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Evaluating the teaching impact of a prior, context-based, professional development programme

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Abstract
This paper explores the impact of teacher involvement in a context-based teaching project, involving continuous professional development and classroom module implementation two years after the event. Five chemistry and biology teachers were interviewed to ascertain the degree of ownership gained from the project related to continued use of the teaching modules and a new type of teaching, structured on a 3 stage model. From one-on-one interviews, data was gathered and discussed related to the degree of continued use of modules, the teaching style used, obstacles to continued module use in the manner intended and the value of the continuous professional development sought. Recommendations were made for further continuous professional development which builds on the teaching model and which relates to a new style curriculum introduced into Estonia.
Keywords: Continuous professional development, 3 stage model, teaching modules

Introduction

In today's rapidly changing world, our daily lives are increasingly affected by different technologies and scientific achievements. In turn, this has led, in many countries, to school reforms and paradigm shifts in teaching: no longer can schools be expected to solely prioritise the memorisation of facts and educate student specifically to become young scientists. There is a growing awareness of the need to focus on creating citizens who are versatile and capable of coping in our modern technological society (AAAS, 1989; EC, 2004; OECD, 2007; Fensham, 2008).

The latest European Commission documents point to the need for a change of emphasis in the teaching of science subjects from teacher-centred and content oriented approaches to inquiry based, with an everyday issue approach (EC, 2007). Furthermore, innovative and knowledge-based societies need young people who are equipped with a wide range of skills such as problem-solving, decision-making, communication skills, collaboration abilities, reasoning skills, etc. (Driver, Newton & Osborne, 2000; Osborne, Erduran & Simon, 2004; Sadler, 2004, Sadler & Zeidler, 2005; Hofstein, Eilks & Bybee, 2010). All such skills can be promoted through the teaching and learning of science; and, without this, there is the danger of science education becoming isolated from general education and seen as irrelevant by students (Roth and Lee 2004; Jenkins, 1999; Holbrook & Rannikmäe, 1997; 2007).
Teachers usually accept a new curriculum more easily when it is in accordance with the learning goals they personally value (Johnston, 1992), or when it is perceived by them as a

possible solution to problems they currently experience (Van Driel, 2005). The work of Joyce and Showers (1995) showed that teachers are more likely to make changes in their practice if presentations and workshops have been arranged in which the new skills have been described and demonstrated, and teachers have had opportunities to reflect on their own performance. Furthermore, innovations have succeeded when teachers have felt a sense of ownership in the innovation, or that they were part of carrying out the innovation and it was thus not simply imposed on them (Ogborn, 2002; Pinto, Couso and Gutierrez, 2005). A sense of participation through ownership has led to teachers effectively carrying out their tasks in the classroom geared to the intended innovation.

At the present time, Estonia is introducing a new national curriculum (Estonian Government, 2011), accompanied by ongoing educational reforms, which are intended to lead to significant changes in school life. For example, upper secondary schools (gymnasiums) have the opportunity to act as independent institutions, each offering education in three different streams: science, social science and humanities, where the emphasis is on increasing the number of elective courses for students. In the science domain, such elective courses not only target in-depth modern science developments, but also the development of students' creativity, argumentation, and decision making skills, plus a more interdisciplinary understanding of issues and phenomena in the surrounding environment using evidence-based approaches.
A further, important change is the replacement of national examinations with domain specific school-based examinations. For students who have chosen to study in the science stream, this means a complex assessment structure, including cognitive tests linking knowledge with a wide range of skills acquired in learning biology, chemistry, physics and investigatory based laboratory activity to demonstrate acquired competencies.

The above mentioned curriculum changes (and school reform) have put forward new standards for teaching. A Tartu declaration (2010) recognises that the key for developing science education is the teacher: high-quality teacher pre- and in-service education, in the form of continuous professional support, are essential in order for teachers to create sustainable rich, relevant, interesting, current and timely science and technology education. This study seeks to determine the gains made by a purposive sample of teachers related to an innovative and context based model, introduced through an in-service programme, on their teaching success in using the approach advocated, the obstacles involved in the continuing use of the modules introduced and an evaluation of the professional development programme which they had undergone.

Theoretical background

A major concern in science teaching today, at least in developed countries, is the lack of students' positive attitudes towards school science (EC, 2007). Such science teaching is seen as "irrelevant, not liked, boring and abstract" (Schreiner & Sjoberg, 2004). Unfortunately, the science in which students are engaging in school often has little connection to everyday life outside of school. A contributing factor to this is the manner in which science is perceived as being promoted to enable students to become young scientists (Birkhouse, Lowery & Schultz, 2000). Other have suggested that science teaching in school focuses too heavily on aspects that are important from a scientist's perspective, rather than recognising it is more important to consider the teaching from the viewpoint of the learner and society (Holbrook & Rannikmäe, 2007). Yet students are shown to be motivated, if the teaching themes in science classes are related to aspects of real life (Teppo and Rannikmäe, 2003; Bybee and McCrae, 2011).

Student motivation has clearly been shown to be promoted by the learning environment created by the teacher (that is, extrinsic motivation). Yet, a more powerful approach, referred to as self determination theory (SDT) has been shown to be stimulated by the student's own intrinsic motivation through experiences of autonomy, competence and relatedness (Ryan and Deci, 2000a; Ryan and Deci, 2000b). The autonomy component is stimulated by opportunities for self determination, while competence is a feeling associated with achievement. Relatedness has close association with relevance enabling students to be motivated by learning that perceived to have meaning.

Teaching approach

To stimulate intrinsic motivation in students, emphasis is placed on the development of context-based teaching materials (Prachman et al., 2006; Eilks, Marks & Feierabend, 2006). However, research has shown that just the use of materials is not enough to promote changes in the teaching emphasis offered by teachers (Laius et al., 2009). The work of Joyce and Showers (1995) showed that teachers are more likely to make changes in their practice, if presentations and workshops are also conducted in which the new skills are described and demonstrated, and when teachers have opportunities to reflect on their performance.

One innovation to guide teachers in the implementation of teaching materials is through the use of a 3 stage model, designed to promote students' intrinsic motivation to become more interested and engaged in the learning of conceptual science ideas and, in particular, to undertake inquiry learning (Holbrook & Rannikmäe, 2010). The intention of the model is to provide a wider coverage than just ideas for developing and implementing existing teaching material; the model gives directions for teacher professional development orientation in order to sustain a paradigm shift in teachers towards more motivational approaches to education through a context of science. Besides promoting student motivation, it also places emphasis on inquiry-based learning and an 'education through science' philosophy to promote wider learning than just aspects related to the nature of science (Holbrook and Rannikmäe, 2007).

The three main stages within the model encompass (Holbrook, 2008a; Holbrook & Rannikmäe, 2010): Stage 1, the stimulating students' through intrinsic motivational stage, initiated by a carefully chosen title perceived to be relevance for students. The goal of stage 1, however, goes beyond students' desire to be involved and, by means of a scenario, seeks to motivate students to recognize the importance of attaining the science underlying the socio-scientific scenario.

Stage 2 picks up on the students need to acquire conceptual science learning and through an inquiry-based science education approach, students are guided to obtain evidence associated with gaining the science and scientific skills, identified as important by students. It includes also, as appropriate, the promoting of students' creative or ingenious thinking, as well as encouraging student-student collaboration and an awareness of safe working, self-responsibility and self-determination.

Stage 3 is the consolidation phase for the science learning, in which the acquired science is transferred into a socio-scientific decision making situation, thus promoting argumentation/ reasoning skills to reach a consensus, first within a small group and then for the class as a whole.

Teachers enact this model through carefully crafted teaching modules, which are designed to promote scientific literacy in a manner considered by students to be both enjoyable and

relevant. The modules are created accordingly to the specific philosophy (Holbrook, 2008a) and having its roots in activity theory – establishing a motive based on a student need leading to a desire to undertake an activity (van Aalsvoort, 2004). As student engagement through thinking and doing is an important thrust for science teaching, inquiry-based science learning is specifically promoted within each teaching module. Teachers meet the modules for the first time through a continuous professional development programme (CPD) which guides the teacher intervention of modules in the classroom situation.
As research has shown that the 3 stage model can be interpreted differently by different teachers, related to their professional experiences and how they deal with constraints faced during teaching (Holbrook et al., 2008), this study seeks to determine whether teachers continue to use modules 2 years after the CPD and if so, in what ways do they promote the teaching-learning process. The outcome is intended to allow reflection on the CPD provided for future guidance to additional teachers in using the 3 stage model and the modules developed based on this teaching approach.

Continuous Professional Development (CPD)
CPD is widely acknowledged to be important in the pursuit of improvements in teaching and learning (Craft, 2000). While there are many interpretations of CPD, at its core is the enhancement of pedagogical content knowledge (Shulman, 1987) and teacher reflection on their beliefs and classroom actions. In fact, as Day (1999) suggests, CPD can be taken to relate to all natural learning experiences, plus those conscious and planned activities which are intended to be of direct or indirect benefit to the individual, group or school.

Teachers for this study had undertaken professional development over an extended period in which attention was paid to introducing the 3 stage model and the manner in which this related to the developed teaching modules. Prior to the study the teachers had been guided in their classroom intervention, where a number of modules were tried out with students. The teachers had been given opportunities to reflect on their practices and to discuss with other teachers the value and methodology of using the teaching modules and how student assessment could be undertaken.

Research questions:
1. In which ways do teachers, previously introduced to teaching modules based on a 3 stage approach, use modules in their current teaching?
2. What are essential components of future CPD that enable teachers to utilise modules and overcome constraints in adopting philosophical and curriculum changes for effective science teaching?

Methodology of the Study
The Sample
The sample group comprised of teachers who had participated in training courses during the years 2007 to 2008, together with intervention, where they taught 4 or 5 modules based on the 3 stage model, taken from an international module bank (www.parsel.eu). The actual sample consisted of five teachers, all of whom were teaching at the upper secondary school level, were all female, while four of them taught chemistry and one, biology.

The Instrument
A semi structured one-on-one interview was held with every teacher, each taking about 30 minutes. The interviews were conducted on two consecutive days under similar conditions.

During the interviews a list of module titles used during the intervention study was solicited from the teachers.

The semi-structured interview instrument covered four areas, focussing specifically on:

A) Matters relating to the use of modules:

This area was introduced by mentioning that it is now 2 years since the previous study finished and the following questions were posed:

- Are you still using the module approach?
- Which modules do you continue to use and why?
- How do you understand the 3 stage model and its implementation now? *(If appropriate, the questioning continued to include do you include all 3 stages in you teaching?)*
- Have you modified any modules, or developed any of your own?

B) Teaching style used

This was approached in two ways:

(a) Examining the relationship teacher saw between the teaching style they used and use of the modules. The major focus was to determine whether teachers were more inclined to use student-centred teaching in using the modules and hence whether there was any link between the use of modules and a shift towards greater use of student-centred teaching approaches

(b) Seeking to determine how far, and in what ways, the teachers focussed on motivating their students to learn? By reminding the teachers that inquiry teaching was an essential component in the new curriculum, questions were posed – what is and how much do you use an inquiry approach in your teaching? This was followed up, where positive responses were gained, by asking the teacher to give an example. Also included was the question - do you like to organise group work, debates, etc?

C) Obstacles to the use of modules.

The teachers were asked the following:

- Do you find any obstacles which stop or limit your use of modules? *(Where the response was positive, this was followed up by the question - How do you strive to overcome those?)*

And how to ascertain whether the modules available might be inappropriate because teachers felt they did not relate to the curriculum (as perceived by the teachers), the question was posed :

- Do you need more modules which are linked with the curriculum content?

To guide teachers to reflect on the lack of self-efficacy related to the use of the 3 stage model and teaching using the modules teachers were asked:

- Do you feel you need more CPD to feel comfortable to modify modules, or better understand the 3 stage model philosophy?

D) Training issues.

The fourth area covered in the interview was the teacher's perception of the effectiveness of the professional development support they had received through the long-term training.

The section was introduced by reminding the teachers that Estonia is now introducing a new curriculum. The questions asked focussed on:

- Do you think the intervention study in which you were involved would be a useful type of CPD to offer to others?

- What do you recommend to change within the programme you experienced?
- Where would you feel it important to place greater emphasis?
- Do you recommend continuing to introduce the 3 stage model approach and the modules in science teaching in Estonia?
- Would you like to participate in another intervention programme?

The interviews were recorded and the transcribed interviews were subsequently analysed by the first author. Three teachers from the five were approached a second time, by telephone, to validate their answers. Finally, two independent researchers validated the interpretation of the interview outcomes.

Results

Using modules:

From a set of 10 modules introduced during the previous training, teachers were expected to have tried out 3 or 4 of these. Two years later, the teachers were asked how many of these were still being used. Those used are identified in table 1, together with the teacher(s) using them and reasons are given for their use, plus modifications made.

Table 1. Modules used by teachers in their teaching 2 years after the intervention study.

Nr	Module title	Teacher(s) using the module	No. of lessons required	Reasons given for continued use	Modifications made by the teacher
1.	How to Best Maintain a Metal Bridge?	A, C	6 stated in script, but only 3-4 used in teaching	Very relevant to the curriculum (elementary school and gymnasium level). Includes practical work and group problem solving tasks.	Scenario was changed: bridge was replaced by nails. Doing this was just an inquiry experiment, which was linked with stage 3. Stage 3 was missing
2.	Should we do more to save cultural monuments from corrosion?	D	4	Very relevant to the curriculum (gymnasium level). Two practical activities on the corrosion of metals.	Scenario was modified according to students' interests (or the neighbourhood and history)
3.	Which Soap is Best?	A, C	4	Somewhat related to the curriculum. Practical work on properties of (laundry) soap.	Soaps as well as washing detergent were used
4.	Salt – the good, the bad and the tasty?	A	3	Somewhat related to the curriculum. Practical work on electrolysis and crystallization.	Only the crystallization experiment was used. Stage 3 was linked with fertilizing plants and salting roads
5.	Lara (16) is pregnant!	E	6	Very relevant to the curriculum. The scenario is presented in the form of PPT, includes group work, debates and a letter from Lara, where each student is asked to express his personal views on juvenile	Additional information was collected from the media on youth and anti-pregnancy counselling. A meeting of young students' over a magazine replaced the PowerPoint presentations.

				(teen) pregnancy.	
6.	I love candy! And they keep telling me not to eat it!	E	6	Applies to the curriculum. Practical work on home healthy food preparation and calorie calculation.	Module modified for the simultaneous use in biology and chemistry classes. Group work was introduced to find out information and prepare a wall poster on nutrients and health hazards, in addition to practical work on making advertisements.
7.	Shall we create new organisms?	E	4	Very relevant to the curriculum. Compiling a report and role-play.	Scenario modified to be relevant to Estonia. It was modified by being based on local research developments geared to cloning and diabetes.

The table shows that:

1. The teachers interviewed used from 0 (teacher B) to 3 modules (teachers C and E). Teacher B did not use modules because the school was under renovation and facilities were not available. Relevance to the curriculum, or the ability to include practical work were the usual reasons given for using modules, while modifications made were often to reduce the number of teaching lessons and to relate the module more to local Estonian contexts.

2. The teachers did make modifications to the modules. These were made to all stages related to the 3 stage model, but especially to stage 2. The changes made are illustrated in table 2.

Table 2. Modifications linked to the three-stage model, solicited through the interviews

1st stage	*Teacher*
Modify the scenarios according to students' interest.	A;C;D;E
Guide students to put forward scientific questions from the socio-scientific scenario	A;C;D;E
2nd stage	
Guide students to put forward a hypothesis for investigation	A; C; D
Use guided inquiry (practical work). Students are free to choose what and how they research about a topic, compiling a research plan is given to them as homework. Inquiry question is given by the teacher.	A; C
Use of structured inquiry. To save time teacher D guides the students by discussing with them how to conduct an experiment Teacher E gives the students the inquiry question and method of investigation.	D;E
Guide students to undertake theoretical investigation/problem solving (a pencil and paper investigation)	C;E
Involve students in learning through group works of various types (role play, laboratory work, debates, presentations)	E
Promoted effective peer to peer learning through student group work	A, C, D, E
The group works leading to oral presentations	A;C;D;E
Evaluation of individual worksheets or written records	C;D
Incorporate different subjects and safety aspects	A;E
3rd stage	
Socio-scientific decision-making which takes into account economic, ethical, environmental and / or political aspects.	A;C;E

Teacher's shorter name when referring to modules

In the interviews teachers made reference to the modules by giving a shortened name. Usually this reference reflected its content, rather than the everyday life aspect of a social scientific problem. The short names, as used by the various teachers, are shown in table 3.

Table 3. How teachers referred to the module during the interview

Actual module title	**The shortened titles used by the various teachers**
How to Best Maintain a Metal Bridge?	*A - Corrosion/ bridge* *B - Bridge* *C - Corrosion of bridges* *D - Corrosion - different ways*
Should we do more to save cultural monuments from corrosion?	*D - Corrosion- several ways*
Which Soap is Best?	*A,C,D - soap* *B - Washing powder*
Salt – the good, the bad and the tasty?	*A - Salt crystals*
Lara (16) is pregnant!	*C - Lara* *E - Lara is pregnant*
I love candy! And they keep telling me not to eat it!	*E - OK loves candies*
Shall we create new organisms?	*E - Is the creation of genetically modified organisms possible?*

Teacher D gave priority to the substance of teaching, while teachers A and C placed importance on practical skills. Teacher B tended to refer to modules based on the practical or decision making skills. Teacher E referred mainly to modules in relation to decision making skills.

Teaching style associated with using the module

The preferred teaching style adopted by the teachers was influenced by the modules they used and the manner in which they were used. Table 4 illustrates the relationship between the teaching style and how modules were used.

Teachers A and D stressed the subject content, which was assumed to be the priority they gave to the substance of teaching. Teachers A, B and C put emphasis on experimentation, or on the conceptual science object of study. Teachers B and E concentrated more on the problem raised in the scenario.

Identified student skills involved in modules

When the teachers were asked directly, “Which student skills were developed during the module?” all teachers mentioned an increase in problem solving and teamwork skills and content knowledge was not included. This is illustrated in the following table, where the identified curriculum skills are given in the first column and teacher responses are included in the second

Table 4. Relationship between teaching style and using the modules

Teacher	Teaching style	Use of Modules	Modules used in teaching
A	Student centred (according to own view). Often uses the practical work, inquiry learning, group work, student presentations. Attempts to focus on solving problems.	Uses the ideas of the modules in an abbreviated form for 2-3 lessons. Selected modules by content or experiment.	A big problem for Magalhães (Magellan): Food preservation. How to Best Maintain a Metal Bridge? Which Soap is Best? Salt – the good, the bad and the tasty?
B	Student centred (according to own view) But currently not able to undertake practical work with students. Rarely uses group work, but student presentations are frequently uses. Appreciates the work of talented students. An essential ingredient of module sis the link to everyday life solving of problems. Did not use role play and debates.	Did not use modules. Previously had selected modules by problem or experiment.	A big problem for Magalhães (Magellan): Food preservation. How to Best Maintain a Metal Bridge? Which Soap is Best?
C	Student centred (according to their own view). Often uses practical exploratory work, rarely uses role plays and debates. Knowledge (of the content matter) as well as problem-solving skills should be of equal importance.	Continued to use two modules. Followed the structure of the module in 2-3 hours/lessons. Selected modules by experiment.	How to Best Maintain a Metal Bridge? Which Soap is Best? How much can you drink to drive legally? Lara (16) is pregnant!
D	Teacher-centred rather than student-centred (according to their own view). Role-play and debates not included and use of experiments is rare. The teacher does relate the material taught in everyday life and problem solving skills.	In the last academic year, no modules used. One module was used in the previous year. Selected module by content.	How to Best Maintain a Metal Bridge? Which Soap is Best? Should we do more to save cultural monuments from corrosion? How much can you drink to drive legally?
E	Student centred. Often uses group work, student presentations, student identification of the problem of learning, a students' exploratory learning style. Less commonly uses experiments, role play, or debates. Attributes use of modules to inclusion of important subjects from everyday life.	Continued to use three modules, following the structure of the modules. Selected modules by the problem/issue posed.	Lara (16) is pregnant! I love candy! And they keep telling me not to eat it! Shall we create new organisms? Milk – Keep it refrigerated

Table 5. Teacher comments on student skills developed through use of the modules

Curriculum indicated student skills	Teacher interpretation
a) acquiring and utilising empirical knowledge about biological and physical-chemical systems in exploring the environment and societal issues;	None related to modules
b) mastering scientific methods	Teacher C - mastering scientific methods
c) developing scientific problem-solving and socio-scientific decision-making skills	Teachers A, C, D, E - problem solving
d) developing students' personal competencies, including being creativity, gaining communication and interpersonal and teamwork skills	Teachers A, B, E - teamwork skills Teacher E - communication skills Teacher C – thinking skills

Problem solving was clearly recognised by all teachers during the interview as an expected student skills, expect teacher B, and mention was included of teamwork skills by teachers A, B and E.

Obstacles to the use of modules.
All teachers mentioned that they were constrained by obstacles in the use of modules in their teaching. The main obstacles were seen as:

- syllabus very extensive (cited by all 5 teachers),
- the lack of testing facilities and supporting staff (cited by all 5 teachers).
- big class size e.g. 36 students in the class (cited by 4 teachers),
- the need to consider the external examinations (cited by 4 teachers),

All five teachers indicated they would prefer sub-group lessons (class split into 2 sub-groups to be taught separately). The reason put forward for this was the constraint in undertaking assessments and also the length of time required to teach using the modules. Nevertheless, teacher E did not consider the large size of classes to be an obstacle since the modules used did not contain practical work in the classroom and the examinations at the end of the 9th grade were not seen to be of great importance.

Teacher B specifically commented that*:*

> *"Our school is undergoing renovations so we have been using substitute rooms which are completely unsuitable for practical activities. The renovation period has been very stressful for me and I haven't been able to accomplish as much work as I would have wanted. Working conditions have a significant impact on a teacher's willingness to spend more energy on teaching."*

Teacher E indicated: *"I do not know why I'm not using modules. Lack of interest may be due to the lack of suitable physics modules."*

Teacher D mentioned: *"Due to illness I haven't used modules this year. The remaining teaching time is short and the curriculum is extensive."*

Training issues.
The teachers made few comments on the CPD programme they had received and were rather reticent to put forward suggestions for future CPD programmes to be offered to other teachers. But all teachers stressed that the preparation for the teaching of modules, for the first occasion, takes a very long time and thus it is important that, through the CPD, teachers are strongly motivated and convinced that the use of such modules was worthwhile. In this way the teachers agreed that teaching using the modules would be more meaningful and valuable learning experiences for students.

The teachers recognised that there are obstacles of a more subjective character, such as the teacher not being keen to put in sufficient effort to overcome temporary problems. Teacher motivation is stressed as necessary to overcome such lethargic thinking and put the student needs as the centre of focus.

Teachers A and D stressed the need to pay strong attention to 'playing-through' modules in the training courses in order to get a better understanding of philosophy of the modules and save time for first time preparation for the lesson. However, teacher B thought "playing through" may hold back teacher's creativity, because teachers try to copy what has been done during the in service

Discussion

While it was found that the teachers did continue to use modules in their teaching after the initial training, they were very selective in which modules they used. It was found also that the teachers could name the 3 stages on which the philosophy of the modules was based, although they were not capable to integrate (link) their teaching between the stages. This inevitably meant that reference to the modules was by shortened names, highlighting the conceptual science, especially in preference to the acquisition of problem solving, decision making skills and hands-on process skill experiences.

The outcomes indicates that the teachers found the modules of use and were motivated to use them even in limited circumstances, but the philosophical advancements were not appreciated and the teachers continued to view conceptual science as the overriding focus of science teaching even though this had been shown by research to be irrelevant and difficult in the eyes of students (EC, 2007). A paradigmatic change in teaching was not very apparent.

Teachers judged the value of using a module from two perspectives:

1. whether the module was initially relevant to students and thus contributed to the students' intrinsic motivation, and
2. how the modules helped to achieve the learning outcomes specified by the curriculum.

If one of these dimensions were lacking, the teachers disregarded use of the module. In fact the main reasons given for not using modules were the weak link to curriculum content and the need to make major or sophisticated modifications to increase the perceived relevance for students.

Even if modules did meet the above criteria, modules were only chosen if:

a) there was a perceived possibility of modifying them in a short time in accordance with the national curriculum, and
b) the presence of interesting experiments.

When choosing modules, the surveyed teachers thus based their decisions on matching the module to the curriculum objectives and learning outcomes. However, other important considerations were the scenario (teachers generally liked the use of an introductory scenario) and manageable practical work which did not require sophisticated equipment. This approach to choosing modules overrode any suggestion that student motivation should be stimulated by specifically addressing the articulated needs of the students and hence focussing the learning for maximising student gains based on student expressed relevance.

Teachers were willing to make modifications to modules, but these were made to confine the teaching more to the content curriculum, or to introduce local examples related to the scenario. Nevertheless, innovative modifications were also evident. One interesting idea for the teaching module on 'candy' was its modification for use in both chemistry and biology lessons. As the same students were involved in both subject classes, this enabled the integration of subjects, noting that several concepts and processes are taught in chemistry as well as in biology classes. Students got a wider and more complete "picture" and they were able to see the link and bridge pre-knowledge with that newly acquired.

All the teachers thought the modules were suitable for both stronger and weaker students alike. In this regard, teachers C and D stress the importance of forming groups, so that each group would include both weaker and stronger members. But as teacher A commented:

"Really, it suits both. The stronger student knows how to get more out of it; they have greater knowledge so they can see the more complex problem or issue. And the weaker student sees the problem that was hinted at in the introductory part."
All the teachers saw the use of scenarios as being motivational for students, but at the same time, they did not try to prolong this motivational aspect. They tried to save teaching time by shortening discussions, in part because of a lack of self efficacy in handling the associated teaching technique and partly because the teachers wished to put emphasis on the science leaning aspect that would follow, often driven by prescribed worksheets.

A positive, direct impact of the modules was to raise the level of student-centred methods e.g. groupwork, or whole class brainstorming of ideas. If research tends to show teachers don't like to entertain groupwork and prefer teacher centred approaches, then the current studies shows the intervention through the use of the modules has had a permanent positive impact on introducing student-centred teaching methods. Also, if the modules originally included practical work, teachers were willing to consider student-centred aspects such as experimental planning, formulating the science question and hypothesis. However, this was not the usual practice and teachers did not value the skills involved even though they recognised these were related to an inquiry-based teaching approach recommended in the national curriculum.

Reflections on teacher comments on the modules used:
Teachers made comments on specific modules to indicate why these were chosen. Thus teacher A commented on the module 'Corrosion/bridge' (How to Best Maintain a Metal Bridge?) indicating that it applies very well to the syllabus and the teaching materials are very good and provide new knowledge. Also for the module on 'Soap' (Which Soap is Best?), the teacher indicated that students were fond of this module because the topic was familiar and necessary.

The emphasis on curriculum relatedness was very evident, although the liking of the scenario showed agreement with the suggestion that one way for engaging students with science was to raise their interest towards science and this could be done by connecting school science with everyday life (Teppo & Rannikmäe, 2008). The teacher could also play a key role in illuminating the personal relevance of the topic, by allowing students to relate it to personal experiences (Waden, 2001).

Teacher B, in praising the use of modules, highlighted the observation that the students were actively engaged when working with modules; they immediately started to generate ideas to come up with appropriate experiments. The modules helped involve all the students in the class– nobody was just sitting around. Nevertheless, for all the praising, the teacher did not find it possible to overcome the constraints imposed by the restructuring of the school premises.

The comments thus illustrate how teachers found the modules to be of use and were motivated to use them. The evidence suggests that the teachers believed students are motivated if themes are related to aspects of real life (Birkhouse, Lowery & Schultz, 2000; Teppo and Rannikmäe, 2003; Bybee and McCrae, 2011) and they are willing to take steps to move away from a focus, even though not strong, seen as important for becoming a scientists (Holbrook and Rannikmäe 2007).

Nevertheless, there is also evidence to suggest that the teachers' belief in their key role, as one of the teacher leading the student learning, is strong. This is perhaps less to do with the extrinsic motivation develop by the classroom atmosphere, as it is by the need to meet the curriculum requirements. Relatively little faith is put in student-led teaching and in seeing student's intrinsic motivation as important for all components of the teaching and hence in guiding the conceptual science learning, as implied by Ryan and Deci (2000).

Value of the 3 stage model

Teachers did see value in using the various stages of the 3 stage model (Holbrook and Rannikmäe, 2010), but they tend to see this as 3 isolated components. In stage 1, teachers focus primarily on getting students to enact the scenario rather than seeing this as a motivational approach to stimulate students towards learning the science included in stage 2. A common practice by the teachers is to use the scenario, either as is, or in a simplified modification (simplified to bring the scenario closer to student everyday life, but at the same time narrowing the learning down to exclude more diverse issues/aspects). The teachers were 'the deciders' (not the students) whether to use the scenario as is, or to simplify. For example, in the module on cultural monuments, the original scenario paid attention to high value historical monuments as opposed to less significant local ones (it was recognised that if local monuments were used, they don't have the historical/cultural background and hence this doesn't lead to the more diverse discussion. However, the thrust preferred by the teachers was to only bring in the science and ignore the socio-scientific link). This is illustrated in the following teacher comments:

Teacher E: *"The scenario is relevant to students if they listen calmly and ask questions after the scenario. There will be many questions and from different fields, some might even appear silly to the teacher, but to students it's important. Sometimes students even started arguing. I discovered later that the cow cloning story even appeared in student blogs – the argument continued after the lesson."*

Teacher C: "*The scenario helped the students to learn to adjust. The science content knowledge which followed the story was no longer so frightening but was, of course, necessary. The scenario creates associations and gives direction to help students find the links or something of that kind."*

It is interesting to note that the teachers assessed the scenarios' relevance to students by activity levels, i.e. how many questions the students had with regard to the scenario.

The components of stage 2 were clearly seen as relating to the curriculum and teachers appreciated the experimental ideas and, in some cases, the introduction to experiment planning based on scientific questions, perhaps related to a hypothesis and leading to problem-solving, but this was not universal and teachers were not able to describe inquiry-based learning in such a manner. The experimentation was still seen as elucidation of the theoretical and, at best, was guiding teachers away from a verification approach towards the use of an induction teaching approach.

While all teachers said they used the second stage to promote teamwork there were clear differences in the activities. Chemistry teachers use practical work, using either guided or structured inquiry learning (all modules specified practical work), while the biology teacher relied less on practical work and tended to give less attention to the promotion of teamwork. This suggested a teacher perception that this stage referred to practical work as outlined in the modules and tends to exclude motivation, argumentation and decision-making skills. Teachers C and E pointed out that it is possible that instead of practical work, role play or debates, collecting and analysing data from the literature could be used and these were possible to undertake through inquiry-based teaching.

The third stage was the weakest aspect as handled by teachers and interconnection between the science and ethical, economic, political or environmental aspects was not seen as a focus. Teachers A and E did see the importance of the third stage to solve socio-scientific problem (use scientific knowledge in a new situation). The same teachers also created links between the different subjects and cross curricular themes (for example, health and safety). For example, teacher E commented:

"In the third stage, essay writing, or advertising will make students better understand the social-scientific nature of the problem and make a decision. It helps draw student's attention to the ethical, environmental and social aspects."

But, in general, stage 3 was recognised as the presentation of results, collecting feedback and a stage for making summaries. The ideas that this stage was to allow students to illustrate their science learning by transferring the conceptual ideas gained to a decision making situation (that of the initial socio-scientific scenario) was not evident. From this stage 3 was seen as useful for a summarisation stage, but that any involvement of student in the decision making discussions and debates was a separate entity and could take place at any time if the science ideas had been taught at some time in the past.

Modifications made to modules

All teachers modified the modules based on the curriculum, the local Estonian context or to reflect student's personal experiences. In interpreting the intended curriculum, the teachers chose two different methods to fulfil curriculum requirements: shortening modules by increasing homework components (such as experimental planning, or searching for information), thus striving to develop stronger student self-determination, or diversifying the second stage with different group activities, thus enabling discussion of different subject-related problems within class, even though not all students had undertaken each activity. From the interviews it appears that teachers saw a major area where they perceived the need to shortening discussion time was related to the scenarios. This reinforces the isolationist view of the scenario as an initiation introduction, rather than a serious attempt to motivate the students to develop a 'want' to study the unknown science and hence as an approach to try to overcome the lack of relevance of the science learning (EC 2007).

The interviews confirmed that where teachers were willing to modify modules during the intervention study, they continued using the same modules after the end of the intervention. This supports the point made by Ogbon (2002) and Pinto et al. (2005) that innovations succeeds when teachers feel a sense of ownership of the innovation, or that it belongs to them and is not simply imposed on them.

The teachers acknowledged the need for strong subject-related knowledge as an essential component for carrying out inquiry learning with students, but did not see that a strong knowledge base was also important for stage 1 (the motivational stage). This suggested a mismatch between teachers' understanding/PCK and their teaching in the classroom and as a consequence the teachers did not match the conceptual science part to aspects of education through science, the more pedagogical personal and social development parts. (It is interesting to note that the literature has also shown that to contextualise SSI, strong interdisciplinary knowledge is also important).

Components of future CPD

Data shows that a key aspect related to the use of modules is assessment. Research shows assessment drives learning (Tattersall, 1994; Klassen, 2006; Torrance, 2007; Holbrook, 2008b) and in studying, via the modules, students need to feel they learn more than only what is assessed. The data thus shows the need for more teacher support to guide the assessment by teachers away from final examination type cognitive orientations and towards giving more attention to the wider learning associated with the modules.

Teachers did say they used formative assessment methods, but from interviews they illustrated confusion with the intentions of formative assessment and show they were not good at balancing different assessment types of within teaching and in using a variety of teaching assessment components.

Where assessment attention focussing on class tests, the needed for this assessment became an issue linked to time constraints, as testing took away actual teaching time and thus lengthened the time need for the modules as a whole. As assessment geared to the curriculum was seen as important, teachers preferred to see the modules as add-on to their previously planned science content teaching, rather than being incorporated into the overall compulsory learning. Linked to his, modules were not chosen if they could not assess related to the content curriculum. Even students were tuned into this. The relevance of the socio-scientific component tended to be lost in guiding the science part and the decision making exercise because students did not see this as important through a lack of assessment. The socio-scientific components tended to be seen very much seen as an extra add-on to bring diversity into the teaching.

As an important change within Estonia is the replacement of national examinations with domain specific examinations, assessment was clearly a teacher concern. For students who have chosen the science stream, the future is seen as a complex school-based assessment structure, including cognitive test linking knowledge with a wide range of skills acquired in learning biology, chemistry, physics and investigatory-based laboratory activity. Clearly the assessment strategies indicated in the modules relate to the new assessment directions in Estonia and it is not surprising that the teachers indicated more guidance in this area was needed.

Enabling teachers to work with modules during training and give feedback by questionnaires and through interviews was seen as providing strong indicators of teacher progress. Student feedback questionnaires (Holbrook et al., 2008) were shown to lead to positive teacher attitudes.

In making comments on future CPD programmes, the teachers suggested the CPD needed to be viewed from two different and separate learning components. The 1st component is focussing on introducing the overall ideas behind the 3 stage model, an introduction to the modules and their design, plus planning classroom interventions for trying out modules and

the associated ideas. The teachers, recognising the modules are not directly linked to the curriculum, are not asked to plan to integrate modules into their teaching, but to concentrate on trying out the module ideas and gauging the motivational reactions of their students. Thus, in the first phase, teachers are not expected to see the modules as components of the overall classroom curriculum design. After the first half year, the CPD is stopped and teachers continue to teacher as they so wish, although the teachers are made aware that they will be asked to design the curriculum in year 2 so as to incorporate modules into the overall design.
Then, in year 2, the CPD is continued guiding teachers to undertake the invention with modules viewed directly within their teaching curriculum and as a reflective practitioner to provide feedback to other teacher participants on the manner in which the modules stages were integrated and used to promote motivational learning for students. The focus is thus very much on teaching the modules as intended so that the motivation aspects link to the inquiry learning and this stage 2 goes beyond structured inquiry learning.

Unfortunately there was no teacher comments on interdisciplinarity related to their teaching. No comment was made on its importance for student learning, or how well prepared teachers are for handling learning in an interdisciplinary mode, or attention is needed in the CPD on recognising the interdisciplinarity of the science component in the everyday life related scenarios and ensuring teachers are well prepared to handle this. Furthermore, it seems teachers need additional guidance to appreciate that while the scenario has social aspects (for example teachers were able to link with health and safety aspects), there is also the intended science components involved. Stage 1 needs to be viewed by teachers as setting out to identify the science unknown or unfamiliar to students and thus provide a link to the motivational science learning in stage 2.

Teacher suggested additional CPD components
The teachers underlined the need for the following in any attempt at devising further CPD programmes associated with the understanding and teaching of such modules:

a) including specialists in the field of psychology and science into the training process;
b) training carried out over a longer period and with the establishment of a network of cooperation for teachers leading to a change of teacher beliefs;
c) providing more guidance on how to undertake the modifications as teachers are expected to modified the modules in line with the intended philosophy;
(d) going through a module collectively to develop better understanding (and gain practical experience before teaching a class);
(e) discussing ways to gain the support of colleagues and school management;
(f) exploring possibilities for sharing experiences between those on the CPD programme and with others;
(g) providing more explanation of the module assessment guide (perceived as too complex).

A further area on which future CPD needs to concentrate is recognition of the constraints such as those indicated below and how to deal with them:

(a) extensive content coverage curricula that do not leave time for practical work and discussion;
(b) absence of experimental equipment and laboratories;
(c) national external examinations seen as fact-centred;
(d) both teachers and students required to have excellent understanding of the subject and interdisciplinary knowledge.

Conclusion

1. Teachers do see value in continuing to use modules after the CPD provided they meet teacher perceived needs and can be modified to fit with the constraints teacher face. The biggest impact on teacher change is related to using motivating scenarios.
2. Teachers, inclined to use student centred teaching, exhibit greater acceptance of the 3 stage model philosophy and are more inclined to overcome constraints so as to continue to use modules.
3. A major obstacle is suggested as the lack of formative assessment skills and techniques.
4. Longitudinal, learner centred, interdisciplinary courses which include intervention by the teacher in the classroom have a positive lasting impact on teachers' opinions. Essential components appear to be a clear philosophical rationale, exemplar materials which are classroom ready and an approach which teachers feel will be of interest to their students. This can be modified to meet constraints such as teaching time, curriculum emphasis and assessment know-how.

Recommendations

The teachers recommended the following should be taken into account in planning further training courses:

(a) stronger interconnectedness of module components (the three stages not handled separately). This indicates much stronger emphasis on the manner in which the teachers can flow from stage 1 to stage 2.

(b) additional guidance on inquiry-based learning (teachers confused this with experiment-based learning). This indicates the need to emphasis the cognitive learning that is expected to take place in practical work, but in terms of higher order conceptual science and also the development of process skills related to scientific problem solving.

(c) promotion of the teaching of argumentation and reasoning skills. This indicates attention to giving teachers first-hand experiences by undertaken decision making exercises with the CPD.

(d) ensuring an overview of scientific experimental results, before transferring to the social context (emanating from an initial scenario). This indicates follow-up on ways to consolidate the science gained from experimentation and for example include concept mapping as an assessment technique for students where the newly gained concepts are incorporated into concept maps, together with interrelated concepts stemming from the students' prior learning.

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