results of the pre-data-analyses it becomes also clear that there are possibilities to optimize the motivational learning environment in classes like this.

That it is really possible to enhance the motivational learning environment in classes such as this becomes obvious if we take a look at the results of the data-analyses we received after the treatment (and especially if we compare these results with the results of the post-treatment-analyses). Again we can state that nearly all MoLE variables are assessed more positively by the pupils now; once more the means are higher than 4.0. However, we have to say “nearly all MoLE variables” because again one variable is not assessed by the pupils in a positive manner, but this time it is not the variable “relevance” like it was the case in the pre-test-analyses (now the relevance of the topics covered in the lessons are assessed very positively; the mean of this variable is 5.0 in the post-test-analyses); in the post-test-analysis the variable “subject orientation” is estimated by the pupils lower than 4.0. So we can assume that the subject orientation

was not overemphasized in the treatment lessons as it often is to find in ‘conventional science classes’ (Bolte, 2006).

Since we know that during the project week the pupils had – indeed – to deal quite often with science subject matters we explain these results as follows: Because the science contents have been embedded into contexts relevant to the pupils they did not realize that they have dealt with both, science subject matters and topics they are confronted with in their everyday life; or maybe more than this: Because the science subject matter was embedded in contexts and questions they are dealing with outside the school and the science topics they worked on in the project week helped them to answer these questions, the science contents itself became relevant and lost the threatening face that “sciences” often have in the opinion of pupils.

Furthermore, we can point out that the motivational learning environment in the project week was assessed more favorable by the pupils than it was assessed with respect to their regular chemistry classes. Here, all MoLE variables – except the variable “subject orientation” – and the variable “willingness to participate” were estimated higher in the post-test than in the pre-test assessment. Especially if we take a look at the MoLE variable “satisfaction”, the success of the treatment becomes clear because the assessment of this variable shows the highest increase if we compare the pre- and post-test findings.

But how can we explain the decrease of the pupils’ willingness to participate actively in lessons when the assessment of all the other motivational learning environment variables changes into a more positive direction than before? We would explain this with the theory of interest oriented learning: Hence the pupils were more (intrinsically) motivated to learn science within the project week they got into state

of “flow” (Bolte, Streller & Hofstein, 2013), even if they were engaged in learning science, and because of this flow they did not realize and/or assessed this the same way they usually would do. If this interpretation really fits to the motives why the pupils assess the MoLE as they did in our case study then we can assume that the treatment “teaching pupils based on the PROFILES approaches” leads to the results and impact we and the whole PROFILES consortium wish to reach; namely to a science education which fits the “students/pupils gains” (see WP7 in PROFILES, 2010; Bolte, 2006; Bolte & Streller, 2011; 2012).

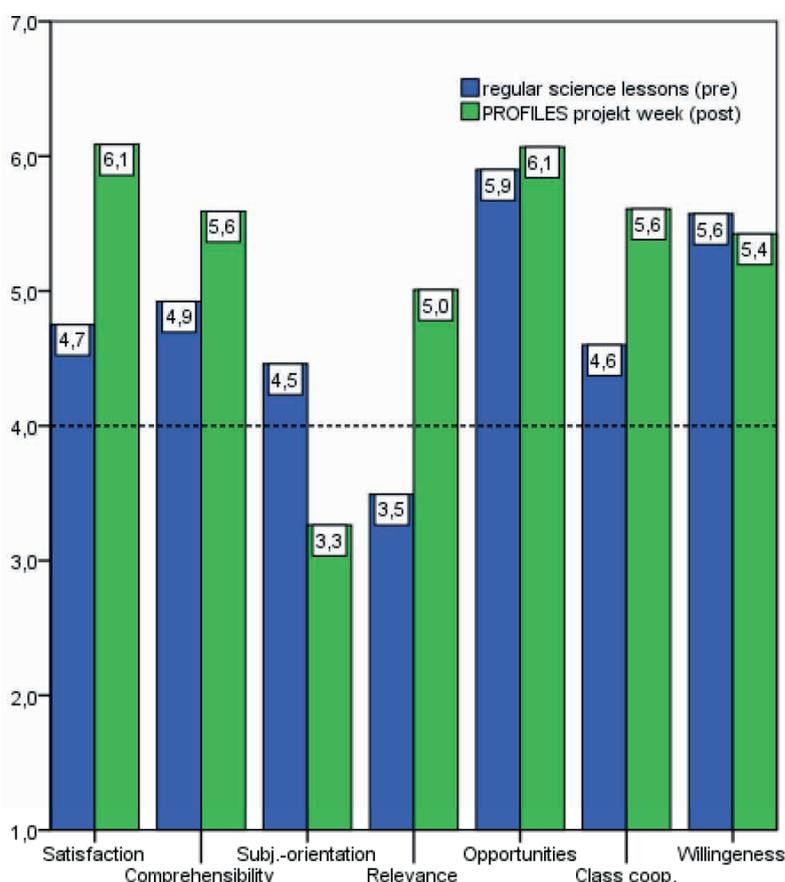


Figure 3. Pre and post results of MoLE assessment (N=110)

Conclusion and impact

Based on the evidence found by the CPD providers of this programme it can be concluded that the adapted SoC questionnaire is suitable to gain insights into pre-service teachers’ attitudes and concerns towards IBSE in general, and to evaluate a specific educational course offer (such as this

FUB CPD programme) within the framework of pre-service science teachers' educational courses at university in particular (Schneider & Bolte, 2012).

Taking everything into account we can state that our teacher students benefit from the CPD programme. Also the participating pupils' gained something positive from the PROFILES project week because they assessed the motivational learning environment in these classes much better than they estimated their regular science classes.

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3.8 Professional Development for Science Teachers: Experiences and Reflections

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Abstract

With the constantly changing demands posed by a modern approach to science education, it has become particularly important to determine the most effective methods for the continuous professional development (CPD) of science teachers, a major focus of the PROFILES project (Bolte et al., 2012). This article presents an approach to devising and implementing a CPD course to enable science teachers to develop their professional skills according to the goals of the project, particularly with respect to motivational inquiry-based learning by students geared to science education. The article discusses the conclusions drawn from the implementation of the CPD course and puts forward suggestions regarding further steps that should be taken in the development of teachers' professional skills, based on the opinions expressed by the participants and their evaluation of the CPD sessions.

Introduction

A major concern expressed by the European Commission (EC, 2007) is the lack of relevance of science education offered in European schools. All too often the lessons are seen as irrelevant for the students, promoting abstract academic science ideas without indicating their relationship with everyday life and interrelating science learning with the issues affecting the lives of students. PROFILES, an European Commission-supported project, seeks to address this problem by strongly promoting student-centred learning and teaching. The approach builds on students' prior learning and engages them in inquiry-based learning, as well as guiding students towards undertaking socio-scientific decisions. In this way science learning can impact on social issues in daily life and thus enable well-reasoned decisions to be made in a socio-scientific sense. For such a change of paradigm to take place, in-service support for teachers needs to receive more attention and it is a major focus of the PROFILES project.

Teachers' needs

An important element of implementing the PROFILES project is organising an effective continuous professional development (CPD) course for teachers. This means a course which caters to the professional needs of the teachers in areas related to the PROFILES philosophy and approach. To

determine these needs, a Likert-scale skills-needs questionnaire, developed within the PROFILES project was used. This questionnaire covered teacher competences through 50 items, grouped into 9 categories and was used to evaluate the extent to which the teacher felt they had developed these competences and their interest in further development. A three point scale identifying perceived need was used with 3 representing little need for professional development and 1 indicating a strong need. Teachers' also indicated levels of interest in receiving CPD, based on a 5 point Likert scale. A high level of interest is indicated by 1 and no interest by 5.

The teachers' responses are shown in Table 1.

The results of the teachers' self-evaluation show that, in general, the teachers see their professional competences as quite highly developed (the mean score for the level of professional competence development was 1.92).

Level of teachers' competence development

Although the participants declared that they had acquired the competences related to students' motivation and interest (1.80) most successfully, differences were recorded between the mean scores for particular categories of professional competences. Two items within this category

Category of competences	Items	Level of professional competence * (Mean)	Level of interest in further development** (Mean)
1. Nature of science	1–3	1.96	2.16
2. Scientific and technological literacy (STL)	4–7	1.90	1.94
3. Goals and process of education	8–13	1.91	2.01
4. Inquiry-based learning	14–17	2.04	1.84
5. ICT in science education	18–23	1.86	2.43
6. Integration / project method	24–30	2.04	2.34
7. Classroom learning environment	31–38	1.92	2.38
8. Students' motivation and interests	39–44	1.80	2.32
9. Assessment	45–50	1.84	2.17
All groups of competences	1–50	1.92	2.18

* Scale: from 1 (high) to 3 (low);

** Scale: from 1 (very high interest) to 5 (no interest).

Table 1. The results of the skills-needs questionnaire (No. of teachers responding = 30).

These were:

- (1) making students aware of the usefulness of the knowledge they have gained in everyday life (1.54), and
- (2) using suitable methods and aids to stimulate students' interests (1.56).

The implication of this is that although motivation and interest was included in the CPD, assumptions were that teachers recognised the importance of linking science to everyday life and that they recognised ways to stimulate student interest and were thus full aware of the need to maximise student involvement in the learning.

The competences which the teachers felt they had acquired the least successfully were related to:

- (1) inquiry-based learning (2.04), and
- (2) the integration / project method (2.04).

The implication here is clear. Both inquiry-based science education and integration within the teaching through PROFILES modules were made specific CPD components.

Within the category of competences related to the use of ICT in science education, the aspect acquired the least successfully was the ability to

use education platforms in the education process (2.52). And again this aspect was made a specific component of the CPD by introducing the teachers to the Moodle environment and its use.

Level of teachers' interest in further competence development (in receiving CPD)

The teachers' interest in developing their professional competences can be seen as relatively high, with a mean score of 2.18. The mean scores (see Table 1) for each category differed only slightly. The teachers expressed the greatest interest in developing their competences in the areas of: inquiry-based learning (1.84), and scientific and technological literacy (1.94).

Within the category of inquiry-based learning, the teachers were particularly interested in improving their skills in stimulating students' cognitive activity (1.75).

Both of these topics were seen as crucial for PROFILES teaching and included in the CPD as specific topics. While inquiry-based learning interrelated to inquiry-based teaching, the

emphasis in the CPD was on student-involvement in both the conceptual thinking as well as conducting the experimental operations, thus illustrating to teachers how the skills of stimulating cognitive activity can be increased. Through this, attention was paid to ways in which students could be involved in putting forward the science question for investigation, the prediction (hypothesis) related to the solution to the scientific problem and planning the procedure for carrying out the experimental work towards seeking evidence for the answer to the scientific question.

Two categories of the teachers' competences were given scores which indicate that the participants were not very interested in developing them, namely: the classroom learning environment (2.38), and ICT in science education (2.43).

However, out of the eight items included in the category related to the classroom learning environment, four had scores which showed that the teachers had high interested in learning more. These were:

- (a) creating teaching situations that would enable students to reach a consensus and make group decisions (2.04);
- (b) individualising students' work in class (2.17);
- (c) organising effective learning through group work (2.29), and
- (d) developing students' skills in oral and written communication (2.31).

Based on these results a major consideration for inclusion in the CPD was that the science teachers wished to develop their competences in:

- (a) motivating students and developing their interests;
- (b) using inquiry-based learning ideas;
- (c) making effective use of the classroom environment;
- (d) using assessment strategies, especially related to formative assessment;
- (e) using the project method as a way of integrating science content (the project method is obligatory in schools in grades 7–9).

These competences are not only within the scope

of the PROFILES project, but they are also included in the priorities for education in the core curriculum developed by the Polish Ministry of Education (MEN, 2008; Janiuk, Samonek-Miciuk & Dymara, 2012). One of the important goals for general education in grades 7–9 in Poland, to be achieved in science classes, is for students to apply their knowledge gained when completing tasks and solving problems, as well as how to plan, conduct and document observations and experiments. The document, drawn up by the Ministry, more specifically emphasises that students need to be assisted in developing the following competences:

- (a) scientific thinking; that is being able to use scientific knowledge to identify and solve problems and also to draw conclusions based on observations and experiments concerning society and the environment;
- (b) using ICT effectively;
- (c) finding, selecting and (critically) analysing information;
- (d) interpreting information and explaining causal relationships;
- (e) identifying examples of phenomena in the real world governed by the laws discussed in class;
- (f) using the knowledge and skills acquired in class in everyday life;
- (g) developing an interest in the world around them, and
- (h) working in a team.

The core curriculum also emphasises that schools should pay special attention to the effectiveness of science education, since, as stated in the priorities of the Lisbon Strategy, it is the key for further progress in Poland and Europe.

The PROFILES CPD programme for teachers

The initial expectation was to base the CPD programme on a suggested PROFILES model, composed of the following 4 components:

- teacher as learner (learning more conceptual or content science);

- teacher as teacher (raising the PCK of teachers);
- teacher as reflective practitioner (reflecting on teaching);
- teacher as leader (giving guidance to other teachers and obtaining evidence for the success of PROFILES).

However, in discussions with the teachers at the start of the course, it was found that the need for further support in science conceptual ideas (the teacher as learner) was unnecessary and teacher as leader (preparing teacher to seeking evidence of their acceptance and ownership of PROFILES ideas) was left for other occasions. The CPD model was thus solidly centred on raising the PCK of teachers and their reflections on their teaching.

When designing the CPD course, carefully consideration was given to the outcomes from the teacher skill-needs questionnaire described above and the priorities of the Polish policy

regarding science education. Moreover, the CPD programme was also prepared according to professional development (PD) principles adopted in the PROFILES project, using evidence-based best practice strategies. These PD principles were:

1. introducing the 3-stage model on which the PROFILES approach was based;
2. planning school-based interventions by the teachers to promote inquiry learning for the students using PROFILES teaching-learning modules;
3. approaches to engaging students in creative, scientific problem-solving and socio-scientific decision-making procedures;
4. enhancing students' motivation for learning science.

Thirty teachers from lower secondary schools in the Lublin region enrolled on the first round CPD course. The participants are described in Table 2.

No. of teachers enrolled	No. teachers completing the course		Subject taught				Years of experience	
	Female	Male	Chemistry	Biology	Physics	Geography	10–15 yrs	15+
30	23	3	16	5	4	1	10	16

Table 2. Background of the teachers enrolled on the PROFILES CPD course

Schedule	Topics / Contents / Activity
On-line communication (e-learning using a Moodle platform)	<ul style="list-style-type: none"> • Questionnaire: Teachers' acquisition of professional skills and needs regarding their improvement. • Making the teachers familiar with the philosophy of the PROFILES project and devising the CPD course. • Receiving the teachers' suggestions as to the content of the course. Revising the course. • Making the teachers familiar with the modules which were developed in the PARSEL project so as to choose the modules which best suited the requirements of the Polish education system with regard to science subjects.
Face-to-face meeting October 2011	(a) Education through science: lecture and group discussions. Developing competences indispensable for citizens for self-fulfilment, social integration, having an active civic attitude and obtaining skills appropriate for the job market. STL importance and principles in science education.

Schedule	Topics / Contents / Activity
Face-to-face meeting October 2011	(b) Workshops for teachers – topics: <ul style="list-style-type: none"> • Inquiry-based science education and its organisation. • Conducting a lesson based on a socio-scientific scenario. Group decision-making among students. Student benefits. • Making the teachers familiar with the 3-stage model of the PARSEL modules and • Participants choose the modules they will try out in the classroom. • Dividing the teachers into groups according to the module they had chosen. Teachers suggest modifications to the modules (workshop). • Reflection (focus group discussion). • Meeting evaluation (teachers' satisfaction).
November 2011 On-line communication (e-learning platform, chat, Skype and discussion forum)	<ul style="list-style-type: none"> • Having the teachers suggest adaptations of the modules. • Creating and organising the learning environment. • Planning instructions and interventions. • Sharing experiences.
December 2011 Face-to-face meeting	<ul style="list-style-type: none"> • Presentation of the final version of the modules. • Revising their final version based on the remarks of the teachers from the groups working on other modules. • Reflection (workshop, group discussion). • Meeting evaluation (teachers' satisfaction). • Instructing the teachers how to survey students using the MoLE questionnaire.
January 2012 Face-to-face meeting	<ul style="list-style-type: none"> • Integration in science education-project method • Methods and tools of formative assessment (lecture). • The teacher as a researcher. • The importance of teacher reflection (workshop, group discussion). • The teacher as a leader (lecture, general discussion). • Meeting evaluation.
February-May 2012 On-line communication	<ul style="list-style-type: none"> • Implementing the modules and gathering the outcomes. • Group discussions. • Mutual support and sharing experiences.

Schedule	Topics / Contents / Activity
June 2012 Face-to-face meeting	<ul style="list-style-type: none"> The teacher as an originator of the learning process. The importance of teacher networking in professional development (general discussion). The PROFILES modules and student benefits (general discussion). The PROFILES teachers and their benefits in the area of professional development (general discussion).
December 2012	<ul style="list-style-type: none"> Final evaluation of the CPD programme. Giving the teachers certificates confirming their participation in the PROFILES project and their acquisition of relevant qualifications.

Table 3. Programme of the CPD course.

The course model was based on blended learning, which included face-to-face meetings and e-learning between meetings. This is because some participants lived in places which were located quite far away from the University and it would have been very difficult to organise frequent face-to-face meetings. Since the skill-needs questionnaire

showed that the teachers had difficulties communicating using a Moodle platform, using this platform in the training course was an opportunity for them to improve their skills in this respect. The final version of the course programme is shown in Table 3.

No.	Title of the module	No. of teachers who chose the module	No. of teaching sessions per module
1.	The pantry at our homes. Food preservation	3	3
2.	Should vegetable oils be used as fuel?	2	5
3.	How can we use cleaning agents in a safe and effective way?	4	4
4.	How does the type of soil influence plant growth?	7	5
5.	Popcorn: a fat free snack	4	4
6.	How can we avoid wasting energy and reduce maintenance costs at home and at school?	4	4
7.	Milk – keep refrigerated	4	3
8.	What is worse: cigarettes or narghile?	2	4

Table 4. Modules selected for implementation

PROFILES modules

An important feature of the CPD course was that the teachers selected the modules taken from those developed in an earlier project (PARSEL) and adapted them to the Polish education system (see Table 4). The teachers' choice of modules was largely based on whether or not the content was related to the requirements for each science subject defined in the core curriculum. This related to:

- (a) biology and chemistry – knowing the factors influencing human health, being aware of the impact of our behaviour on preserving our health, including healthy eating, paying attention to food quality and avoiding addictive substances (such as drugs, alcohol and nicotine);
- (b) biology, chemistry and physics – environmental education, including current issues related to energy (e.g. biofuels); environmental pollution, including from households (detergents, waste, etc.) and their influence on the natural environment;
- (c) biology – explaining the impact of biotic and abiotic factors on the phenomena and processes in living organisms and the environment, explaining how the living organism is influenced by the conditions in the environment and its quality (including the factors which impact the growth of plants).

The module “The pantry at our homes. Food preservation” was developed based on the PARSEL module entitled “A big problem for Magellan: food preservation”. The scenario for the students was changed in the Polish version. It was based on examples from Polish literature (poems, novels). Moreover, the topic concerned food preservation in the climate zone where Poland is located.

The module “How can we use cleaning agents in a safe and effective way?” was based on the PARSEL module “Which cleaning agent should we use?” It was modified to include a different set of experiments which were to help the students learn how particular cleaning agents often used in Poland work and to discuss issues related to environmental protection.

No.	The aspect of the course	Mean \bar{X}
1.	Organisation of the course	1.6
2.	Accessibility of the topics discussed	1.9
3.	Achievement of the course goals including the intervention in teaching IBSE	1.5
4.	Level of difficulty of the topics discussed	2.1
5.	Teaching methods actively involving the participants	1.9
6.	Training materials used	1.8
7.	Instructors' preparation for the sessions	1.4
8.	Instructors' support in clarifying doubts and difficulties	1.4
9.	Time management	2.2
10.	Group collaboration and communication with colleagues	2.6
11.	Instructors' communication skills	1.5
12.	Atmosphere during the sessions	2.3
13.	Appeal of the sessions	2.1
14.	Overall evaluation of the course	1.6

Table 5. Teachers' opinions related to the effectiveness of the CPD course.

The module “How does the type of soil influence plant growth?” was inspired by two PARSEL modules: “Growing plants: does the soil matter?” and “Which soil should we use?” A new scenario was used to introduce the topic. The students also performed observations and experiments, including bio-tests which make it possible to determine which biological and physical-chemical agents influence the growth and development of plants. Special attention was paid to the problem of the degradation and preservation of soils.

The module “How can we avoid wasting energy and reduce maintenance costs at home and at school?” was created as a result of modifying two modules, namely “How can we avoid wasting energy in our school?” and “How should we heat our houses?”

Special attention was paid to the relationship between the type of fuel used to heat buildings, the costs of heating buildings in our climate zone and issues related to environmental pollution.

The remaining four modules shown in Table 4 (No. 2, 5, 7, 8), were used unmodified.

The effectiveness of the CPD course in the teachers' opinion

A post-evaluation questionnaire consisting of 14 items was devised and implemented, after the CPD course was completed, to determine to what extent the course had satisfied the participants' expectations. The teachers were asked to rate the effectiveness of its implementation using a Likert scale from 1 (maximum) to 5 (minimum). The results of the evaluation are presented in Table 5.

The table shows that the participants rated the course highly. Both the mean score for the overall evaluation of the course (1.6) and the mean values for particular categories that were evaluated are below the value of 3, the midrange of the ratings, 1–5.

The categories rated the highest were:

- instructors' preparation for the sessions (1.4);
- their help during the course (1.4);
- their communication skills (1.5), and
- the achievement of course goals concerning IBSE (1.5).

Comment

It is particularly gratifying that achievements concerning IBSE were well received by the teachers and in general the teachers felt the course provided meaningful guidance and helped them during the intervention using PROFILES modules in the classroom situation. From this outcome, it is clear that the mainly high assessment of the course by participants (overall 1.6) was from the positive attitudes of the teachers and the strong preparation and support by the PROFILES team.

The aspects which received the lowest ratings were:

- the collaboration between the participants of the course (2.6);
- the atmosphere during the sessions (2.3), and
- time management (2.2).

The difficulties in communication between the participants and the low effectiveness of their collaboration largely contributed to the fact that four out of the eight modules were not modified by the teachers. These problems also had a negative impact on time management and the atmosphere during the course; for example, the providers very often had to extend the time assigned on planned tasks for teachers, and frequently supported focus group discussions acting as moderators.

A further factor here is perhaps the limited time allocated to reflection on the implementation of modules by the teachers and especially the opportunity to comment on the way other teachers have undertaken their teaching.

Teachers' involvement

The information on teachers as teachers and teachers as reflective practitioners was collected by the CPD providers, who observed the teachers' level of activity during CPD workshops and on-line communication. This was particularly important, as the data gathered through observation made it possible to assess the level of the teachers' competences and compare this against the data from the teachers' assessment of their own competences after implementing the modules; it also allowed the organisers to decide on modifying the programme which was to be implemented in the second round of the CPD course. The results of the observation by the CPD providers are shown in Table 6 (scale: 1-maximum, 5 minimum).

It was observed that the teachers had the greatest difficulty modifying the modules (4.1). Such a form of activity requires creativity and critical thinking on the part of the teachers and suggests that strong initial guidance is needed before teachers gain sufficient self-efficacy in this direction, which the course trainers only rated as 3.8. Collaboration

using the Moodle platform was rated merely at 3.9, although this was seen as a very important element of the CPD course. The elements which caused the teachers the least difficulty, according to the trainers, were:

- (a) understanding the 3-stage module of teaching, and
- (b) planning the implementation of the modules, developed in the PARSEL project.

Teachers as teachers

In order to survey the teachers' views on their competences related to science education in accordance with the PROFILES model, a questionnaire was carefully constructed. The questionnaire was completed by the teachers after they had implemented the modules in their schools. The teachers were asked to assess their level of acquisition of 8 categories of competences using a 5 point Likert scale listed on a scale, 1 (maximum), 5 (minimum). The categories, together with the mean scores, are shown in Table 7. This is also an indicator of the self-efficacy of the teachers towards PROFILES.

In general, the teachers rated most successfully:

- the educational effectiveness of the topics covered in particular modules (1.8);
- their competences in the area of creating an

- atmosphere conducive to learning (1.4), and
- promoting collaborative learning (1.5).

Unfortunately, the teachers, as a group, rated their professional skills in developing intrinsic motivation the lowest (2.4). This strongly indicated that it was necessary to put more emphasis on issues related to motivation in the second round of the CPD course, which was duly noted. In the second round it was also felt that more attention needed to be paid to promoting scientific and technological literacy (STL) in science education.

The outcomes from the questionnaires showed that before starting the CPD course, the teachers rated their professional competences higher than after implementing the modules (see Table 1 and Table 7). This is particularly noteworthy with respect to:

- STL (1.9 before the course and 2.2 after the course);
- students' motivation (1.8 and 2.4, respectively);
- strategies of IBSE (2.04 and 1.8, respectively);
- the classroom learning environment (1.92 and 1.4, respectively), and
- assessment (1.84 and 2.1, respectively).

These outcomes were interpreted to mean that teachers felt that they needed less support in these topics following the CPD course. Thus thanks to taking part in the professional development

No.	Activity observed	Mean \bar{X} (1- max.; 5 - min.)
1.	Adopting the 3-stage model of teaching (CBL, IBL, decision making) and understanding its relevance	2.2
2.	Modifications made to modules	4.1
3.	Critical thinking and creativity	3.8
4.	Participation in discussions	3.4
5.	Systematic and accurate performance of tasks	3.2
6.	Group collaboration and communication with colleagues	2.8
7.	Active involvement in module adaptation, IBSE planning, etc. during workshops	3.5
8.	On-line cooperation with other teachers and other on-line activity	3.9
9.	Work organisation	2.7

Table 6. Assessment of Teachers' learning activity by the CPD providers during CPD meetings

course the teachers became more aware of their competences and the level of their self-efficacy improved, thus indicating that an important goal of the CPD course had been achieved.

Teachers as reflective practitioners

At the end of the CPD course, interviews were conducted with the 26 participants in order to survey their opinion on how they think they should improve their work if they wished to achieve better results in teaching based on CBL, IBSE and socio-scientific decision-making (Hofstein & Mamlok Naaman, 2013). The data gathered in the interviews supplemented the results of the survey described above and showed that the teachers had concrete needs regarding their teaching.

The teachers' responses show that they think they need to focus on the following aspects more when organising the teaching/learning process in the future (the responses were categorised and are presented starting from the most frequent to those least frequently mentioned):

- (a) motivating all students to learn actively (22 teachers – 84.6%);
- (b) making students aware of the opportunities offered by inquiry-based learning (19 teachers – 73.1%);
- (c) assisting students by clarifying concepts, processes and phenomena (18 teachers – 69.2%);

- (d) guiding students in their tasks by posing suitable questions (16 teachers – 61.5%);
- (e) improving students' decision-making skills (14 teachers – 53.8%);
- (f) providing students with opportunities to record information, by using tables and diagrams (12 teachers – 46.1%);
- (g) making sure that the students' inquiries are completed (10 teachers – 38.5%);
- (h) improving students' laboratory work skills (9 teachers – 34.6%);
- (i) evaluating students' progress in acquiring knowledge and skills (8 teachers – 30.8%);
- (j) guiding students' cognitive activity by asking them questions (6 teachers – 23.1%).

The teachers' responses confirm that their participation in the PROFILES project gave them an opportunity to reflect upon, analyse and draw conclusions concerning the organisation and implementation of the process of teaching/learning. The responses also show that attention to motivation in the PROFILES philosophy is important and teachers are becoming aware of the need for intrinsic motivational approaches. Also, the teachers are becoming more aware of student-centred teaching. Thanks to taking part in the course, the teachers show they are becoming more reflective practitioners. They appreciate the influence of the actions undertaken by teachers on students' motivation in the learning process and the importance of paying attention to the key elements of a good classroom learning environment.

Categories of teachers' professional competences	Mean \bar{X} (1- max.; 5 - min.)
1. developing the scientific and technological literacy of the students in a multidimensional aspect; teaching in context	2.2
2. promoting collaborative learning	1.5
3. using educational tasks based on socio-cultural dimensions	1.9
4. using tasks which stimulate intrinsic motivation	2.4
5. using strategies for inquiry-based learning	1.8
6. classroom learning environment/atmosphere conducive to learning	1.4
7. developing meaningful assessment/feedback strategies	2.1
8. effectiveness of teaching/learning module assessed overall	1.8

Table 7. Teachers' self-efficacy outcomes after the CPD course

Conclusions

An analysis of the implementation of the PROFILES project carried out with the aim of finding optimal ways to improve the professional competences of science teachers has shown that the project has brought its participants many benefits.

1. The teachers were able to develop their professional skills thanks to the opportunity to diversify the forms of work and methods used in class and to gain access to materials developed based on the latest advancements in the field of teaching science subjects.
2. They were able to extend their knowledge both in the subject-area and in methodology by participating in sessions and symposia organised as part of the project.
3. They improved their skills in diagnosing the needs and interests of their students and stimulating their intrinsic motivation.
4. They appreciated the importance of being able to evaluate their work.
5. They were able to cooperate and share experiences with other science teachers.
6. Many of the participants had an opportunity to take part in an international project and to communicate with the science teacher trainers from UMCS for the first time.

It should be borne in mind, however, that the greatest and final beneficiaries of the PROFILES project were expected to be the students who were taught by the teachers that participated in PROFILES. It was expected that the changes in the methods used by their teachers would have a positive impact on students in terms of developing their talents and interests in science subjects and that it would encourage them to adopt an active attitude towards research, improve their skills in collaborative work and raise their self-esteem by making them gain confidence in their own abilities and potential. Another valuable outcome of the project was building a good rapport between the teachers and students, based on openness and respect. As an additional benefit, it was recognised that the schools whose teachers participated in the project would also benefit from it. These schools would be able to offer better education

opportunities and to improve the quality of education, thanks to creating an atmosphere conducive to modernising the methods used in the classroom among all teachers, some of whom could start using more innovative methods of teaching. Such changes could have a positive influence on the reputation of the schools and help raise its prestige.

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**SECTION 4:
CASE STUDIES ON PROFILES
NETWORKING AND DISSEMINATION**



Case Studies on PROFILES Networking and Dissemination

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PROFILES envisages the setting up of teacher networks (and interacting with other networks) to both maximise the dissemination and to make teachers more aware of the PROFILES project and the goals it is setting out to achieve. To get a common understanding of networks and the factors that determine them, the theoretical background of networks is briefly explained.

In the early 1980s, the notion of “networks” became very popular within society as a whole and the scientific community in particular. Naisbitt (1984) talked about a “megatrend” of transformation within and of hierarchies, arguing that informal networks of small groups have become necessary in order to optimize organisational processes of problem-solving which could no longer be performed by hierarchical structures. According to Castell’s (2000) notion, networks constitute a new social morphology in society, where dominant functions and processes are increasingly organized around networks. New information technologies provide the material basis for its pervasive expansion throughout the entire social structure. Castells (2000) conceptualizes his notion of ‘network’ as a highly dynamic, open system consisting of nodes and flows. In the wake of these general social trends and structural transformation, networks in educational contexts have also become increasingly attractive in educational systems. In the 1990s, systemic school modernization processes were launched by policymakers, prompted by the need for reformatory change in the light of the results of international assessment (like the TIMSS and PISA studies). Intermediate structures (Czerwanski, Hameyer & Rolff, 2002) such as networks are expected and conceived to fill a structural gap and take over functions traditionally assigned to the hierarchy. Ideally, networks are conceived as an interface and an effective means of pooling competencies and resources (Posch, 1995; OECD, 2003). As intermediate structures, they manage autonomy and interdependent structures and processes, and try to explore new paths in learning and cooperation between individuals and

institutions.

The development of PROFILES networks was based on international work in the field of educational networks and social networking theories. In this process, authors consider the following aspects paramount (Rauch, 2013):

Mutual Intention and Goals: Networks orientate themselves on a framework topic and goal horizon that has been agreed upon by all (Liebermann & Wood, 2003).

Trust Orientation: Mutual trust is a prerequisite for exchanging and sharing knowledge, and therefore a prerequisite for learning. Networks encourage new, innovative paths (risk-taking) and support conflict resolution (McDonald & Klein, 2003; McLaughlin, Black-Hawkins, McIntyre & Townsend 2008).

Voluntary Participation: Networks do not impose sanctions. Interventions can be vetoed (Boos, Exner & Heitger, 2000; McLaughlin, Black-Hawkins, McIntyre & Townsend 2008).

Principle of Exchange (Win-Win Relationship): Information can be exchanged whenever an occasion arises. Mutual give and take is vital. Power and competition, while not being excluded, are addressed and dealt with between the centre and the periphery on the same level (OECD, 2003; McCormick, Fox, Carmichael & Procter 2011).

Steering Platform: Networks are not occasional interactions, but institutionalized configurations. Networks have to be coordinated and maintained in order to support exchange processes, cooperation and learning (Dobischat, Düsseldorf, Nuisl & Stuhldreier, 2006).

Synergy: Networks enable synergies through structural organization; they offer an alternative to classic rationalization strategies and are characterized by the dismantling of structures (Schäffter, 2006).

Learning: Networks are support systems based on reciprocity. Those involved can exchange views and information, and cooperate on mutual concerns. They learn from and with each other (Czerwanski et al., 2002; O’Hair & Veugelers, 2005).

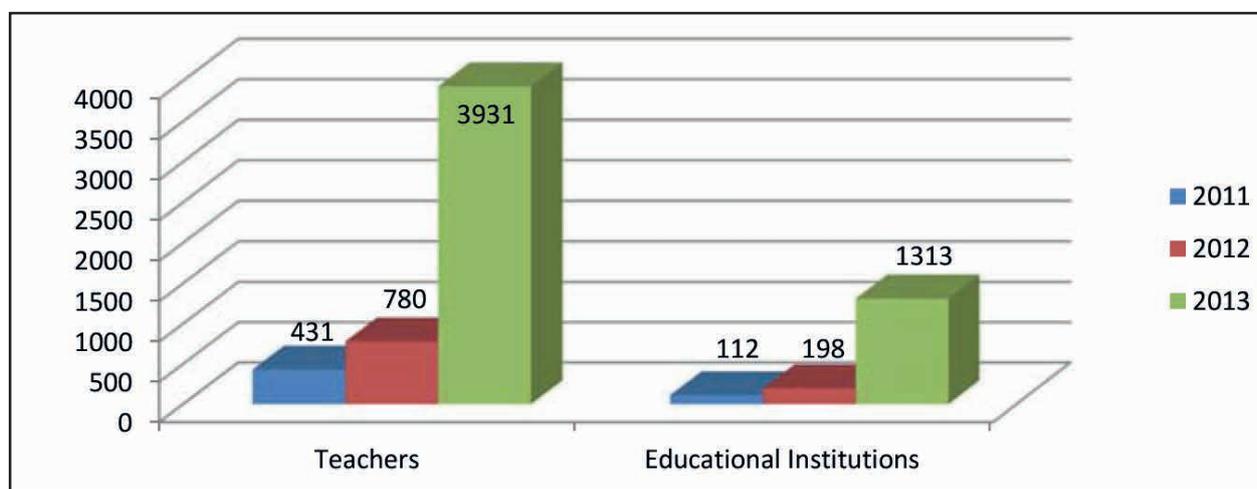
Per Dalin’s (1999) description of how networks function in education is an important theoretical basis underlying the formation of networks in the PROFILES project. Accordingly, networks have an informative function which becomes visible in a direct exchange of practice and knowledge for teaching and school, and as a bridge between practice and knowledge. Through networking, further opportunities for learning and competence development (professionalization) are encouraged by the members, who establish the learning function. Trust is a prerequisite for cooperation within a network. It is the basis for the psychological function of a network which encourages and strengthens individuals. In a fourth function of networks, the political function, enforceability of educational concerns increases, following the motto “together we achieve more”.

Although the initial situation differs in every partner country, all partners can build on already existing structures (Rauch & Dulle, 2012). After two years of PROFILES, progress is visible in all partner countries. In April 2013, PROFILES networks (in connection with other science education networks) include 3.931 teachers and 1.313 educational institutions across all partner countries. Furthermore, 10 partners involve 26 non-educational institutions.

Based on the data of an annual network questionnaire, graph 1 shows the development of PROFILES Networks from 2011 to 2013. Within the past two years, all partners significantly increased the number of participants (teachers and institutions) involved in their network processes. By 2013 PROFILES networks (in connection with other science education networks) include 3.931 teachers and 1.313 educational institutions across all partner countries. Furthermore, 10 partners involve 26 non-educational institutions.

Within PROFILES, networks are distinguished with regard to their complexity, from networks at schools to inter-school networks and networks at local, regional, national and even international levels. Networks at the level of teacher-groups, schools and local structures are likely to be closely linked to instruction and may contribute the most to improvements in the regional structures (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



Graph 1. Development of PROFILES Networks from 2011 to 2013

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 at 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.

- International networks
- The networking takes place at an international level, mostly as part of international projects (i.e. PROFILES), or existing structures (like ICASE).

Taking a look at the types of networks existing in PROFILES countries (see Table 1), we can see that 19 (of 21) partners already set up *teacher networks* (cooperation of science teachers in one school) and 18 partners include *school networks* (cooperation of two or three schools). *Local and/or regional networks* (partnership of schools within one school district/region) exist in 15 partner countries. 12 reported to have *national networks* (nation-wide scope of the programme), and 9 include *international networks* (collaboration at an international level).

PROFILES Partner	Teacher NW	School NW	Local/Regional NW	National NW	Internat. NW
Austria	✓	✓	✓	✓	✓
Berlin	✓	✓	✓	✓	✓
Bremen	✓	✓	✓		
Cyprus	✓	✓	✓		
Czech	✓	✓			
Estonia	✓	✓	✓	✓	✓
Finland	✓	✓	✓	✓	✓
Georgia				✓	
ICASE (Nantes group)					✓
Ireland	✓	✓	✓	✓	✓
Israel	✓	✓		✓	
Italy	✓	✓			
Latvia	✓	✓	✓	✓	
Poland	✓	✓	✓		✓
Portugal	✓	✓	✓		✓
Romania	✓	✓	✓		
Slovenia	✓	✓		✓	
Spain	✓		✓	✓	✓
Switzerland	✓	✓	✓	✓	
Sweden	✓	✓	✓		
Turkey	✓	✓	✓	✓	
Total	19	18	15	12	9

Table 1. Types of Networks in PROFILES partner countries

The concept of the types of networks is not a step-by-step model. PROFILES networks exist in every partner country, but not all of them cover teacher networks. A school, network for example, does not necessarily build upon a teacher network, and a local network can exist without teacher- and school networks. Georgia includes a national network of Biology teachers, but no local networks at schools. The partner, ICASE (International Council of Associations for Science Education), is an international network/association itself and covers only the international network dimension. At the moment, ICASE is about to build up a PROFILES teacher network in France. Spain covers all network types, except a school network, because the Spanish schools work independently. And some PROFILES countries, like Ireland, Finland, Estonia, Austria and Germany/Berlin, include all types of networks.

To determine the supporting and hindering factors of networks, partners, in completing a questionnaire, show that PROFILES Networks are mainly supported by the following six factors:

1. *Information and Communication Technology (ICT)*: The communication via e-mail, videoconference or an online forum/platform, as well as the distribution of information and news via the project webpage, is mentioned by nine partners as an essential support in the networking process.
2. *Interest and motivation of teachers and participants*: Seven partners see the interest, motivation, and thus enthusiasm, of involved teachers concerning the content (e.g. new teaching methods, Inquiry-based Science education etc.) as an important support factor, because the participation in networks is voluntary.
3. *Support of institutions and other networks*: The facilitation and support of PROFILES networks by institutions, like ministries of education, universities as well as science education networks and programmes is valued by six partners. The support in this respect ranges from providing contacts to teachers, schools, municipalities and institutions and providing locations and experts for teacher trainings to

promote the networking process.

4. *EU projects like PROFILES*: Five partners are of the opinion that the participation in EU projects like PROFILES supports the local networking process to some extent, mainly due to the international dimension (wide dissemination level) of such projects.
5. *Clear network concept*: To structure the networking process, two partners use a clear concept. Austria includes the experiences from the IMST project and Slovenia set up a concept based on the support of experienced consultant and leading teachers.
6. *Curriculum reform*: The change of educational framework conditions (curriculum reform) in the two partner countries Cyprus and Sweden supports the development of educational networks.

Evaluation data show that barriers to the networking process are located mainly in the fields of resources (lack of time and finance) and interest (lack of motivation of teachers and participants). Eight partners reported that networking does not only request time and administration from the side of the network coordinator in the sense of a steering platform (Dobischat, Düsseldorf, Nussli & Stuhldreier, 2006), but also from the participating teachers to be able to attend network meetings and workshops. Moreover, teachers need additional time to implement the PROFILES modules in class. Another eight partners consider the lack of finance as a barrier. To assume travel costs of teachers is an incentive to enable their participation in meetings and workshops and thus, expand the network. Because networking is voluntary (Boos, Exner & Heitger, 2000; McLaughlin, Black-Hawkins, McIntyre & Townsend, 2008), it depends strongly on the motivation of the participants. Seven partners report a low motivation of teachers and other participants to engage in the networking process. Moreover, partners mention the additional workload appearing due to the network process and the need to meet other obligations, like the regularly work for teachers in school or the participation in other projects. Five partners report constraints due to the framework conditions in their countries. In Cyprus, Portugal, Slovenia, Switzerland and the Czech Republic, there is a lack

of an existing network structure/tradition that can support the establishment of networks in science education.

Although there are these challenges, partners are optimistic about the future. An outlook to 2014 gives an insight into the planned activities and next steps of PROFILES partners to facilitate their network processes. Partners focus mainly on expanding the network, including new members and interlinking with other networks and associations. The activities need to be disseminated to a wider circle via the attendance of different national and international conferences. Furthermore, partners plan to conduct regional and/or national seminars and workshops. Some partners also intend to increase the use of information and Communication Technology (ICT) and include online and virtual networking sessions.

The following three case studies give an insight into the development and the role of PROFILES Networks in the partner countries of Latvia, Austria and Romania, based on evaluation data.

In Latvia a teachers' collaboration network was created as a multi-level model that acts at the national, municipal and school levels involving approx. 480 teachers of natural sciences and mathematics, school leadership, experts, municipal specialists, and the Center for Science and Math Education at the University of Latvia (CSME). Teachers involved at the national level study together with CSME experts with the aim to share experiences with other teachers in the local (municipal) network. The teachers' network is a new, successful, horizontal model for teachers' learning and for dissemination of innovative ideas (like PROFILES philosophy) and promoting a new teaching experience in Latvia. Although it has a strong impact on teachers' performance, it requires substantial input from both experts and teachers. The local network succeeds where it involves school leadership and municipal education experts.

While educational networks are quite a new structure in Latvia, in Austria they are already well established for several years. The nation-wide 'IMST' (Innovations Make School Top) project aims at improving instruction in mathematics, science,

IT, German language and related subjects. To put innovative instructional projects into practice IMST supports regional networks in all nine Austrian provinces, and three thematic networks which operate at national level. To some extent, they fill the gap of lacking subject didactic centres in higher education throughout Austria and provide research-based didactic professional development for teachers. The IMST Regional Network of Vienna acts as a basis for the Austrian PROFILES Network by providing initial coordination and the contact to the teachers. Covering approx. 50 teachers, the Austrian PROFILES Network is structured as a community of practice, a regular working group, characterized by cooperation and reflection.

In Romania, the dissemination and networking activities are seen mainly in relation to the development and results of the national accredited teacher training/continuous professional development programme. Within the frame of PROFILES, a collaborative teacher network is established to provide teaching and research interest in the field of science, to offer opportunities to cooperate actively, and to promote exchange of ideas and materials for training, by disseminating best practices, seminars, workshops etc. Actually, the Romanian network is based on *lead teachers* within PROFILES Continuous Professional Development courses, who play an important role in the extension of the PROFILES Network at the national level.

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4.1 National Networking of Teachers as a Tool for Dissemination of Innovative Teaching

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Abstract

This article reviews experiences in Latvia on possibilities of exploiting a model of a teachers' collaboration network for professional learning and promoting the further dissemination of the *PROFILES* philosophy related to scientific inquiry.

Introduction

The implementation challenge associated with change is to make real changes occur in the classroom. The implementation of scientific inquiry, which forms the basis of FP7 Science in Society projects of which one is *PROFILES*, started in Latvia in 2008. It offers developed samples of inquiry-type modules to teachers and students and organizes in-service training classes for teachers as a part of a holistic reform.

The *PROFILES* teacher needs questionnaire, administered in October 2011, shows that irrespective of the teacher's experience, in undertaking scientific inquiry for two or more years, teachers feel (66 participants) there is a strong need to learn to:

- promote higher order thinking skills amongst students (82%),
- encourage students to ask questions and discuss (65%),
- develop students argumentation skills (71%),
- provide suitable positive motivational changes (67%) etc.

The teachers themselves have also expressed a very strong need to improve their reflection skills.

This finding corresponds with data gained from piloting a new curriculum. During lesson observation in schools between 2009 and 2011, a group of experts working in the National Center for Education (NCE) under project 'Science and Mathematics', witnessed a range of successful teaching performances but also frequent cases that needed attention. Although the students were

formally divided into groups in such cases and the assigned task contained a short scenario and a problem, the scientific inquiry during the lesson was organized as a frontal, teacher controlled process of delivering information, which involved questioning and practical work. When analysis and reflection of the lesson took place, the discussion with the teachers revealed that the teachers thought their performance qualified as scientific inquiry. The experts concluded that there was a discrepancy between the actual performance of the teachers in the classroom and their understanding of what they were doing. Apart from that, it was obvious that teachers had insufficient skills for teaching scientific inquiry and exploiting methods typical for an open learning process, for example, group work, discussions, discovery, etc.

The lack of skills had a grounded explanation. Traditionally a science subject teacher was educated as a teacher of a single subject (chemistry, physics, biology) and acquired a science based programme (up to 90% of the subject content). Moreover, for a number of years, teacher in-service training was mostly organized as delivery of new information. A school usually employed only one physics, chemistry or biology teacher and the exchange of experience among them, or between schools, was poor or focused mainly on delivery of new information. As a result, many teachers' views and teaching knowledge were limited to their personal experiences, or the manner in which they were taught at school. Therefore developing new forms of teachers' professional development was crucial.

As research in western countries shows (Olson, 2003), teachers may well be more comfortable with

teacher-directed and controlled lessons. The main differences between education traditions in the east and the west, not only in Russia as mentioned by Pavlova and Pitt (2003) and the UK, is that the focus lies on:

- the whole class versus the individual;
- uniformity versus individual needs of the student;
- specialization versus breadth of knowledge;
- depth of knowledge and theoretical approach to inquiry versus empirical approach;
- content versus practice.

A very important point is the fundamental differences arising from the country's historical experience. This means that apart from learning new philosophies, new content, new teaching-learning strategies and gaining ICT skills, teachers need to change their beliefs about what constitutes teaching.

If a teacher lacks the skills to use inquiry-based modules (irrespective of whether local or PARSEL or PROFILES type modules), students fail to experience meaningful and efficient learning in the classroom. Neither students nor teachers themselves see any benefits from such insufficient methods for study. The teacher is the key for successful implementation of scientific inquiry and for this, he/she needs the necessary teaching skills, experience in teaching elements of scientific inquiry and an awareness of the benefits that this teaching orientation brings to the students and to him/herself as a professional. Accordingly, one of the ways a teacher can learn of other teaching experiences and skills is to initiate a system which enables teachers to learn from each other and share their scientific inquiry best practices. This suggests that, alongside traditional hierarchical teacher in-service training patterns, alternative approaches need to be introduced. Such an example is a collaboration and teacher's mutual experience exchange-based model. In the case of the Latvian system, it means both, at the same time, a change in teacher's practices in the classroom and also the training process.

The quality of the teacher is the single most important determinant in the learning by student

(Sanders, 1998). Professional teaching is about improving as an individual, raising the performance of the team, and increasing quality across the whole profession (Hargreaves & Fulan, 2012). It is assumed that improvement in teaching is a collective rather than individual enterprise and that analysis, evaluation and experimentation in concert with colleagues are the conditions under which teachers improve (Rosentholtz, 1991).

In the western world, different teacher collaboration groups and networks have been operating, at least since the 1980s. Naisbitt (1984, cited from Rauch) talked about a 'megatrend' of transformation within and of hierarchies, arguing that informal networks of small groups become necessary in order to optimize the organizational processes of problem-solving, which can no longer be performed by hierarchical structures. The message is not about whether we form professional learning communities, use smart tools, or conduct data teams; rather it is about teachers being open to evidence of their impact on students, critiquing each other's impact in light of evidence on such impact, and forming professional judgements about how teachers then need to – and indeed can – influence learning of all students in their class (Hattie, 2012).

Through the development of teacher professional collaboration models in Latvia, during the project 'Science and mathematics,' we came across a successful model in one school where a team of science and mathematics teachers included a representative from the school leadership. The results obtained corresponded to the views of Fullan (2011, p. 34): well developed teamwork improves the quality of practices as teachers work and learn from each other. Cooperation within this model was organized as sharing (materials & teaching strategies) and joint work – where teachers teach, plan or inquire into teaching together. This encouraged us to find ways of using this practice in the implementation of PROFILES project ideas.

Despite the evidence and the fact that almost every other profession conducts most of its training in real-life settings (doctors and nurses in hospitals, clergy in churches, etc.), very little teacher training takes place in a teacher's own classroom, the

precise place in which it would be relevant enough to be most effective (Barber & Mourshed, 2007, p. 27). We thus focused learning for the teachers on real-life practice at school.

The goals and structure of the network in Latvia

In the fall of 2011, parallel to PROFILES project activities, the question of how to create a structure for further dissemination of innovative experience became urgent. This resulted in establishing a network of innovative experiences with the help of municipalities and the National Center for Education.

There was an obvious necessity to create a structure:

- that can achieve a particular goal – to disseminate innovative ideas of teaching in science and mathematics,
- is based on real-life school practice where teachers learn particular methods, ideas, etc. from each other,
- where teachers learn by collaboration and exchange of experiences,
- where teachers feel their colleagues' support,
- where teachers can learn how to reflect,
- that is coordinated but not hierarchical,
- where the activities are regularly performed.

A joint collaboration network was created as a multi-level model that acts at the national level, municipal level and school level and involves teachers of natural sciences and mathematics, school leadership, experts, municipal specialists, NCE and the Center for Science and Math Education at the University of Latvia (CSME). Teachers involved at the national level, study together with CSME experts with the aim to share the experiences of the teachers in the local (municipal) network. Actually, these teachers perform two roles at the same time; 'teachers as reflective teachers' and 'teachers as leaders'.

The national network was formed from the teams of schools that already had experience in the

piloting of innovative study aids within the project 'Science and Mathematics' and who had acquired practice, based on a professional development programme of 160 sessions. The network included 22 schools, supported by 19 municipalities all over Latvia: 2 schools in Riga, 11 in other cities, 9 in the countryside, 18 schools with the Latvian language of learning and 4 bilingual or Russian language. Table 1 provides details on the size of the schools.

Number of pupils	<200	200–500	500–1000	>1000
Number of schools	4	11	6	1

Table 1. Size of schools involved in the National Network

The CSME experts (8 persons) led sessions, organized classes for the development of reflection skills, provided feedback for the involved teachers and developed the research.

Each school that is part of the national network has a team (4–5 persons) of science and mathematics teachers (one in each subject) and a leadership representative. The team jointly plan, implement and evaluate different activities for further development and dissemination of the ideas of innovative science education among other teachers and students. Team members share mutual trust and support; the teachers learn together through workshops and seminars, as well as lead workshops and master classes for their colleagues from other schools.

At the municipal level, each school is attached to a network of schools corresponding to the local situation. The teachers are involved in joint planning, exchange of study aids, leading and mutually observing lessons, etc.

The National Network: Learning for further dissemination of PROFILES ideas

The above experience, and data obtained from PROFILES teachers' questionnaires, form the basis of the idea that dissemination of a scientific inquiry philosophy and its professional application in practice is one of the basic tasks of the developed teachers' network, thus identifying its aim as to help teachers apply the scientific inquiry type module for its didactic purpose.

During the learning phase, the teachers were divided into groups (from 5–6 schools) according to regional criteria. For example, in the Riga group (the subgroup of teachers included: teachers from 6 schools from the Riga area; 6 chemistry, 6 physics, 5 biology and 6 math teachers, plus 6 school educational leaders with experience in innovative teaching and learning for more than 6 years). Learning was carried out during the school year from November 2011 to April 2012 and in the school year of 2012/2013. Each group participated in a cycle of 5 workshops, each of which took place in a different school and included a real-life observation of lessons with joint lesson analysis, as well as input sessions on a particular issue.

The goal of the study programme for the teachers participating in the national network was to learn from each other in a real-life session how to teach science and improve their reflection skills. The programme involved components such as:

- teaching skills and strategies for scientific inquiry,
- the development of HOCS through scientific inquiry,
- students' motivation through scientific inquiry,
- formative assessment in the science classroom.

Development of the reflection skills was based on the idea of a multiple activity cycle performed during joint lesson analyses – as in the action research spiral “Observe – reflect – write – discuss” a few times during every workshop and multiple times during the whole cycle of workshops.

The main focus of the practical workshops carried out in the study year of 2012/13 was on the development of reflection and leadership skills by strengthening the analyses component in the practical workshops. Mutual exchange of experience was organized to follow up on the progress of the teachers involved in the network.

The Local Network: Dissemination of innovative experience

The goal of the local network is:

- to disseminate innovative natural science and mathematics teaching and learning ideas through particular, real-life examples;
- to enable teachers to see how to apply different teaching methods and techniques in the lesson;
- to learn particular methods from each other, to share ideas, etc.;
- to learn through collaboration and exchange of experiences;
- to appreciate that learning is not hierarchical;
- to ensure regularity of the performed activities.

At the beginning of the school year, 2011/2012, according to the local needs, and in collaboration with the local municipality, each school reached out and invited teachers of science subjects and mathematics, as well as the school leadership from the respective municipality. This was a new venture for the municipalities because the previously operating hierarchical model was based on teachers' methods associations with a municipality's appointed person at the head. Although teachers' involvement was on a voluntary basis, there were a few cases when school managers used pressure to motivate and encourage the teachers. Therefore the nature of teachers' participation differed. Schools had complete freedom to choose the forms of work in the local network and were encouraged to jointly plan, lead and analyze lessons to help teachers acquire practical experience in doing things differently. Let us look at the Vecumnieki municipality as an example.

The school team of natural science teachers has been working together for over 8 years. The team includes teachers of physics, chemistry, biology and mathematics, as well as the deputy principal of the school. The local network of Vecumnieki involves 7 schools – 4 high schools, 3 junior high schools, 23 teachers of physics, chemistry, biology and mathematics as well as a school leadership representative. The local network is supported by the school principal and local municipality. During the school year 2011/2012, the Vecumnieki Secondary school organized four events for the teachers involved on lesson observing and analysis in the school and 4 events in other schools. During the school year 2012/2013, 2 events were held in Vecumieki and 6 events in other schools (together 30 lessons observed and analysed). Each seminar included lesson observation and analyses, as well as an exchange of experience on a crucial aspect of teaching and joint lesson planning for teaching of particular skills. Each participant led a lesson and during the next meeting other teachers reflected on his/her performance. Each meeting included evaluation and feedback. The work was similarly organized in several local networks.

In the following section we will focus on training needs and dissemination within the Latvian network.

Research question and methods used

The research question: is the collaborative networking model effective in meeting teachers' professional learning needs for further dissemination of the scientific inquiry philosophy advocated in the country?

A teacher needs questionnaire (PROFILES) served as a tool to study teachers' learning needs. The impact of the performed activities was analyzed with the help of teacher questionnaires from 2012 and 2013, school leaderships questionnaires and analyses of the written feedback after seminars. Experts gave a conclusion drawn from focus groups discussions after each network event.

Results

Analyses and results of the teachers' training in the national network show that teachers were actively involved in the development and attendance of practical workshops giving added value to their skills. Teachers of the national network agree they benefited most from observation of practical teaching and learning methods in their colleagues' lessons. According to the teachers' questionnaire (74 respondents, Likert scale 0–5) from 2012, teachers indicate that along with developing students' inquiry skills, they have improved their own lesson planning and leading skills (41% completely agree and a further 44,5% indicated they agree). Teachers assert that leading and analyzing lessons has helped evaluate their strengths and weaknesses (62% and 92%) and improved skills to reflect on their performance with colleagues (58% and 97%). Teachers confirm that they have learned how to reflect on the goal and efficiency of the lesson with other teachers (55% and 97%). Among other benefits, teachers listed the following:

"I have an insight into my colleagues' performance and this encourages me to think about my own."

"I have gained ideas of how to guide students to think."

"Each college teacher had two or three ideas in their lessons that I could take with me to use in my own lessons."

The above is also supported by a focus groups discussion of CSME-experts who, as a group, concluded:

"Lessons are becoming more student-centered and they successfully involve student's inquiry. Teachers have become better observers and analysts – they make conclusions based on fixed data in particular lessons – not only for lessons of the subject they teach. Teachers' self-confidence has grown as well as their ability to reflect on their performance and formulate aspects that still have to be improved. Teachers are ready to listen to constructive recommendations; they

devote more time to lesson plans and discuss them with their colleagues.”

It is important to note that joint learning and collaboration among a group of teachers has been going on for at least four years already! It is a likely reason why focused learning has resulted in significant progress. In this model the relationship of trust among teachers and between teachers and experts is crucial.

However at the same time this model includes several risks. The experts note that ‘Scientific inquiry in lessons is still overly ‘managed’ and structured. Quite often the focus lies on formal procedures, completion of work sheets, experimental activity, but less on analyses and conclusions. There is no teacher–student discussion before and after the experiment.’

Experts also point out risks of the analyses during the lesson. Methodological problems during the lesson make it difficult to evaluate the lesson in point of fact and sometimes the desirable is presented as the existing. The situation could be improved through enabling teachers’ groups for deeper discussions on particular teaching, including scientific inquiry, aspects and problems.

Local Network

Each school that is a member of a local network has started work with several local municipality schools. However the ways of working and the number of involved schools and teachers differed. A total of 480 teachers from 149 schools were involved in networking during school year 2011/12. We can conclude that on the whole the network achieves the goal. It is involving a large number of teachers who learn from each other, exchange experience in real-life settings at school and focus on the lesson. Feedback from the participants in the local network in the Vecumnieki area and Riga form the basis for this article. The following quotes are obtained from a questionnaire administered in Vecumnieki high school in May 2013.

“I gained from a positive, satisfying experience. Over the two years I obtained lots of different ideas and methods, many of which I was able to use in the classroom. I began looking at the organization of the study process from a different, less traditional angle. Now, when I plan an open lesson and look for materials my habit has become to plan a goal oriented lesson.”

“Finally I saw group work planing from which I could learn.”

“I learned several ‘tricks’ from other people that I use in my lessons. Now, when I lead a lesson and solicit feedback, I often find out things of which previously I was not aware.”

“I learned how to encourage students to think how to organize learning, how I can encourage pupils’ activity and how I can positively evaluate and analyze the lesson.”

These quotes were obtained from questionnaires on performance in 2012/13 from the network at Riga State Gymnasium No 3.

“I was encouraged to use more scientific inquiry in my lessons!”

“I learned how to organize lessons, master particular inquiry skills before students are engaged in scientific modules and how to make use of routine items in laboratory work.”

“I gained new, creative ideas and benefited from the exchange of experience. I improved my lesson analyses skills and learned to see the positive aspects. I became aware that my way of teaching meets the requirements of a modern lesson.”

“The most important gain for me was ideas and materials that I can use in my lessons.”

“I found the laboratory work performed by teachers from other schools interesting.”

Collaborative Network

Several schools focused on creating positive relationships and a good social environment among teachers through specific socializing events. This is interesting as in the first year of the network collaboration showed that teachers had problems opening up completely. If this network model works successfully for two years, possibilities to continue collaboration will be sought.

As the collaboration network among schools in the country is a completely new structure, school leadership became the primary focus for resolution of organizational issues and support to teachers, exercised by the principals, their deputies or municipality representatives. According to the data, the most successful results were achieved where education experts from the local municipality joined the local collaboration network and personally participated in workshops and other activities. It was noted that:

- 64% of teachers from the national network pointed out that the level of interest and understanding of the school leadership had a great impact on the outcome of the joint work and collaboration with other teachers.
- 69% state the significance of school leadership support in resolution of practical problems.

At the same time school leaders of the national network admit that they face difficulty, even lack of understanding, when involving their colleagues from other schools in the network. School leaders have pointed out the following:

“the most significant gain is the possibility for teachers to learn from each other. Teachers who were leading lessons were also learning to reflect on them and listen to different opinions, which helped them raise their qualification and self-confidence.”

Teachers from the local networks gave the following feedback on the performance of the teachers from the national network:

“Thank you for an opportunity to finally observe a lesson that was not from my profile and I could learn new teaching methods.”

“We should seek and continue collaboration in planning events for students and organizing fairs of methodological ideas for teachers.”

“Expand! Dig deeper! Find a joint things-topics skill to work on through the school year.”

Asked about their future wishes, teachers from the local network wrote that they would like to continue learning together with other teachers:

- how to successfully carry out scientific inquiry assignments in the classroom,
- how to lead group work,
- develop modules for science teaching,
- improve students’ scientific inquiry in lessons,
- encourage cognitive skills in students, etc.

Impact of collaboration models

In 2013, the teachers were asked to evaluate the impact of the professional collaboration models on their own professional development by means of a 6-point Likert scale questionnaire. This provided a summary of opinions on evaluation of the model of collaboration networks by experienced teachers working as team members, participating in national network events and organizing events for local network. (Respondents – 85 teachers). The questionnaire showed that activities on the national level have made the biggest impact on the skill to professionally apply teaching and evaluation skills (52% – certainly ‘yes’) and reflect with colleagues on the aim and efficiency of the lesson (59%), which was set as a goal. Participation in the school team and national network improved the teacher’s own skills...

- for collaboration (64%, – school team, 68% – national network),
- gaining positive emotions (64%, 59%),
- learning to respect differences (51%, 60%);
- collaboration in the school team, this helps

teachers to experience mutual support (85%) and develop greater confidence (71%).

At the same time we should note that the model of teacher demonstrating open lessons to their colleagues can cause stress (33% and 27% 'definitely yes' and 'yes'). The model possesses the following risks: teacher's overwork, necessity to rearrange the syllabus so that teachers can attend training, participation of the more active teachers in several projects, limited funding.

The new model has significantly increased teachers' readiness to share ideas and experiences (schools 67%, local 47%, national 45%), as well as the necessity to deepen their professional knowledge (61%, 52%, 77%). Apart from that, the following risk appeared – only 10% of teachers marked that collaboration with colleagues helped them clearly understand that they wanted to be leaders. Over 70% of the respondents (experienced teachers) state that expert support and feedback are crucial for successful results. This relates to the thesis from the beginning of the article that teachers lack skills to organize an open learning process. The paradox is that the more the teachers learn, the higher their learning needs as expressed in questionnaires (comparing the learning needs of this group with the needs of inexperienced teachers).

Summary

A strong need to improve the teachers' teaching and reflection skills was identified. If the teachers have insufficient skills for teaching scientific inquiry and exploiting methods typical for an open learning process, students fail to experience meaningful scientific inquiry learning in the classroom. Before beginning to work with PROFILES type modules in the classroom, it is important to focus on a clear picture of scientific inquiry type learning and improvement of teaching and reflection skills of teachers.

The teachers' collaboration network was created as a multi-level model that acts on a national, municipal and school level. The teachers' network is a new, successful, horizontal model for teachers'

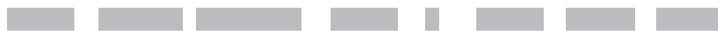
learning and for dissemination of innovative ideas (like PROFILES philosophy) and promoting a new teaching experience in Latvia. It has a strong impact on teachers' performance, However, it requires substantial input from both experts and teachers.

Experienced teachers who are involved in the national network point out the important gain of improvement of the particular teaching (including inquiry) skills as well as reflection and collaboration skills through joint involvement in lesson planning, designing and analyses within the network (e.g. observe – reflect – write – discuss – a few times during every workshop and many times during the whole cycle of workshops). Participants confirmed that they had learned to reflect on colleagues' practices during the networking. Those teachers who collaborated and developed mutual trust during the workshops came to a common understanding of teaching science and learning about the philosophy to disseminate it among other teachers.

Teachers from local networks highly value the opportunity to acquire a different kind of experience through lesson observation. The local network succeeds where it involves school leadership and municipal education experts. A specific conclusion related to Latvia is that involvement of teachers in the collaboration network is voluntary or 'voluntarily compulsory'. This can be explained with the historical tradition in teachers' education and school leadership in the country.

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4.2 Science Education Networks in Austria – The Case of the Viennese PROFILES Network

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Abstract

This case study reflects the PROFILES networking process in Austria (especially in Vienna) and the development of a so called “community of practice.” PROFILES envisages the setting up of teacher networks (and interacting with other networks) to both maximise the dissemination, and to make teachers more aware of the PROFILES project and the goals it is setting out to achieve. In Austria, the nation-wide project IMST (Innovations Make Schools Top) aims at improving instruction in mathematics, science, IT, German language and related subjects. This acts as a good basis for the development of a PROFILES network. To support this process a community of practice operates within the frame of PROFILES teacher training courses (CPD) in Vienna. The community is a regular working group of approximately 40 interested teachers who meet several times per semester. This teacher group is developing dynamically and is characterized by cooperation and reflection. The analyzed case study tries to illustrate not just the development of the Austrian PROFILES network, but also the role of the community of practice as “heart” of this process. Theoretical concepts, network structures and network activities, as well as evaluation data are presented.

IMST Networks as basis for PROFILES Networks in Austria

The following chapter gives an overview of the nation-wide ‘IMST’ (Innovations Make School Top) project and focuses on the sub-programme “Regional Networks”. The IMST project aims at improving instruction in mathematics, science, IT, German language (the latter targeted at literacy) and related subjects. The focus is on student and teacher learning (www.imst.ac.at). Since 1998, the Institute of Instructional and School Development at the Alpen-Adria-Universität Klagenfurt has operated the project, being repeatedly commissioned by the Austrian Federal Ministry of Education, Science and Culture. The project currently involves some 21,000 teachers who participate in projects, attend conferences, or cooperate in regional and thematic networks.

The IMST ‘Regional and Thematic Networks’ programme supports regional networks in all nine Austrian provinces, and three thematic networks which operate at national level. Within the IMST thematic programmes, teachers put innovative instructional projects into practice and receive support in terms of content, organisation and finance. Furthermore, 18 Regional Educational Competence Centres (RECC) all over Austria act,

in science subjects, as a cooperative structure between universities and teacher education colleges. To some extent, they fill the gap of lacking subject didactic centres in higher education throughout Austria and provide research-based didactic professional development for teachers. Gender sensitivity and gender mainstreaming are key project principles, their implementation being supported by the Gender Network. Evaluation and research are integral to all levels, assessing the impact of IMST.

The following three goals are pursued in the medium term by the establishment of the networks:

- Raising the attractiveness and quality of lessons and school development in mathematics (M), biology and ecology (BIU), chemistry (CH), physics (PH), information technology (INF), geography (GWK), descriptive geometry (DG) and related subjects, as well as cross-curricular initiatives in secondary academic, vocational and secondary general schools, as well as primary schools (since 2007). The results and content of the IMST² project create a framework for guidance for the instructional and school initiatives in the network;
- Professional development for teachers;

- Involvement of as many schools as possible (widespread effect).

The regional networks were formed according to the following two principles:

- Use of existing personnel, institutional and material resources in the federal provinces.
- The persons and organizations involved take responsibility for the development of regional networks in each of the federal provinces.

The idea underlying IMST allows a steering committee in each regional network to coordinate and be responsible for the creation of content. In these steering committees, the subjects of maths, science, IT, and the province education board (including since the autumn of 2007 teacher training colleges) are represented. To emphasize the fact that the regional networks are sustainably embedded in the federal provinces, IMST support is linked to each of the federal provinces, and resources (teaching hours, funds) are made available. The detailed task profile of a regional network is geared to the needs of the schools in the region and to existing resources. It always includes the establishment of a platform for schools and teachers, arranging opportunities for sharing experiences and further education, supporting the creation of concentrations and their development in schools, developing a pool of experts to advise on didactic and school matters, drafting an annual report and interim reports on the activities of the regional and thematic networks, as well as evaluation.

The networks are aided by financial support, a platform for ongoing process management, two seminars per year for the network steering committee members, public relations (leaflet, IMST newsletter), as well as accompanying research and studies on the development of networks through the network team at the Institute of Instructional and School Development (Rauch, 2013).

The development of a PROFILES Network in Austria in Vienna

Based on research data, the following chapter describes the development and structure of the Austrian PROFILES network and its interrelation with the IMST Regional Science Network Vienna. Evaluation data from the project IMST focuses on self-evaluative measures, consisting of qualitative and quantitative surveys (Wenzl, 2012). A cross-case analysis of the annual IMST reports from all nine Austrian federal states (Rippitsch & Rauch, 2013) includes qualitative content analysis (Mayring, 2007). Furthermore, interview and feedback data (reflective papers) from PROFILES teachers are included.

The Viennese Network (VN)¹ was developed within the frame of the project IMST in March 2004. The initial steering group consisted of science teachers from the subjects: mathematics, biology, chemistry and physics. Meanwhile, informatics and geometry teachers have also joined, as well as representatives of vocational colleges, compulsory schools and the teacher training college. Many steering group members have also worked in other educational institutes, which offers additional synergies and co-operations.

A focal point is the improvement of quality as a new culture in education, including the concepts of sustainability, reflection, individualisation and the development of communities. Furthermore, the VN aims at establishing co-operations with other educational institutions, like AECCs (Austrian Educational Competence Centres) and other Austrian networks. The VN provides support for conducting evaluation studies and the implementation of innovative teaching methods, disseminated by different means, especially by presentations of good practice. Twice a year, teachers receive information about future events and training courses via a newsletter. The main aim of the VN is the professional development of science teachers towards quality improvement in the classroom and visible improvement of pupils' performance. Thus, the VN initiates a broad range

¹ Further information (in German) about the VN can be found under the following link: <http://nawi.brg19.at/>

of training courses in science subjects and offers events for all types of schools, e.g. lab days, information events with AECCs, inquiry learning events and teacher training within the framework of educational standards. Furthermore, the VN offers training courses on the competence-based school leaving certificate, a new measure associated with the Austrian curricula, where teachers can deepen their knowledge in competence-based teaching methods (Wenzl, 2012). In 2012, the VN offered 18 events and workshops, allowing participation by 1,450 teachers, students and pupils (Rippitsch & Rauch, 2013).

Over a period of five years, the VN has become established in the educational landscape of Vienna, not least because of its efforts in imparting pedagogical and didactical knowledge.

“Meanwhile the network has achieved a high level of recognition and reputation in Vienna. The public sees that it offers high-quality events. (...) In Vienna we are perceived as ‘the experts.’”
(VN coordinator).

The important position of the VN becomes particularly apparent as a platform for information and training, as well as a contact point for teachers. The VN coordinator (Ilse Wenzl) is responsible for the organisation of further education, networking and the establishment of co-operation. In this sense, she is the initiator of the PROFILES network, based on contacts with science teachers from the VN. The next chapter shows how the PROFILES network was established as a *community of practice*.

The Austrian PROFILES Network as a Community of Practice

Inquiry learning is one of the key principles of PROFILES. Beside the development of inquiry-based teaching modules, the project provides professional development for science teachers (CPD courses) (Bolte et al., 2012). The VN already participated in projects that focus on inquiry learning, like the Sparkling Science project KIP – Kids Participation in Research, in the past. Thus, when introducing the PROFILES project, this learning method is already a topic of interest for

VN members. In Austrian science lessons rarely include inquiry learning due to time constraints and the lack of facilities like labs, which are not available for all schools. Furthermore, teachers need special training and preparation to be able to guide pupils through research units that are based on independent conduction of experiments. The PROFILES CPD courses support teachers in acquiring knowledge and skills necessary for inquiry-based science education (IBSE).

To establish these courses within the frame of a PROFILES network in Austria, Ilse Wenzl, VN coordinator, participated in the first international PROFILES meeting in Tallinn, Estonia in November 2011, where aims and tasks were discussed. The next step was to structure and implement the projects’ tasks so as to promote the project among Austrian teachers and motivate them to participate in the PROFILES CPD courses. The idea, to structure the participation of teachers in the form of a *community of practice* was developed.

The term *community of practice* (CoP) actually stems from theories based on the idea of learning as social participation. Wenger (1998) states that learning is fundamentally a social phenomenon and is placed in the context of our lived experience and participation in the world. Learning is part of a more encompassing process, which places individuals as active participants in the practices of social communities. CoP are defined as

“a group of professionals informally bound to one another through exposure to a common class of problems, common pursuit of solutions, and thereby themselves embodying a store of knowledge” (Hildreth & Kimble, 2000, p. 3), and as

“groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.” (Wenger, McDermott & Snyder, 2002, p. 7).

The first PROFILES CPD course was announced via the Austrian Teacher Education College in Vienna in 2011. The course aimed at establishing a CoP

to deepen the knowledge of science teachers and develop their expertise in IBSE. In Austria, the participation of teachers at CPD courses has been voluntary. Thus, the number of participants depended heavily on the attractiveness of the course and the interest of teachers. Ultimately, 25 teachers participated in the first CPD course. Special topics of interest included the issue of inquiry learning, as well as the international dimension of the PROFILES project and the possibility of gaining an insight into science teaching practices outside of Austria. The project, its aims and philosophy, as well as teaching modules from a previous project (PARSEL) were introduced to teachers.

As a first step, the teachers were asked to choose a module and implement it in the classroom. In the next meeting teachers discussed their experiences with the module implementation and jointly reflected on them. Furthermore, teachers developed their own teaching modules according to the PROFILES principles in groups.

“You do not merely develop a module; you discuss it, read literature, do research, adapt and exchange materials, and finally you implement it in class and evaluate it.”
(teacher comment).

Another 25 teachers participated in the second PROFILES CPD course, offered in the following year.

Emerging from these courses, interested teachers formed a CoP, a regular working group, characterised by cooperation and reflection. The CoP met several times per semester to develop PROFILES modules and reflect on their implementation in class. The meetings not only covered the official time during the course, they also took place in informal settings, as one CoP-member described: *“The regular meetings of the working group take place either in our homes or within the frame of a working breakfast.”* In 2013, the CoP consisted of approx. 40 teachers, who were regularly informed and invited to additional meetings. Out of this group, eight teachers were very active and worked intensively and independently. These eight teachers took on the function of so called *lead teachers* (Hofstein et al., 2012), spearheading the professional development

of additional teachers at pre- and in-service levels, initiating workshops for key stakeholders and extending the PROFILES network. In this way, the PROFILES idea was disseminated. *“Our teachers multiply what they develop, because they bring it to their own schools”* (VN coordinator).

PROFILES Network Vienna

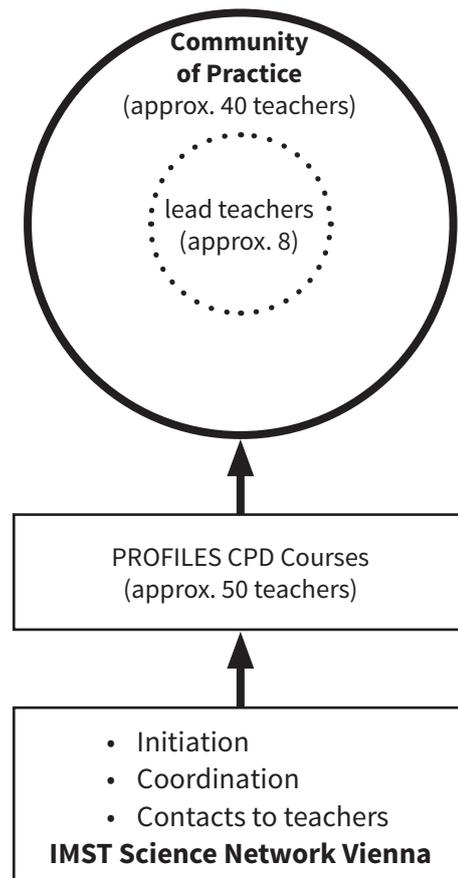


Figure 1. The Austrian PROFILES Network

Figure 1 shows the development and structure of the Austrian PROFILES Network as a Community of Practice (CoP). The IMST Science Network Vienna acts as a basis, providing the contacts to the teachers and initiating PROFILES CPD courses, where approx. 50 teachers have participated so far (by 2013). Out of these teachers approx. 40 persons have demonstrated an interest and willingness to participate in the PROFILES CoP. These teachers are informed regularly and are invited to meetings in addition to the CPD courses. Approximately 10 to 15 teachers participate in each of these meetings.

Within the CoP the so-called *lead teachers* are very active and work intensively and independently to strengthen the professional development of and within the PROFILES network.

According to Wenger (1998), a CoP defines itself along three dimensions (pp. 73–85) which are related to practice itself. The first component is *mutual engagement*. A CoP has an identity and resides around people engaged in certain common actions, ideas, in a domain of interest. Membership therefore implies a commitment to the domain and a shared competence that distinguishes members from other people. In our case, the PROFILES project acts as the domain and frame of mutual engagement. The community members share the project's ideas and philosophy: P – Professional, ROF – Reflection Oriented Focus, IL – Inquiry-based Learning, ES – Education through Science.

The second component is *joint enterprise*, which goes beyond stated goals (e.g., mission statement, objectives) and creates mutual accountability among participants which is constantly renegotiated by the members. In pursuing their interest in their domain, members engage in joint activities and discussions, they share information and build relationships that enable them to learn from each other. The joint enterprise of the PROFILES CoP is the professional development of science teachers in courses, as well as in their daily practice as teachers. In CPD courses, as well as in individual meetings, CoP-members share information and reflect on their experiences in class, focussing on individual and mutual learning. One community member expresses the value of learning and individual development within the CoP as follows:

„The training programme enables me to increase my skills and competences. I have the feeling that I can contribute my ideas, and in return I receive constructive feedback. In this way I can develop myself.”

Another teacher conveys the open discussion within the CoP:

“The harmonious co-operation enables

constructive discussions about ideas concerning the modules, where even concerns and reservations can be expressed openly. ... Everybody fulfills his tasks in time.”

The third component is a *shared repertoire*. Members of a CoP are practitioners, who include

“routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts that the community has produced or adopted in the course of existence” (Wenger, 1998, p. 83).

The shared repertoire in our case is the development, adaption, implementation and reflection on the PROFILES teaching modules that act as a toolbox for the teachers. The following statement by a teacher highlights the work on the modules and the aspect of practice:

„I especially enjoyed the exchange of ideas and the competent feedback that was very helpful for the development of teaching modules. The work in small teams supported the fast adaption of modules towards a suitable and practical form. Regular meetings of the involved colleagues showed progress and were an opportunity to reflect on various details critically.”

In the initial phase of establishing the CoP, challenges could be seen in the coordination and motivation of teachers. Because the participation was voluntary and based on personal interest, the CoP needed coordination to get teachers actively involved. For that reason, the VN coordinator oversaw the coordination of the CoP, which was supportive regarding the exchange of know-how between the PROFILES-CoP and the VN. In that way, the CoP could be regarded as a loosely coupled sub-structure of the VN. But with time it developed dynamically and the participating teachers started organizing themselves.

“I have no leading role anymore; it [the CoP] has become independent to a certain extent.”
(VN coordinator).

The VN formed the base institution for the

PROFILES network. The coordinator initiated the PROFILES network by providing contacts to science teachers and took on the coordination role at the beginning, but the CoP developed independently from the VN (see Figure 1). Hovland stated, in this sense, that successful organisations are

“shifting from management based on compliance to management based on self-control and self-organisation” (Hovland, 2003).

At the same time, the VN profited from the PROFILES network, because it promoted the VN at an international level. *“It was like an advertisement for us.” (VN coordinator).*

Reflection and Outlook

Networks in education offer goal-oriented exchange processes among teachers (information function) which support the professional development of teachers (i.e. fresh ideas for classroom teaching, interdisciplinary cooperation at schools) (learning function). Therefore networks have the potential to create a culture of trust, with the effect of raising self-esteem and risk-taking by teachers (psychological function) and upgrading science at school (political function). In the long run, a balance of action & reflection (goal-directed planning and evaluation) and autonomy & networking (analysis of one’s own situation, but also support by “critical friends” i.e. colleagues at school, facilitator) is paramount in order to set up a sustainable support system for schools. Evaluation and research need to be driven by an interactive link between an interest to gain new knowledge and a developmental interest. A culture of self-critical and collective reflection may flourish, but reflection cannot be allowed to hamper a project from being taken forward.

The key aspect that motivated teachers to participate in the PROFILES CPD courses and be involved in the PROFILES network was the focus on inquiry-based science education that supported pupils in gaining various competences. In 2009, competence-oriented teaching was incorporated into the Austrian school curricula, including the competence-oriented school leaving

certificate. *“The competence-oriented teaching will be implemented now” (VN coordinator).* So the PROFILES network offered a good opportunity for teachers to deepen their knowledge in this field and develop professionalism. The PROFILES teaching modules complied with this new development in the educational system of Austria and could be regarded as a helpful tool for teachers:

“Now you could use a PROFILES module, which the pupils did not see before, in an exam or in the school leaving certificate” (VN coordinator).

As the CoP is characterised by dynamic development and self-organisation through its members, the future development of the PROFILES CoP is not exactly easy to predict. According to the transformation stage of community development by Wenger, McDermott & Snyder (2002), the PROFILES CoP could merge with other communities and networks, might fade away, or could bring about the beginning of a new community. Networking has been well implemented in the Austrian educational sector due to projects like IMST, therefore it could be expected that the PROFILES CoP would continue after the completion of the PROFILES project, most likely by merging with other educational networks.

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4.3 Analysing the Relationship between the Effectiveness of the PROFILES Continuing Professional Development Programme and the Dissemination/Networking Process

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Abstract

The dissemination and networking activities were conducted in relation to the development and results of the national accredited, teacher training/continuous professional development programme undertaken as a component of the PROFILES project. In this sense, the dissemination was not only carried out by the promoters of the CPD programme, but also by the stakeholders and the teachers involved as trainees in the training phases. This CPD addressed a clear orientation on the users' (science teachers) needs and ensuring a continuing process during and after the life of the project. This case study illustrated not just the dissemination actions performed by the members of the Romanian PROFILES network, but also explored the relationship between a successful CPD programme and the most effective ways of dissemination of its achievements and results.

Introduction

Professionalizing the teaching career, and reconsidering the teacher degree system from this perspective, represents one of the main aims of the Romanian Government Programme (2012), which continues the National development strategy of initial and continuous teacher training (2001). Recent years have highlighted, more than ever, a real need for developing training programmes for teachers. In fact, as education represents an area that requires specific training, supported by theoretical and practical knowledge, the continuous professional development process provides two essential elements (Harwell, 2003):

- (a) offering to participating teachers the opportunity to practice that to which they have been exposed, and
- (b) creating the ideal environment for interaction among participants.

In this sense, it is obvious that high quality education can be enacted through very well trained and devoted teachers.

On the one hand, it is clear that the success of the Romanian education reform depends, crucially, on the quality of the teacher training process and the design and development of training programmes for reaching specific standards for teaching. On the other hand, it is well-known that in Romania – as

also in Europe – a decrease in students' interest in science and technology is seen in recent years, and also a lower attractiveness of S&T professions (OECD, 2006). This is explained by the orientation of the teaching process towards high levels of theoretical scientific topics and the absence of a relationship between theory and practice during science lessons. Since the same trend is recorded also at the European level, the Romanian Ministry of Education encourages participation of educational institutions in a large number of national and European projects, dedicated to developing different training programmes in which new strategies that promote the integration of the sciences, starting from the socio-scientific context, are proposed, and in which a great number of teachers and students are involved. In this context, the Romanian universities, as continuous professional development providers, organize different projects in which CPD represents the main component. At the same time, the dissemination of the results obtained, after the end of the training programmes, encourages the educational environment to be sensitive to such approaches, based on the real benefits gained in relation to the teachers' new acquisition of experience and skills.

Each transnational project is expected to propose and implement a systematic process of dissemination and exploitation of results, with a view to increase the impact of the project activities and their results. Moreover, when

the dissemination and exploitation actions are produced by a constituted network structure, the transfer of the related project processes and products to the educational community, as well as overall successes, is enhanced.

Dissemination comes as an agreed procedure of providing relevant information on the quality, importance and effectiveness of a project activities and results. In the case of PROFILES, the defined local, regional and national networks are called to support the dissemination process, not only with the view to increase the project impact and visibility, but also – together with the exploitation actions – its sustainability. Thus, the designed dissemination activities ensure that the project outcomes and results are recognized, demonstrated and implemented on a wide scale.

The „PROFILES – Education through Science” Continuous Professional Development Programme

PROFILES – Professional Reflection-oriented Focus on Inquiry-based Learning and Education through Science, an FP7 Science in Society aims to promote Inquiry-based Science Education (IBSE) through “raising the self-efficacy of science teachers to take ownership of more effective ways of teaching students, supported by stakeholders views” (PROFILES Consortium, 2010). This paper seeks to provide an overview of the actions undertaken by the Working Group of the Valahia University Targoviste (VUT) in Work Package 5 – “Continuous Professional Development” – and 8 – “Dissemination and Networking” – in the frame of the PROFILES project.

In the period June – October 2011, VUT team members created a specific Continuing Professional Development (CPD) programme dedicated to secondary education science teachers (Chemistry, Physics, Biology teachers). The programme entitled “**PROFILES – Education through Science**” was designed according to a need analysis performed in Spring 2011 (Gorghiu et al., 2013) and was focused on the basic concept of the PROFILES project – promoting *Inquiry-based*

Science Education methods – and aimed to increase the teachers’ skills through the acquisition of new, effective teaching methods. The overall aim of the “**PROFILES – Education through Science**” training programme is represented by the development of science teachers’ skills and competences to conduct a teaching process based on *scientific research and an integrated approach within the curriculum* (Drăghicescu et al., 2013). At the same time, in the frame of the project, a collaborative network was established to provide teaching and research ideas in the field of science, to offer opportunities to cooperate actively, and to promote the exchange of ideas and materials for training. This operated by disseminating best practices, seminars, workshops, etc.

The training programme was designed to contribute to the modernizing and improving of the quality of the education process. In this respect, the proposed training offered science teachers a professional training opportunity and career development, taking into account the specific objectives of the programme, which were:

- (a) development of vocational training skills based on scientific research;
- (b) capitalization of potentials and experiences of individual students;
- (c) promoting an integrated approach to science related topics, and
- (d) achievement of an educational approach in line with the principles of the constructivist paradigm.

The VUT team sought accreditation of the training programme by the *National Centre for Teacher Training (CNFP)*.

THE CPD course

The total duration of the accredited programme was 60 hours (18 hours of lectures, 36 hours of practical applications and 6 hours of evaluation) and teachers who successfully completed the programme received 15 transferable credits. The programme was divided in two courses: *Guidelines for Modern Science Teaching and Inquiry-based Science Education*.

In the dedicated lectures part, the following topics were presented:

- (a) Education and Science,
- (b) Education through Science – concepts and specific terminology,
- (c) Curriculum – integrated approach,
- (d) Teaching and learning science from the perspective of a constructivist paradigm,
- (e) ICT as a support tool for teaching science,
- (f) Inquiry-based Science Education (IBSE) – concept and context,
- (g) Pedagogical foundations of IBSE,
- (h) IBSE specific methodologies,
- (i) IBSE model for science teaching,
- (j) Role of scientific and technological literacy in shaping scientific skills,
- (k) Data processing methods in IBSE implementation.

During the practical application sessions, the participants worked individually and in groups, to develop PROFILES integrated modules centred on IBSE methodology, by following exemplar modules which were discussed with the tutors. At the same time, teachers were asked to ensure a trans-disciplinary character for the designed modules (Dinu et al., 2012). Consequently, participant teachers were asked to disseminate and make known the work undertaken during the training sessions and to start the networking process in their schools, together with their colleagues. Teachers were strongly guided to take into consideration the dissemination process, with a view to establishing a strong relation between their

acquisitions made during the CPD programme and the permanent promotion of the new knowledge, through specific interconnection channels related to other colleagues, educational managers and stakeholders. In this way, the PROFILES teachers did not remain ‘sole islands,’ rather they acted as ‘information bridges’ and creating feasible science networks. Actually, the Romanian network is based on *lead teachers* within the PROFILES CPD programme, and they play a great role in the extension of the PROFILES Network at the national level.

Results and Discussions

In order to select the best candidates for participating to the training programme, the VUT team was involved in different dissemination activities like:

- (a) meetings with representatives of Dâmbovița, Buzău and Teleorman County School Inspectorates;
- (b) meeting with Physics, Chemistry and Biology teachers from secondary education;
- (c) dissemination of flyers and newsletters containing the structure of the training programme, and
- (d) supporting networking activities with secondary teachers, using on-line facilities.

The first edition of the PROFILES CPD programme, from January to May 2012, involved 35 teachers of Physics, Chemistry, Biology, from 20 schools in Dambovita County.

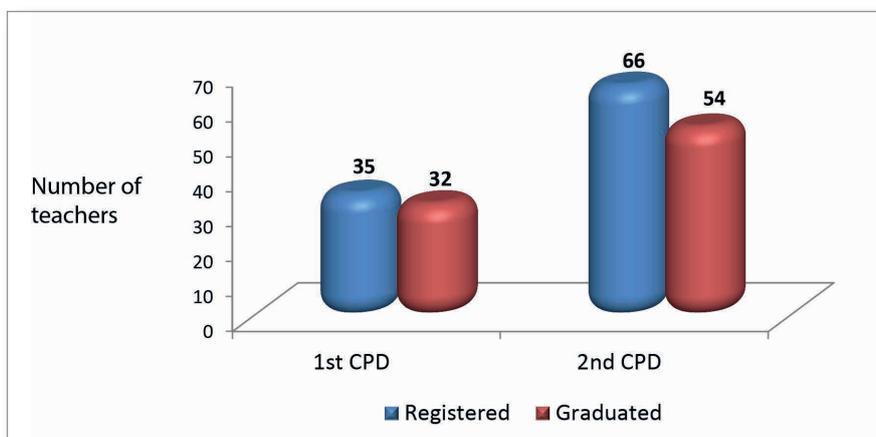


Figure 1. Teachers graduation rate of PROFILES CPD programme in Romania

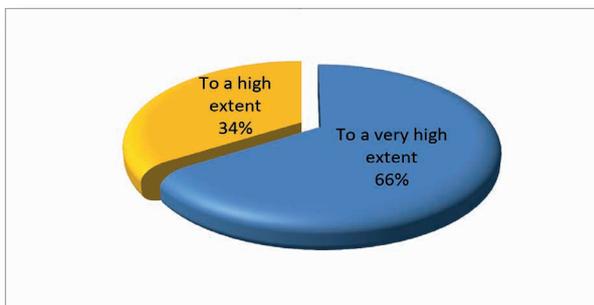
A second round of the programme was organized between January and May 2013, and involved 66 teachers from 49 schools from Dâmbovița, Buzău and Teleorman Counties. Figure 1 illustrates the teachers' graduation rate for both versions of the CPD programme. The chart shows that 91.4% participants in the 1st CPD version and 81.8% in the 2nd CPD version graduated in the PROFILES CPD programme.

The evaluation of the training process was based on the teachers' feedback (collected through discussions between tutors and trainees during the direct meetings), questionnaires (applied during the training process) and a final questionnaire (filled in by all participants at the end of the CPD programme). An analysis of data is presented in the following paragraphs.

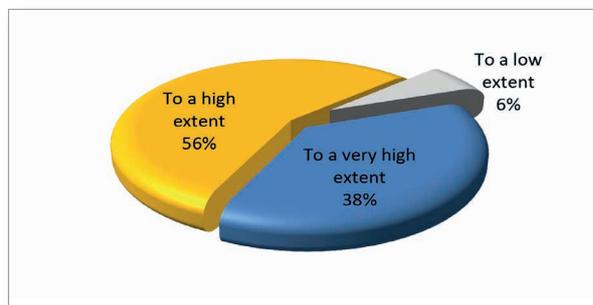
One question in the final questionnaire tried to establish whether the objectives of the CPD programme were completely understood and acquired by the participants. Figure 2 presents the teachers' feedback for both versions of the course.

Analysing the charts, it can be seen that the results obtained at the end of the second version of the programme are slightly higher. The CPD providers suggested this might be a result of experiences gained during the first CPD. In fact, after the first version of the course, all the training materials and PROFILES modules used as examples during the practical application sessions were revised.

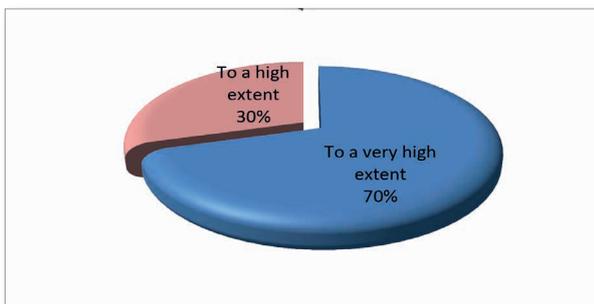
The VUT team were interested whether the content of the CPD programme was meaningful in terms of teacher needs. The participant's answers for both editions of the training programme were as illustrated in figure 3. To some extent the more numerous participation numbers in the second version was explained by teacher perceived need for this kind of course. In addition, a short view on the teachers' feedback proved that the content of the training programme was very well received by the teachers (94% of the trainees in both the 1st and 2nd versions of the course appreciating the content to a high or very high extent).



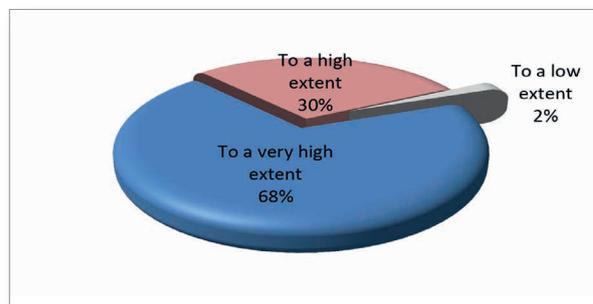
(a)



(a)



(b)



(b)

Figure 2. Teachers' feedback related to the understanding and acquiring level of the PROFILES CPD programme objectives: (a) 1st version of the programme; (b) 2nd version of the programme

Figure 3. Teachers' feedback related to the accordance of the PROFILES CPD programme content to their needs: (a) 1st version of the programme; (b) 2nd version of the programme

Another aspect was whether the teaching methods and practical activities organized during the face-to-face meetings supported the learning process. The trainees' answers were as presented in Figure 4. Due to the large variety of the teaching methods and the way of organizing the practical activities used during the CPD programme (lectures, focus groups, workshop in groups, individual reflections), 94% of teachers from the 1st version and 96% from the 2nd, highly appreciated the teaching methods component.

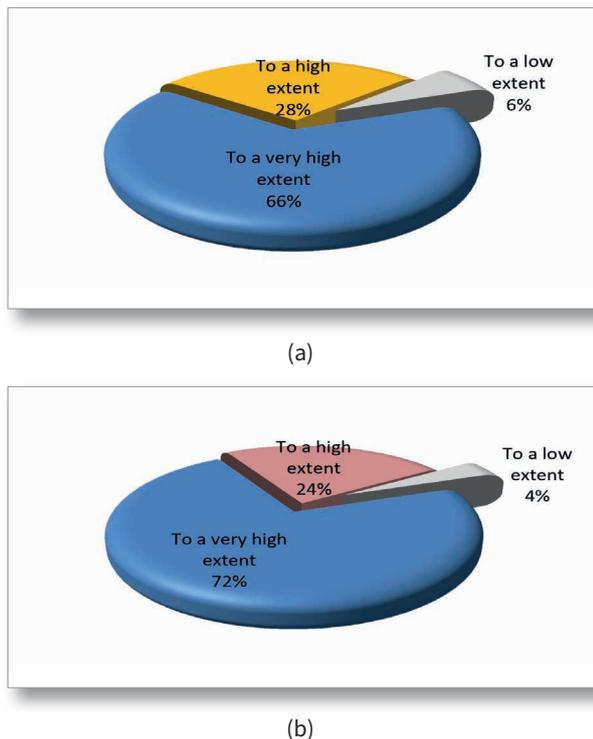


Figure 4. Teachers' answers related to the support of the teaching methods to the learning process: (a) 1st version of the programme; (b) 2nd version of the programme

Bearing in mind that materials presented during the training sessions were very important for the success of the training programme, one questions on the final questionnaire sought teachers' opinion on the usefulness of the training materials and the PROFILES modules used as examples during the practical activity sessions. Again high satisfaction was indicated in both CPD versions with results slightly superior for the 2nd version of the course. Participants in the second version had additional materials as examples, largely because the first version participants designed additional modules, in their native language. In addition, six experienced

teachers who attended the 1st version of the course were involved as lead teachers during the 2nd training process.

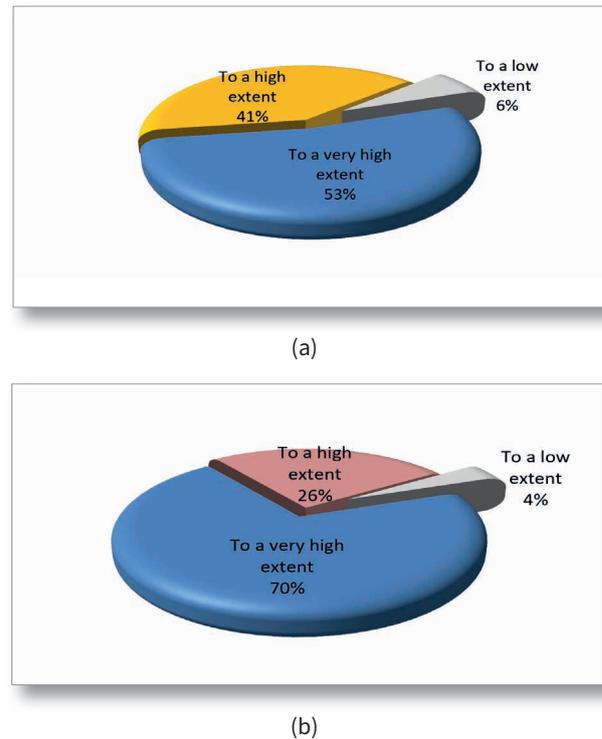


Figure 5. Teachers' opinion concerning the utility of training materials and PROFILES modules used as examples during the CPD programme: (a) 1st version of the programme; (b) 2nd version of the programme

To seek teachers' perception related to the usefulness of the CPD programme, participants were requested to choose one of the following which best described their situation:

- (a) I found the training programme useful;
- (b) Few of the things learned in the programme were new for me;
- (c) I tried to apply aspects learned during the programme in my teaching;
- (d) I successfully applied aspects learned during the programme in my teaching;
- (e) I was afraid to apply aspects learned in the teaching course, because I still have not mastered them sufficiently well;
- (f) I attended the training course mainly to get credits.

The obtained results are illustrated in Figure 6.

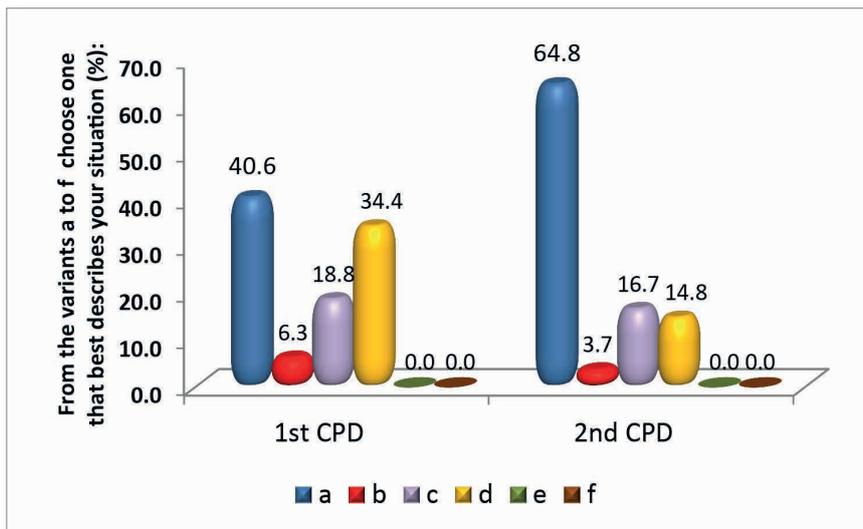


Figure 6. Teachers' perception related to the usefulness of the PROFILES CPD programme

Analysing the data, it can be seen that the percentage of the teachers finding the training programme useful has greatly increased in the 2nd version of the course. This can be explained by improvement of the training materials, and the mentors' involvement and trainers' expertise – more experienced after the 1st version of the training programme. In addition, the figure illustrates an important percentage of teachers who tried to apply aspects in their teaching). A large number of participants indicate they successfully applied aspects learned during the course. A very important finding was that none of the teachers involved in this course simply to obtain credits and none expressed concerns related to applying the gained knowledge in their classrooms.

It is obvious that the most important gain at the end of the CPD programme are the competences acquired by the trainees. In addition, also important is the usefulness of the acquired competences in their daily teaching, and the teachers' confidence in this respect. If the teachers highly rate the importance of the new competences, they can be expected to increase their self-confidence and develop a real sense of ownership. To this end, the collected data indicates that teachers are highly appreciative of the new skills acquired, as is shown in Figure 7.

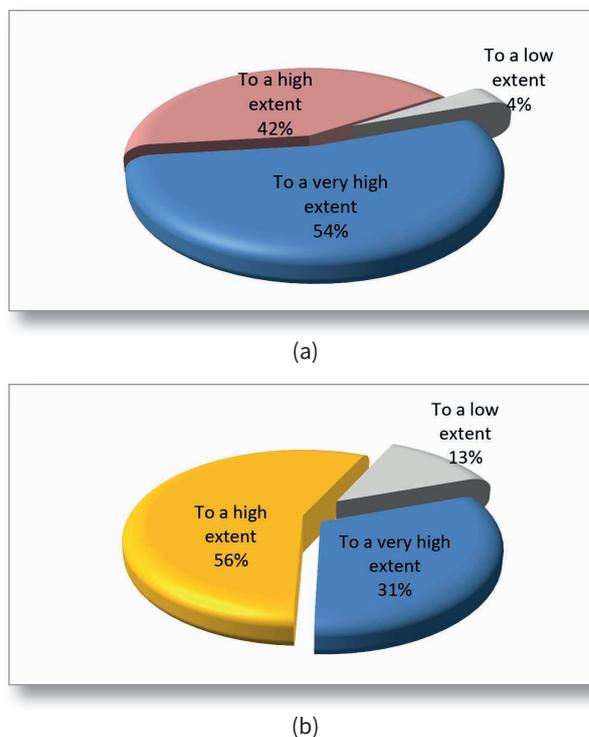


Figure 7. Teachers' feedback concerning the level of usefulness of the new competences in their future work: (a) 1st version of the programme; (b) 2nd version of the programme

Comparing the results between the two versions of the CPD programme, it can be seen that even though the teachers involved in the 2nd version were more numerous, a higher percentage (54% versus 31%) appreciate, to a very high extent, the importance and usefulness of the new competences for their future activity. There is also a larger percentage of teachers involved in the 2nd version of the course

(42% versus 31%) who appreciated the same aspect to a high extent, while the percentage of reticent teachers who decided that the new skills will not help them, decreased (13% versus 4%).

An additional question in the final questionnaire sought what type of improvements in teaching teachers indicated after the PROFILES CPD programme. The question requested teachers to choose 2 from 16 variants that best completed the sentence:

“After participating in the CPD programme, I expect to be able to ...”.

The 16 possibilities offered to respondents were:

- (a) create a more attentive learning environment for my students;
- (b) achieve a greater student-centred level in the entire teaching process;
- (c) achieve better designed lessons;
- (d) effectively use various teaching methods;
- (e) adequately use a range of teaching resources;
- (f) realise a better selection for the teaching content;
- (g) give more relevant feedback to students;
- (h) achieve better assessment of students' progress;
- (i) better support students with special educational needs;
- (j) design a new curriculum;
- (k) collaborate more effectively with students' families;
- (l) collaborate more effectively with the education community;
- (m) collaborate more effectively with colleagues at school;
- (n) design my teaching career more efficiently;
- (o) develop successful projects with other schools;
- (p) better use of ICT in the teaching approaches.

The teachers' perceptions, related to the possible improvements in their teaching approach at the end of the PROFILES CPD programme, are presented in Figure 8.

The highest percentage of participants (26.6% from the 1st version and 26.9% from the 2nd) felt they would be able to create a more attentive learning environment for their students. Also 15.6% participants from the 1st version and 17.6% from the 2nd were confident that they would use various teaching methods more effectively. Teachers (12.5%) in the 1st CPD version believed they would achieve better designed lessons, while 10.9% considered that a range of teaching resources would be more adequate used in their lessons, and 9.4% aimed to develop successful projects with other schools. Teachers (16.7%) participating in the 2nd CPD version considered they achieved a better student-centred level of teaching, 7.4% felt that they would realize a better selection of teaching content and 5.6% think they would collaborate more effectively with colleagues at school. Although the percentage of teachers from both version who reported a better use of ICT in their teaching approach was not so high (4.7% from the 1st CPD version and 2.6% from the 2nd), this aspect was seen as important to convince teachers to involve more ICT tools (like multimedia products, virtual models and experiments, interactive simulations, dedicated software applications) in science lessons. This brought to the attention of the VUT team the idea of introducing sessions on quality elements gained by the introduced of ICT tools and giving more examples related to the use of ICT in science lessons during the practical sessions, in future editions of the training programme.

Dissemination and Networking – Two Channels for Promoting the PROFILES CPD Programme

To increase the teachers' confidence in their new achieved competences, the CPD stimulated them to undertake a critical analysis of their PROFILES Modules – emphasizing both the strong and weak points encountered during the implementation process – to collect and evaluate the obtained results and students' materials, and to discuss and disseminate those results in different events, seminars or conferences.

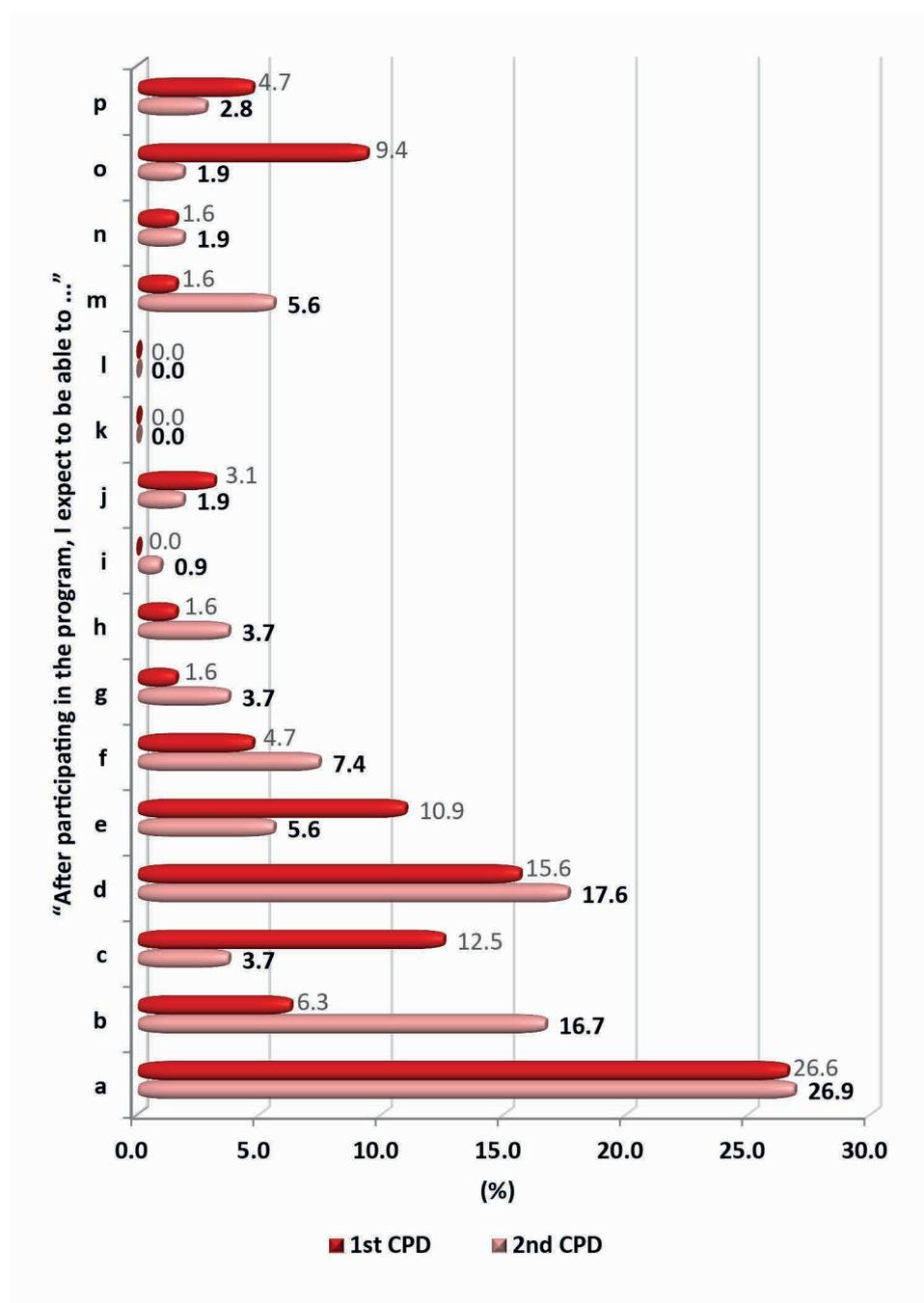


Figure 8. Teachers' perception about possible improvements in their teaching approach based on the new achieved competences at the end of the PROFILES CPD programme.

In this respect, Romanian teachers played an active role. Besides acting as PROFILES promoters in their schools and at County level, they tried to illustrate the benefits of PROFILES in national meetings. As an example, a special section – “Education through Science – FP7 project PROFILES” – was organized in the frame of the 4th National Conference on Chemistry in Secondary Education, on September 7th – 9th, 2012, in Targoviste. Nine papers were

presented in this section, six of them being the experiences of PROFILES teachers who attended the 1st version of the PROFILES CPD programme.

Since many science teachers from different regions of Romania – as also stakeholders with a direct interested in science education – participated to this conference, the very interesting topics chosen by the PROFILES trainers and trainees

raised much interest in PROFILES. The widely disseminated results, through mass-media after the implementations of different PROFILES modules in the classroom, increased science teachers' interest to participate in future versions of the training programme.

Two examples are illustrated in Figure 9. These are articles on how science is perceived by students today and how the participants, from the first version of the PROFILES CPD programme, are presenting their newly developed modules.

Combining different ways for promoting the results of the CPD training programme, it was natural to develop a PROFILES regional network. A simple argument was offered by the number of requests for participating in the 2nd version of the CPD training programme. This was really high and, in this respect, the VUT team had to select the participants in order to decide the locations where this version was ran.

At the moment, the Romanian PROFILES network acts at local and regional level, but it will be extended at national level. The process of networking started at school level (in January 2012), and includes 69 lower and upper secondary schools (June 2013). The network provides a real opportunity for sharing the PROFILES resources (concepts, modules, results of implementations) in the Science teachers' community, but also creates the necessary frame for providing mutual learning and help. Inside the network, 6 PROFILES key-teachers act also as mentors and have the role of *lead teachers* (Hofstein et al., 2012), contributing to the professional development of the in-service Science teachers, making PROFILES known not just with the view to extend the network, but also to popularize the project philosophy and good practices in the educational community. Figure 10 illustrates the actual image of the Romanian PROFILES network, developed in 2 years.



Figure 9. Dissemination of PROFILES experience in mass-media – two articles published in Gazeta Dâmboviței (on May 14, 2012 <http://www.gazetadambovitei.ro/educatie/tiinele-ajung-in-viaa-de-zi-cu-zi-a-elevilor-dambovieni/>, and May 26, 2012 <http://www.gazetadambovitei.ro/educatie/profesorii-la-evaluare-prima-serie-de-cursani-din-proiectul-profiles-i-au-prezentat-astzi-portofoliile/>)

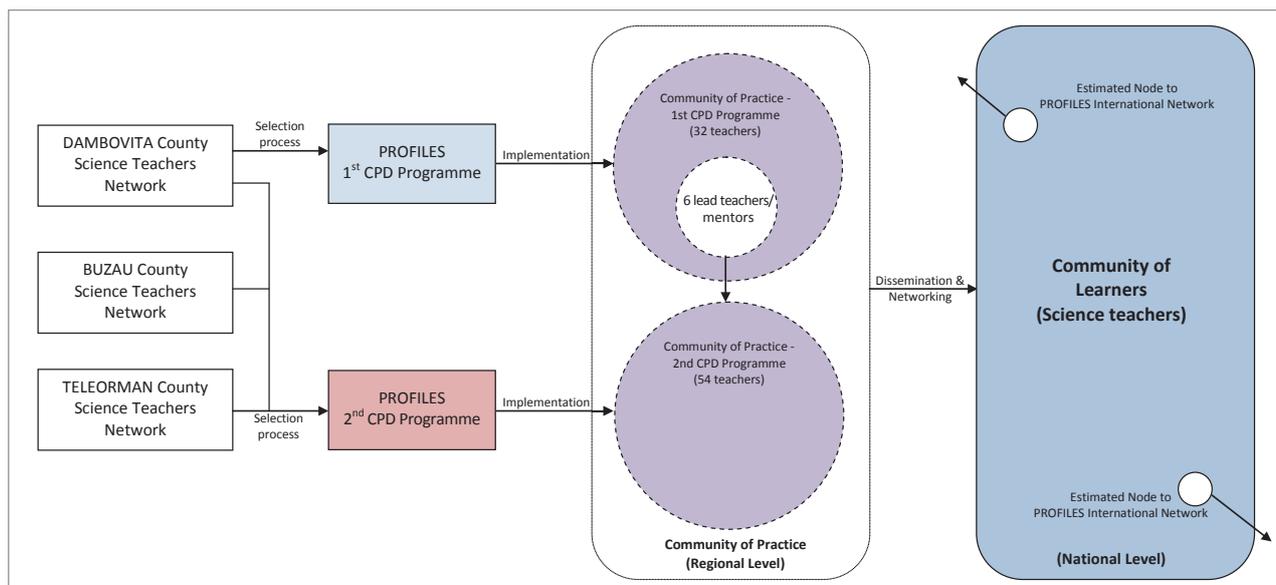


Figure 10. The actual Romanian PROFILES network

It is estimated that the network will cover in 2014 the whole country, having the potential to establish some nodes with the international PROFILES network.

Conclusions

An analysis made by VUT PROFILES team at the end of each CPD version showed that in order to organize a successful training programme there are major aspects that must be brought to the trainers' attention, like:

- the importance of the CPD programme content to match teacher needs;
- the understanding and acquisition level of the programme objectives by the participants;
- the support for the proposed teaching methods in the learning process;
- the usefulness of the training materials and examples used during the CPD programme;
- the achieved competences and their usefulness in the trainees' future work.

Furthermore, the PROFILES CPD programme experience emphasized the importance of critical thinking about the usefulness of the CPD programme and the discussion on the major possible improvements in the teaching approach, based on the new achieved competences. At the same time,

the PROFILES network is playing an important role for sharing the teachers' experience into the educational community and valorizing the good practices achieved in the frame of the project.

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Summary and Outlook

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The intention of this book – the 2nd Book of PROFILES (or as it is termed in the PROFILES Description of Work (2010) the “Book of PROFILES Best Practice”) – is to share experience of PROFILES partners, reflecting their activities and the developments in the PROFILES project, which are in line with the proposed PROFILES goals, philosophy and approach (PROFILES, 2010; Bolte et al., 2011; 2012). This PROFILES book focuses – after a brief introduction – on experiences shared by PROFILES consortium members with those who are or may be interested. These partner case studies are grouped into four sections based mainly on a central focus related to one of the following:

1. on stakeholders involvement and interaction,
2. on PROFILES type learning environments (modules),
3. on PROFILES CPD models and programmes as well as on teacher ownership, and
4. on networking and dissemination.

But beside this central focus, all partners’ contributions try to express how their engagement in this area affects PROFILES developments in other aspects/work packages (see Introduction).

The case studies presented in this book are quite diverse, even within each of the sections. They point out the cultural and educational diversities of the different partners’ countries, their different science education systems, and traditions of teaching science.

Beside these, the partners’ contributions offer a first indication of the challenge provided by the PROFILES teams in meeting the need for meaningful science teaching and learning. Further indication will follow within the project’s live span because – as all PROFILES partners are convinced – the engagement of all partners and stakeholders (e.g. the respective PROFILES consortium members,

their CPD providers and the teachers participating in the PROFILES CPD programmes as well as the students involved in the PROFILES activities) will lead to the enhancement of Scientific Literacy which we – the PROFILES Consortium – will be able to demonstrate in the next PROFILES book.

This summary offers a reflection on the case studies within the four sections in this book.

Section 1: Focus on stakeholders involvement and interaction within PROFILES

The introduction to the 1st section of this book draws attention to one of the overarching questions of the PROFILES project; namely: “What aspects of science education do representatives of different stakeholder groups (e.g. students, science teachers, science teacher educators, and science education researchers as well as scientists) consider advisable and pedagogically desirable for the individual in the society of today and in the near future?” This question is addressed in the PROFILES International Curricular Delphi Study on Science Education (Bolte, 2008; Schulte & Bolte, 2012).

In five contributions, PROFILES partners share their reflection-oriented focus on science education in their countries by discussing the findings of their national Delphi studies, operated as part of the partners’ engagement in the PROFILES project work package 3 (WP3: Stakeholders involvement and interaction). Between the partners’ articles, which address stakeholder views in their respective countries, noticeable similarities appear. The findings from the partners’ investigations show shortcomings in science education practice in the specific countries and relate to teachers’ needs that were perceived and expressed in these countries. In making through the PROFILES International

Curricular Delphi Study collective efforts have been initiated to find out and understand the concerns of the stakeholders in the different countries. By this way it becomes possible to respond to these concerns in PROFILES on various levels.

The insights provided by the findings of the national Curricular Delphi Studies serve as a very supportive source for example when PROFILES CPD providers developed long term CPD programmes suitable for the participating teachers (see WP5 or section 3 of this book) or when teachers who participate in the PROFILES CPD programmes adapted or developed within the CPD courses 'PROFILES type modules' (see WP4 or section 2 of this book) that aim at fostering the students' scientific literacy. Subsequently, these PROFILES type modules are tried out in the participating teachers' science lessons.

Overall it can be stated that the five contributions of the partners and the findings they offer point to the challenge of building a bridge to overcome the gap between 'common concept oriented science teaching' and the need for a stronger emphasis on the ideas of general education theories (in Germany termed as "Bildung"; Bolte, 2008; 2010). Those ideas – expressed in the National Curricular Delphi Studies – of how to promote "Education through Science" are recommending more cross-curricular approaches for the teaching of science, approaches which focus on and deal with nature and science in the contexts of the students' everyday life and society. Also, the findings point towards reconciling traditional approaches with approaches of inquiry-based science education. Beside this, the results from the national PROFILES Curricular Delphi Studies demand more emphasis on the enhancement of the students' 'general key competencies' (e.g. creativity, working collaboratively, problem-solving and decision-making). Reflecting these particular findings against the framework of their national science education curricula, as done by the partners in Sweden and Switzerland, underlines in many cases their emphasis as expressed in the national Curricular Delphi Studies. Discrepancies between the stakeholders' concerns, the national curricula and current science education practice might be interpreted as further points of reference

regarding chances, challenges and implications for meaningful and desirable science education.

Section 2: Focus on PROFILES learning environments

The learning environment is addressed through teaching modules. The introduction to section 2 suggests the intention is that modules go beyond a simple promotion of inquiry-based science education (IBSE) and also relate to seeing meaningful student learning as a major target e.g. the 'education through science' perspective (Holbrook & Rannikmäe, 2007). In going further the introduction indicates 9 criteria to be fulfilled by modules – address familiarity to students, and relevance as seen by students; include a range of educational competences; promote student ownership; include IBSE; developing students' conceptual (higher order) thinking, supports teachers towards gaining module ownership as a feature of their teaching; addresses nature of science, and formative assessment strategies are included.

In this section, nine case studies relate to modules development (and a few highlight modifications of modules from an earlier PARSEL project, based on the same philosophical ideas (PARSEL, 2006; Nielsen et al., 2008; Holbrook, 2008; Bolte, 2008; Gräber, Lindner & Bolte, 2008; Gräber & Bolte, 2010). Clearly classroom use of modules is seen by partners as a major PROFILES project focus and is aided by a strong teacher-participatory, involvement in PROFILES. The modules vary considerably, both in terms of the science and the grade levels for which they were intended, yet the articles overwhelmingly indicate that a context-based focus for teaching is realisable, thereby stressing student relevance and familiarity with the topic within the initial, introductory stage.

Where, in some cases, case studies provide an initial focus more heavily on the science content, the ensuing inquiry-based teaching tends to be limited to a teacher-derived, scientific inquiry question, minimising the IBSE to teacher-directed guidelines (usually in the form of a worksheet).

This, of course, lowers the degree of student-centred teaching and student opportunities for self-direction, or self-development, as aspects linked to motivation (Ryan & Deci, 2002; Bolte, Steller & Hofstein, 2013). Nevertheless, where case studies suggest a teacher-directed approach, this is seen as useful for introducing IBSE teaching to students for the first time. It is interesting that a limitation on student involvement is not shown to be a factor in socio-scientific, context-based modules, as these include wider learning outcomes, enhancing scientific literacy within aspects of the teaching. All modules – allow for teacher modification, when used in a specific classroom setting, and this is well illustrated in the case studies, sometimes linked with the implementation of a particular theoretical construct (e.g. promoting the creative thinking of students; see section 2).

While the term ‘SSI’ (socio-scientific issue) (Kolstø, 2001; Sadler, 2004; Zeidler, Sadler, Simmons & Howes, 2005; Levinson, 2006) is not a feature of the PROFILES project, it is seen as providing a strong context-based approach to science teaching in some case studies. Here, SSI is taken as a major focus of modules and the conceptual science gained through the module is seen as important to feed the relevant, socio-scientific debate. Other case studies, with much less attention to socio-scientific aspects, try to refocus the PROFILES 3-stage model which is geared to, first, context-based, second, non-context-based and third, refocusing on the socio-scientific context (Holbrook & Rannikmäe, 2010). Such case studies seek to make the IBSE motivational and rely on this aspect to promote interest above and beyond conceptual science learning. However, there is general awareness that science teaching shows that science conceptual learning, isolated from a context, is not, in general, appreciated by students (Osborne, Simon & Collins, 2003; EC, 2007).

Section 3: Focus on PROFILES teacher training (CPD) and ownership

A central element of the PROFILES project, and specifically mentioned in the introduction to section 3 as a crucial focus of PROFILES, is the CPD

model. The section introduction also points out that the purpose of the CPD is to enable teachers to gain self-efficacy and ownership related to the PROFILES philosophy, pedagogy and approach for classroom teaching of science subjects, at the grade 6 level and above (mainly secondary school). The case studies and portfolios (mentioned in the partners’ reports) indicate that the last component of the CPD model, namely the “development of leadership” among the CPD participants is not always present. However, the ‘teacher as teacher’ (the 2nd component of the model – promoting pedagogical content knowledge (PCK) is crucial, as it elucidates PROFILES ideas and the important cross-curricula teaching, indicated by the ‘education through science’ (ES) component in the PROFILES acronym (PROFILES, 2010). This is taken to be an essential part of the CPD and is well detailed in a number of the case studies. The ‘teacher as reflective practitioner’ component, although a further key element of PROFILES, is less well articulated. Nevertheless, most case studies indicate that the PROFILES CPD model, as a major feature of PROFILES, provides an effective platform for teachers’ reflections and feedback. The model strongly supports the rationale for the PROFILES project and also establishes the need to guide teachers to pay much attention to motivational strategies (especially intrinsic motivation of their students). In addition, the case studies presented in section 3 of this book draw attention to student-centred strategies, highlighting inquiry-based science education (IBSE), and socio-scientific decision-making.

Commonalities among the case studies include recognition that the CPD is longitudinal (a year-long programme for practicing teachers as well as for pre-service teachers) – essential for classroom interventions to familiarise students to a number of PROFILES modules and thus allowing effective implementation in the classroom and meaningful student feedback. The case studies also involve face-to-face contact, through lectures and workshops, and include classroom intervention components, stressing students’ involvement in cognitive development in science, inquiry learning, and in the manner in which the science is consolidated through socio-scientific decision-making.

Some case studies emphasis more on the effectiveness of the CPD. This is through incorporating of such techniques as SWOT analysis, questionnaires, or the development of PROFILES relevant teaching modules. This is undertaken individually, or through participatory approaches in which a group of teachers get together to discuss a certain pedagogical approach or instructional techniques. Interesting findings emerge, in which students motivation is seen as a key element and teacher participatory involvement in the adaptation, or even the development of new modules, are considered. The case studies show that self-efficacy of teachers, in handling the PROFILES 3 stage model, is an attainable and meaningful target for teaching science in a more interdisciplinary way, particularly when focusing on real, relevant, and familiar, society-related contexts.

Based on the partners' contribution there is evidence that the partners have adopted the PROFILES' philosophy, pedagogy and skills to professionalise their science teachers. While different emphases in operating professional development are used, the majority of partners included the "teachers as curriculum developers" approach to develop, implement and adapt modules (Mamluk-Naaman, Hofstein & Penick, 2007). In this, teachers are shown to be intensively involved in the development and have ample opportunities to reflect on their experiences during the CPD as well as during the classroom implementation. All these factors influence the enhancement of self-efficacy of the teachers regarding PROFILES and its related implementation procedures.

Section 4: Focus on networking and dissemination as a feature of PROFILES

In the introduction to the section on Networks and Dissemination, PROFILES-networks are distinguished with regard to their complexity, from networks at schools to inter-school networks and networks on local, regional, national and even international levels.

While some case studies include dissemination ideas, this is not approached as a major component

within any PROFILES article – this element, for most partners, is work in progress. However, the section highlighting networking illustrates the major role this can play in promoting the success of the PROFILES project. The case studies also indicate that a difficulty with networking lies with how to initiate the networking and show that this is greatly assisted by building on existing networks. In fact, no network is described started from scratch and all see teachers' interest in networking of paramount importance for success.

Based on the case-studies presented, the following general findings can be drawn: Good practice cannot be cloned, but exchanging experience may promote learning and innovation; the networks offer learning of exchange processes among teachers which support the professional development (e.g. fresh ideas for science teaching, cooperation in and among schools); It is necessary to maintain a balance between *action & reflection* (goal-directed planning and evaluation) and *autonomy & networking* (analysis of one's own situation, but also supported by "critical friends" e.g. colleagues at school, facilitator) in order to set up a sustainable support system for schools.

There are a number of risks, e.g. that a network moves away from the interests of teachers and from the teaching and learning of students; common visions and goals disappear; the network fails due to weak coordination and steering or fails due to a lack of resources (money and time).

The overall challenge can be described as keeping momentum between structures and processes or, in other words, between stability and flow to enable sustainable development of learning (Rauch, 2013).

Recommendations and conclusions

The question thus arises – is PROFILES a viable ongoing initiative and how far has PROFILES proved successful in addressing the EC report findings (EC, 2007), and can thus provide a meaningful vision for further science education developments?

First Finding (EC, 2007):

“A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science.” (EC, 2007, p. 2, p. 14)

The case studies in this book – as well as articles provided by PROFILES partners in the 1st Book of PROFILES (Bolte, Holbrook & Rauch, 2012) – point to success regarding the first recommendation on the inclusion of inquiry-based teaching. Although we are aware that until now only little empirically based evidence is available, there is a reasonable amount of evidence emerging from the different case studies and field reports of the PROFILES partners that PROFILES interventions are less teacher-centred (and linked to this, less deductive). In many cases, the contributions show that the context-based scenario can claim to provide a more meaningful initiation to less deductive teaching. It can further be stated that the PROFILES approaches allow teachers to play a major role in directing the teaching in a more motivational and interesting manner.

The PROFILES outcomes indicate through these case studies from partners that the examples given can certainly clarify ways of meeting the 1st EC finding, while the strongly context-based PROFILES modules and the PROFILES student centred teaching approaches seem to hold the promise of enhancing students interests in science, and their motivation to learn in science lessons.

Second Finding (EC, 2007)

“Renewed school’s science-teaching pedagogy, based on IBSE, provides increased opportunities for cooperation between actors in the formal and informal arenas” (EC, 2007, p. 15).

Many case studies refer to the 3-stage model which firmly sees science conceptual learning as its heart. Within this, as strongly amplified by case studies, is the importance of inquiry-based science education, especially where students have the opportunity to go beyond the worksheet and can play a major role in the target and planning of the learning, often

posed as problem-solving. But the model promotes a wider range of pedagogies, strongly promoting links to everyday life and cooperative learning both within and outside the school.

Third Finding (EC, 2007)

“Being part of a network allows them [the teachers] to improve the quality of their teaching and supports their motivation.” (EC, 2007, p. 15)

The PROFILES articles show that the project has success in addressing this finding on indicating that the participating teachers were key players and successful in increasing their students motivation to learn science and in appreciating their PROFILES science lessons. In fact, authors of a number of articles, describing their CPD initiatives are focussing on practising teachers who were and are able to optimize the science teaching in ways that their students will appreciate this more than they did before and once more point to the key role the teachers with proper skills in content and pedagogical content knowledge play in seeing PROFILES type ideas being implemented in practice. Also, the articles on the PROFILES network activities clearly point to networking being very motivational for teachers and show the value of teacher networks in promoting reflective and collaborative teaching as a way of raising the quality of student learning.

Recommendation from the PROFILES project

However, from the PROFILES consortium’s viewpoint, the EC report (EC, 2007) missed a key point in not recognising that the teaching approaches, used by teachers, stem from the perception by teachers of what they see as ‘good’ science education. Case studies in this book show the importance of teachers appreciating the wider PROFILES ideas and not simply implementing content, or science conceptual learning. The teaching approaches, promoted by PROFILES type modules, go beyond students being involved in ‘hands-on without minds-on experimentation’ and show how the PROFILES CPD programmes play a key role in guiding teachers to gain confidence in

new pedagogical and science educational initiatives such as the PROFILES approaches. The strong vision provided by the PROFILES CPD programmes and the respective CPD provider also enables teachers to play their role in seeking evidence of the value of PROFILES in the classroom setting and thus show the important role of the long term CPD programmes in enabling teachers to move towards PROFILES teacher ownership. Teachers achieving an ownership stage can be expected to incorporate PROFILES ideas and approaches into their science teaching long after the life span of the PROFILES project which will be reached in December 2014.

Outlook

The next – the 3rd – PROFILES Book will be dedicated to the contributions of partners (keynotes, workshops, posters, etc.) at the second PROFILES conference. This book will deal with the evidence which the PROFILES partners will be able to provide regarding the development of their “teachers’ ownership” (see WP6) and the impact the PROFILES approach on “students’ gains” (Bolte & Streller, 2011; Streller & Bolte, 2011). It will be published in August 2014 (when the “2nd International PROFILES Conference on Enhancing Scientific Literacy in Europe and beyond” will start). The book will also be disseminated – as the other PROFILES Books – via the PROFILES International Homepage (www.profiles-project.eu) and/or via: <http://ius.uni-klu.ac.at/misc/profiles/articles/view/31>).

The PROFILES consortium is convinced that the PROFILES project, the experiences we – the partners – are able to share and the projects outcomes point to a meaningful vision for further and future initiatives in the field of science education.

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