PROFILES

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

Guidebook for Providers of Continuous Professional Development within PROFILES

by

Jack Holbrook and Miia Rannikmae

UNIVERSITY OF TARTU 1632

Welcome to PROFILES – a European Commission FP7 project.

An Introduction to the Guidebook

This guidebook is intended to offer guidance to those involved in running CPD (continuous professional development) for science teachers within the PROFILES project.

It is intended to assist the CPD providers:

(a) recognise that PROFILES is about *challenging the existing beliefs of teachers* towards IBSE (inquiry-based science education), and
(b) are able to supply the required guidance on PCK (pedagogical content knowledge) so that teachers are able to make the PROFILES approach a rewarding experience in the classroom.

And as a result of the action by the CPD providers, it is expected that teachers will:

(a) appreciate the PROFILES approach, based on student motivation driving science learning, and
(b) use PROFILES modules to promote motivating, student-constructed science learning.

To support CPD providers, this guidebook specifically promotes:

(i) *the ideas behind* PROFILES (the PROFILES philosophy), and
(ii) aspects seen of importance when *guiding teachers to implement the PROFILES approach* in a competent and confident manner.

[This guidebook is not intended for the teachers themselves. It is not written in such a manner. It concentrates on enabling CPD providers to guide and support teachers to develop their own teaching according to the PROFILES approach. However, while this guidebook is about handling the CPD provision, it does not elaborate on the various CPD models that exist, nor discuss which model is of particular significance – this aspect is provided separately through PROFILES workshops organised by the leader of the relevant work package].

Content

MEANING OF CPD

The term CPD, or continuous professional development, is used in this guidebook to describe the support and guidance to be offered by the CPD providers to teachers within PROFILES. The term CPD is preferred because:

(i) the guidance and support is intended to be available as and when it is needed by the teacher. In this sense it is continuous. The guidance and support extends beyond seminars or workshops (which are seen as examples of specific professional development provisions);

(ii) the support and guidance, offered as and when teachers see a need, is very much related to the teacher being a professional. In this sense, it differs from the concept of in-service training where the provision may be already pre-planned, without reference to the teachers and offered irrespective of the teachers' prior background, or needs.

THE MAJOR CPD TARGET WITHIN PROFILES

The target is to enable teachers to appreciate the PROFILES approach to science education, at any grade level and that it is based on the PROFILES philosophy. This philosophy is summarised as:

TEACHING THROUGH SCIENCE LESSONS THAT PROMOTES RELEVANT, MOTIVATIONAL, STUDENT-CONSTRUCTED LEARNING WHICH IS DESIGNED TO ENHANCE STUDENTS' SCIENTIFIC LITERACY.

CPD PRE-REQUISITES (see the PROFILES Guidebook, part A, for more explanation of terminology)

To support teachers, it is important that CPD providers are aware of the intended meaning of:

- *relevance* (in the eyes of students) and how this can be attained;
- *student constructed learning;*
- *enhancement of scientific literacy* in the PROFILES context.

RELEVANCE

The following hypothesis is put forward for CPD providers to consider and justify to teachers:
If the teaching is seen to be relevant, it is expected to trigger student interest.
(It will trigger students' personal interest, or expressed in other terms, students' intrinsic motivation).

Against this, CPD providers must be aware that research in school science has shown that the current/ traditional approach to the science education provision is seen as **irrelevant and boring** (EC, 2007).

CPD providers are thus asked to guide teachers to accept that:

- *If the students motivate themselves to learn, they will want to learn.*
- *If the students are not interested in the learning, learning will suffers.*
- *If students identify with a situation they feel is relevant, motivation to learn is enhanced.*

The PROFILES philosophy recognises the need to promote ***relevance*** (students identify with a situation or issue that they see as relevant to them) at the initial learning stage. **The PROFILES approach to relevance** is to initiate such teaching via a **SCENARIO**, based on a carefully worded **MODULE TITLE**.

STUDENT CONSTRUCTED LEARNING

Such learning, promoted by socio-constructivist principles, involves active student learning at an individual level, in small groups, or in whole class situations. The approach is therefore very much building on student intellectual involvement, making use of student ideas, guiding students to do the constructing of the learning and is thus far from being driven by textbook information. Student-centred learning is clearly a sub-component of student-constructed learning, as is creative or critical thinking. Such thinking enables the construction to be purely cognitive or it may lead to (for example) physical construction of models, experimental situations or computer-based simulations.

SCIENTIFIC LITERACY

CPD providers are guided to appreciate that science education (the science taught in schools):

- covers more than science content (content is essential, but is insufficient);
- includes knowledge, skills, attitudes and values, and
- context is essential (scientific literacy is socially and culturally embedded).

But to **enhance** (increase) **students' scientific literacy**, the PROFILES philosophy goes further. The philosophy advocates that the **goal of science education** is to build *the **capability to transfer*** the knowledge, skills, attitudes and values gained through science lessons to new or unknown situations.

CPD providers need to realise that science education is about developing, in students:

- **intellectual capabilities of applying cognitive thinking and reasoning;**
- **personal aptitudes (such as initiative, ingenuity, perseverance, safe working);**
- **social skills (such as interpersonal interactions, collaboration, argumentation, leadership, tolerance of others, positive attitudes towards science).**

In the PROFILES approach, scientific literacy is **not** solely about gaining science content. In fact, in isolation, it is suggested that content has little to do with such literacy. On the other hand, context (which of course changes with time, situation and is culturally and socially bound) is very important. Actually, scientific literacy is not an absolute entity and can be visualised at different levels (Bybee, 1997). It also means that a person's level of scientific literacy can decrease, as well as increase, with time. Scientific literacy is dependent on the situation, developments in the society and advancement in scientific ideas by the person, required for transference to the situation. The meaning of scientific literacy thus relates to the **capability to transfer** knowledge, skills, attitudes and values to new situations. For a scientist, this can be taken to mean the capability to transfer scientific ideas and scientific values. In school, it relates to the capability to transfer so as to be able to solve scientific

problems and make socio-scientific, real life decisions. While definitions are numerous, few portray the science for all, in everyday life emphasis. But a possible strong contender is put forward as:

> Developing an ability, to creatively utilise appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible socio-scientific decisions (Holbrook & Rannikmae, 2009).

In striving towards scientific literacy, it is extremely important for CPD providers to realise that:

(a) students in school are **NOT** scientists. They may not even be aspiring to be scientists. In fact, science, even if it is a core subject in schools, is not simply for the sake of making all students to be scientists. Why should it?

(b) students are in school to receive an education. This is true whether the lesson is language, mathematics or science related.

(c) school science is in fact **education through science.** Hence scientific literacy relates to all facets of education, not just conceptual science. As such, it encompasses science learning in terms of critical thinking, problem solving ability, the ability to make justified decisions, as well as personal and social development.

FURTHER IMPORTANT PROFILES COMPONENTS

In promoting the PROFILES philosophy and a PROFILES approach to the teaching of school science, it is important that CPD providers are able to guide teachers to appreciate the ideas behind the PROFILES way and that these are integral to the teaching based on the 3-stage model. The following key aspects within PROFILES are amplified.

1. EDUCATION THROUGH SCIENCE (Holbrook and Rannikmae, 2007)

This idea is so fundamental to PROFILES that it is in the title – the last 2 letters 'ES' represent **education through science**. CPD providers must clearly appreciate this aspect and guide teachers in this direction.

Unfortunately, many teachers think in terms of the opposite expression – that is, 'science through education.' This is very much the traditional, or the syllabus content component approach to the learning. The learning of the subject is taken as the overriding, and maybe the *only*, focus. Other aspects, which can play an important role in student motivation are ignored, or heavily downplayed.

In PROFILES, motivation is seen as a crucial factor in science learning. And, very importantly, in PROFILES, **motivation is seen as driving the learning** (and not vice versa). This is because the vast majority of students do not see conceptual science as motivational, especially in secondary school (EC, 2007). It also means a 'science through education' approach is NOT recommended. PROFILES thus promotes 'education through science', in which the science is actually recognised to be 'science

education' (school science = science education; *it does NOT equal science*). And for science education, motivation is crucial and is needed to drive the conceptual science learning.

The '*education through science'* approach is through first stimulating motivation, so students are inspired to want to gain the education. This education encompasses:

- cognitive learning,
- appreciation of the subject (the nature of the subject - the nature of science in this case),
- the development of the person to be capable of functioning in a meaningful and responsible manner,
- the development of the person as a responsible member of a society, especially in terms of social values.

Science education is thus about intellectual development plus personal development plus social development. CPD providers need to appreciate that they need to convince teachers that **all** are important. Teachers need to recognise that all need to be part of science teaching under PROFILES.

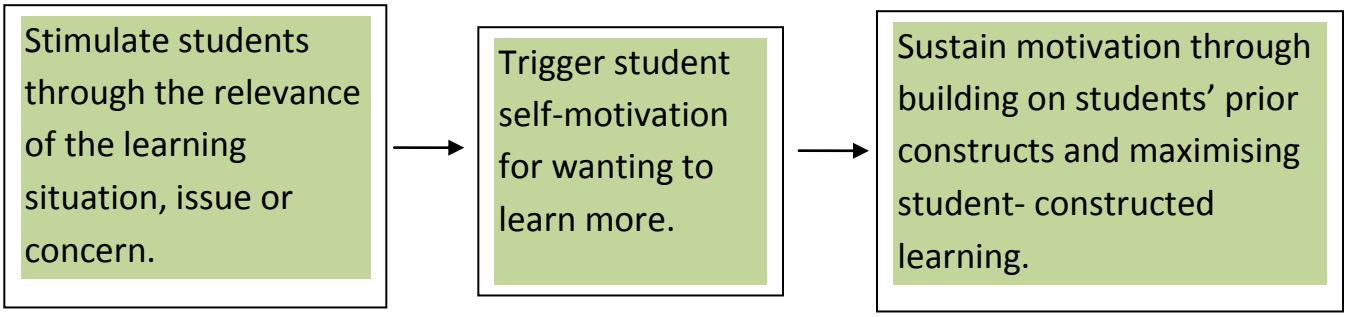
2. TEACHING APPROACH

CPD providers should be aware that PROFILES *accepts that any* teaching approach which stimulates student interest for the intended learning (for a particular class, in a specific situation) is a major focus. However, the PROFILES approach has been developed based on **a 3-stage model** (Holbrook & Rannikmae, 2010).

This is illustrated on the following page.

The 3-stage model is based on the recognition that there is a need to initiate the learning from a *familiar and student relevant situation*. But even that, by itself, is *not sufficient*. Students must **identify** with the initial situation and feel that it is within **their sphere of action**.

The diagram below illustrates how relevance is intended to trigger student's self motivation (or intrinsic motivation) to promote student involvement in the learning. Such motivation is sustained by student involvement and also by any extrinsic motivational aspects supplied by the teacher.



The 3-stage Teaching MODEL	Stage 1	Stage 2	Stage 3
The teaching-learning approach	Real life title and scenario to motivate students; (A KEY FOCUS) emphasis is on student derived motivation to trigger science learning	Teacher facilitated, student constructed, IBSE learning incorporating scientific problem solving (motivation applied to science learning)	Teacher guided, student centred, socio-scientific decision making Applying science gained to a social setting
Educational Skills Developed	Oral communication; prior learning, critical thinking, education through science	Planning, process skills, presentation skills, drawing conclusions, problem solving Interpersonal skills	Interpersonal skills, reinforcement of the scientific concepts, argumentation, social skills, social values, decision making
Science Education Learning	Identifying science in context; Constructivist teaching, identifying scientific inquiry questions	Conceptual learning, concept mapping, IBSE skills	Transference of conceptual learning to new situations
The Key Role of Motivation	Stimulating popularity (interest) and relevance (INTRINSIC MOTIVATIONAL ASPECTS)	Enhancing relevance through activities (STUDENT CONSTRUCTED, STUDENT CENTRED LEARNING)	Strengthening relevance and enhancing scientific literacy VALUING SCIENCE IN SOCIETY (GOING BEYOND AWARENESS OF USES)

THE PROFILES APPROACH UTILISING INTRINSIC MOTIVATION FOR TEACHING SCIENCE

Starting from a carefully worded title (intended to be familiar and of interest to the target students), the teaching progresses, in three stages via a scenario, as follows:

FAMILIAR STIMULUS (THE SCENARIO) (stage1)

SOCIO-SCIENTIFIC SCENARIO, RELEVANT FOR STUDENTS

→ Students identify with the situation *(exhibit intrinsic motivation)*

STIMULATES INTEREST AND MEANINGFUL ENGAGEMENT IN THE LEARNING

Wishes to consider the situation, concern or issue; student willingness to participate

GUIDED BY THE TEACHER, STUDENTS REFLECT ON PRIOR SCIENCE KNOWLEDGE

Communicating in a science context; illustrating extent of conceptual understanding

STUDENT-REALISED NEED FOR NEW SCIENCE KNOWLEDGE. THEN, GUIDED BY THE TEACHER, SPECIFIES SCIENTIFIC QUESTION TO INVESTIGATE

Student creative thinking; willingness to participate

INQUIRY-BASED SCIENCE EDUCATION (stage 2)

EXPLORES SCIENTIFIC QUESTION 1

Student constructed, creative thinking, showing- initiative, conceptual understanding, perseverance, planning ability

PROBLEM SOLVING INVESTIGATION

Exhibits process skills, creative thinking, cognitive reasoning, collaboration with others, leadership qualities, safe working

EXPLORES SCIENTIFIC QUESTION 2,3 etc (if appropriate)

Creative thinking, initiative, conceptual understanding, perseverance

PROBLEM SOLVING INVESTIGATION

Process skills, creative thinking, communication, leadership, cognitive reasoning, collaboration with others

CONCEPTUAL SCIENCE LEARNING
(LEADING TO CONCEPT MAP FORMATION; RELATING NEW AND OLD SCIENCE CONCEPTS)

SCIENCE CONSOLIDATION AND SOCIO-SCIENTIFIC DECISION MAKING (stage 3)

REFLECTION ON/CONSOLIDATION OF NEW SCIENCE KNOWLEDGE GAINED

Conceptualisation, independent thinking, student constructed modelling, communicating

SOCIO-SCIENTIFIC DECISION MAKING

Within the socio-scientific context (the scenario), argumentation, reasoning for making socio-scientific decisions, independent thinking, social values, tolerance of views of others, leadership

SUMMARISING

Within each PROFILES teaching modules:
relevance is triggered by the module title, which is amplified by means of **a scenario**. The title relates to the students' world, using familiar words (unknown, non-general scientific words are absent).

motivation is promoted by exploring a scenario which is intended to offer curiosity, intrigue as well as seen as meaningful by students. The motivation is sustained through guiding students to undertake inquiry-based science education, which promotes a meaningful and acceptable scientific challenge to students.

The CPD provider needs to be aware that:
A major area of expertise expected of the teacher is to *adapt (redevelop/create) a* **socio-scientific scenario** for their students (whatever the grade level, ability level or social setting), which is seen as relevant, meaningful and hence (based on PROFILES philosophy) motivational for students.

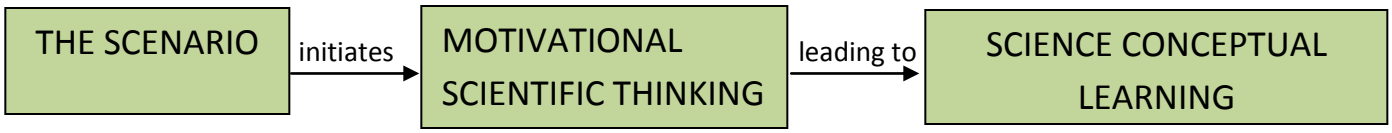
3. THE SCENARIO

The scenario is expected to relate to the local situation as far as possible, rather than that nationally or globally. Students need to appreciate the scenario as being relevant and meaningful FOR THEM. But the scenario also needs to be developed so that students welcome the opportunity to be involved.

The use of an appropriate scenario is important in PROFILES. Not any situation is appropriate. Research shows that students identify with specific words, or expressions and these play an important function in determining whether the modules or the scenario chosen is appropriate. So important is the title and scenario that, if this fails to motivation students, the module should not be used further and the teaching associated with this module abandoned. This is because PROFILES contends that relevance is a very useful precursor for developing students' personal interest and a powerful stimulus for science learning. It provides students with a desire to pursue the learning further, going beyond the scenario and into the accompanying new science learning.

THE LEARNING APPROACH IS THUS MOTIVATION FIRST, LEADING TO SCIENCE LEARNING SECOND. This contrast with the usual suggested approach - make the science itself interesting so that it will then motivate the students (but, alas doesn't !!). In PROFILES, the theoretical construct is that motivation drives the learning of science and the scenario is intended to enable students to **want to get involved** even though this means learning some science. Unfortunately, standard approaches, which assume science is inherently interesting for students, if taught well, have been shown not to appeal to many students.

Once motivation is established, the further learning is, in fact, the curriculum-based conceptual science ideas, which students acquire as steps towards enhancing their scientific literacy. (But it is important to ensure teachers realise that scientific literacy is **NOT** simply the acquisition of conceptual science. In school science, conceptual learning is a necessary, but insufficient condition). For the learning to be meaningful as well as continue to be interesting, the PROFILES approach is for the science learning to build on a **familiar, socio-scientific scenario** as shown in the flowchart.



However, this will not function without meaningful and encouraging support of the **science teacher**. It needs the pedagogical skill of the teacher for the ***link from scenario to conceptual learning*** to succeed. And the three boxes as above **must be** linked. *Without this link,* the scenario is useless. For example, if the scenario is about choosing which soap to buy, the link can lead to motivational scientific thinking on testing soap for desirable properties, which can then lead to experimentation and conceptual learning.

The CPD provider must recognise that the purpose of the scenario is to *stimulate students' interest* and to do this from a familiar and student relevant perspective. The CPD provider must also recognise the importance of persuading teachers to *make changes* to the scenario to ensure such an approach. '*Meaningful relevance in the eyes of students'* is crucial for an effective scenario.

4. GOING BEYOND THE SCENARIO

Once teacher realise that PROFILES is about the need to *initiate motivational scientific thinking in their students*, the task of the CPD provider is to get teachers to recognise that their next step is to determine **students' prior science knowledge** in the area related to the socio-scientific scenario.

In most cases, the teacher should expect to find that the students' prior knowledge is limited and students will be **unfamiliar** with the science ideas associated with the scenario. However, if this is not the case and students really do have a background in the underlying science, then going further to discuss the scenario *will not involve science learning*. [Clearly, for example, if students really do know how to test for the properties of soap in a practical as well as a theoretical way, then it makes *little sense to try to provide learning in this direction*!! – move on to new learning situations]. However, the teaching is expected to build on the students' prior knowledge (limited though this may be) and for this lead students to raising the scientific question(s) related to unknown science, The question (questions) can then be explored to seek the answer(s) in an appropriate, scientific, evidence-based fashion.

There are many teaching approaches for the teacher to consider to promote student learning beyond the scenario (these are not discussed here), but the CPD provider must be aware that *NOT INTENDED* is

any approach whereby the teacher **simply tells** the students. By such an approach, interest is probably lost and students are likely to memorise a set of rather meaningless procedures or facts.

Of importance for the CPD provider is to realise that the teacher is seeking to promote, not simply the learning of information, or even skills and values, but the **capability to transfer that learning to new situations.** The teacher's goal is allow students to build on prior learning, guide students to investigate by promoting student-constructed learning and learn how to acquire the unknown science.

5. PREPARING FOR STAGE 2

While stage 1 is initially about raising student interest, stage 2 is the important stage for the learning of new conceptual science. The task of the CPD provider is to guide teachers to appreciate how to move **from stage 1 and into stage 2.** The expected steps (considered within stage 1) are to:

(a) enable students to recognise that they can discuss little about the scenario without learning the underlying science ideas, and then

(b) develop the scientific question(s) (by the students if possible, otherwise by the teacher guiding the students – *trying hard to not tell*), which are to be answered within stage 2.

Moving from the scenario to developing the scientific question *is heavily dependent on the skill of the teacher*. The CPD provider needs to ensure that **collective teacher discussions**, after teachers have tried out a module, give strong consideration to the ways teachers have handled this component.

6. UNDERTAKING STAGE 2

This is at the very heart of the PROFILES modules. It is likely to be the stage where most of the module's teaching/learning time is spent and where students gain conceptually and also at a personal and social educational level (*education through science*). CPD providers need to be well versed in the expectation that the approach here is one of **maximising student-constructed learning** (inquiry-learning or IBSE) and that the pace of teaching will depend heavily on students' skills, developed on prior occasions. *(It needs to be stressed that students' skills gain through learning in prior grades is invaluable here*).

If students have much prior experience in carrying out process skills, then undertaking evidence-gathering learning (*a key element within a scientific approach*) will be much facilitated. IBSE can be expected to take far less time than in cases where students **have not had** prior opportunities for *student-centred learning*. It is important for the CPD provider to stress the importance of the evidence gathering aspects, whether by experimentation, or by other means. CPD providers need to guide teachers to utilise a student-constructed, inquiry approach as given in the modules (if the module is weak in this area, then the CPD provider must be ready to suggest how the module can be

strengthened in this aspect). Simply put, stage 2 must involve students in (a) student-centred activities and (b) student-constructed learning. **This is crucial for inquiry learning.**

7. INQUIRY LEARNING

CPD providers must ensure teachers have a clear notion of the intentions behind inquiry learning. This understanding must go beyond student attainment of manipulative process skills. The attainment of process skills (such as - planning the investigation, making predictions, controlling variables, determining actual equipment/quantities of chemicals to use, determining the number of readings to take/or whether to repeat the experiment, utilising good recording procedures for data/observations, writing/presenting an appropriate report, giving valid conclusions) are **not sufficient.** The inquiry learning must, in fact, be inquiry-based science education (IBSE) involving student-constructed learning with the teacher as facilitator. It is definitely **NOT** following a worksheet and recoding a given answer.

8. INQUIRY –BASED SCIENCE EDUCATION (IBSE)

This is another term for 'student constructed learning through scientific investigations'. It involves the development of students' abilities to:

- use constructivism, or socio-constructivism to ask scientific questions;
- identification of the scientific question (and sub-questions);
- investigate using appropriate process skills;
- discuss meaningfully and intellectually reflect on the situation, and
- determine eventually whether the scientific question is satisfactorily answered.

Within PROFILES, process skills are important, but are insufficient as the totality of inquiry learning. Thus, any kind of recipe following, or any lack of student developing independent thought, or any reading, reciting or working through examples from the textbook, **is NOT inquiry learning.** Activities which do not support and encourage student-constructed learning have no place within PROFILES.

The following are all very much part of IBSE *(although not actually seen as process skills):*

- *identifying* the science in a socio-scientific situation;
- *putting forward* scientific questions (questions that can be investigated scientifically);
- if necessary, breaking questions down into sub-questions that can be investigated.

Also, students can be expected to learn to use *communication skills* to present their conclusions in suitable ways (written, oral, ICT) and, as appropriate, discuss the limitations associated with the solutions they reach in attempting to solve the problem (answers to the questions).

Furthermore, inquiry learning is also very much interrelated with the development of social skills, especially interpersonal (student-student and student-teacher) developments and also personal skills, associated with aptitudes that support inquiry learning such as initiative, ingenuity, safe-working, perseverance.

DIFFERENT DEGREES OF STUDENT-CONSTRUCTED LEARNING (WITHIN IBSE)

Although elements of IBSE are given above, the CPD provider needs to be aware that teachers can undertake inquiry learning with their students in different ways. Effective IBSE requires prior experience by students and hence students (and even teachers) starting on IBSE, will likely involve smaller degrees of student-constructed IBSE. The degree of student involvement can range from very little (e.g. offering explanations only (in the post-investigation situation) – low level of inquiry) to total student involvement (students undertake all aspects of the investigation – high level of inquiry).

The ultimate goal within PROFILES is to enable students to undertake inquiry learning with no or minimum teacher interference (i.e. students undertake project work or 'open' inquiry). However, the CPD providers need to appreciate that teachers will need to **teach students** to construct their thinking for the different stages of inquiry learning (from providing everything to students – low student scientific construct learning to various stages where students are more and more involved in the process). And teachers must realise that *the more practice students have in IBSE,* the more easily and the more capable they will be in undertaking high levels of student-constructed IBSE.

An example of the various stages (and sub-stages) that teachers can consider in planning specific IBSE experiences for students are illustrated in a slightly adapted version of that supplied by Smith (2011) who in turn modified that by Herron (1971), where given = supplied by the teacher and open = supplied by the students.

Level of Inquiry	Scientific Problem	Material/Equipment	Planning/Procedure	Answer/ Solution
0*	Given	Given	Given	Given
1 Structured	Given	Given	Given	Open
2 Guided *(option A)*	Given	Given *(totally or maybe partly)*	Given *(totally or maybe partly)*	Open
2 Guided *(option B)*	Given	Open	Open	Open
2 Guided *(option C)*	Given	Partially given *(by providing a range of material that includes - as a subset- what is required).*	Open *from* pupils' perspective *(but given by teachers as the need to use materials as provided).*	Open
2 Guided *(option D)*	Partially open *(given as broad parameters)*	Open	Partially given *(e.g. through previous experience of controlling variables, analogy with other experiments or forms of investigation, but open in the sense of not being told what to do).*	Open
2 Guided *(option E)*	Open	Partially open *(this is what we have in the school)*	Open *(but teacher needs to be careful to check on safety aspects)*	Open
3 Open	Open	Open	Open	Open

*Cannot really be considered IBSE

It is important that CPD providers ensure teachers recognise that progression through the approaches given in the paragraph above is **NOT** expected to be LINEAR. The motivation of students, the experience of the students and the context of the PROFILES module affects the manner in which the inquiry learning takes place and hence the degree to which the teacher can involve student-constructed learning. Thus the types within 2 and type 3 (open inquiry) will all depend on the module being promoted. For example, an *emphasis on students seeking information from a variety of sources* can vary enormously from module to module, yet this component cannot be expected to guide the sequence in which modules are taught (usually the sequence of teaching using modules will be governed by the conceptual science to be acquired by students – as per the curriculum).

9. PREPARING FOR STAGE 3

The solution to the scientific question, carefully detailed and recorded, is expected to be the gateway to stage 3. In stage 3, the science gained from the inquiry learning in stage 2 can be used to further consider the socio-scientific issue that was initiated in stage 1. However, there may be more than one scientific question that is addressed. If this is the case and learning involves the acquisition of multiple conceptual ideas, these ideas may need to be interconnected. And new learning may need to connect to prior learning. A good approach for this is to construct a concept map.

CREATING CONCEPT MAPS

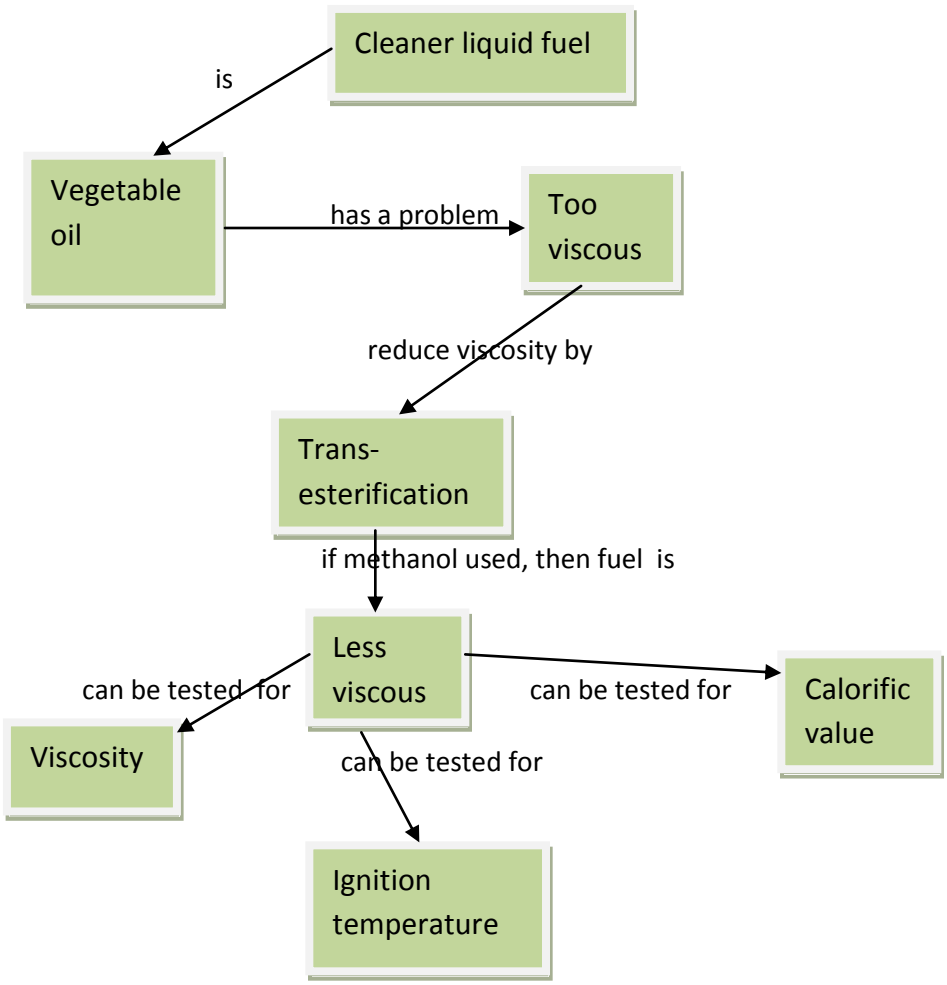
Stage 2 incorporates conceptual science learning. It brings in new science. To be useful, this science needs to be put into a scientific context and, in particular, interrelated with other science knowledge. Novak (1974) has shown that scientific concepts can be interlinked by means of a concept map, although such maps can take on a variety of formats and conform to different styles. Compiling concept maps can be a useful assessment exercise in which students can illustrate their learning of scientific patterns – a valuable aspect in developing the science ideas further.

CPD providers are encouraged to suggest to teachers to make use of concept maps as a means of guiding students to inter-connect science concepts. Nevertheless, the CPD provider should appreciate that teacher can determine its actual width – the range of concepts to be included (the wider the map, the more conceptual science will be taught within the particular stage 2 and presumably the greater the number of lessons devoted to stage 2 within any one module).

The width of the science teaching identified and promoted by the teacher (the range of scientific concepts) will depend on factors such as:

- the teacher's interest;
- the ability of the students;
- the level of interest which can be sustained by students, and, of course,
- external factors such as teaching time available.

An Example of a possible concept map for the module on Biodiesel



CPD providers should be aware and the idea conveyed to teachers that any module does not need to cover the conceptual science as per that indicated in the curriculum arrangement (or the textbook) - it can be wider, less wide, or cover a differing group of concepts, all depending on the teacher's choice (which in turn is likely to be guided by the students' motivation and maintenance of interest in the conceptual science. A teacher always has the prerogative to come back to a science learning area at a later stage, or promote one area of science over another (the curriculum should match the students; not the students struggling to match the curriculum !).

10. UNDERTAKING STAGE 3

The CPD provider needs to be aware that Stage 3 has two major components:

(a) to consolidate the science ideas introduced in stage 2. This is achieved by involving students in additional tasks (above and beyond the module) related to the concepts, preferable interlinking with the students' prior concepts which were identified in stage 1. These tasks may be presented in different formats e.g. oral discussions; answering written exercises; jigsaw method; etc.

(b) utilise the science ideas gained, transferred to the original scenario situation, so as to enable students to discuss the scenario situation in more detail, using the newly acquired science. This is an important component of the learning and is expected to achieve two major learning targets (i) being able to transfer scientific ideas to a new, contextual situation, and (ii) participate meaningfully in a decision-making exercise to arrive at a justified decision related to the initial socio-scientific situation outlined in the title of the module.

Part (b) will involve students in groups, or whole class interactions, in activities such as debates, role playing, or group discussions. Students are expected to put forward their points of view, incorporating the new science in a meaningful and *appropriately correct* manner. Students are thus involved in aspects of ***argumentation***, as well as communicating the new science ideas in a ***conceptually correct*** manner. The end result is a set of small group decisions, or a consensus decision made by the class as a whole. The actual decision is not, in itself, as important as the justifications put forward, but would be expected to comply with social values accepted by the local society as a whole.

CPD providers should recognise that stage 3 is an important consolidation stage as well as developing critical thinking, tolerance and leadership skills. Teachers need to be encouraged not to omit this part, or reduce it to a meaningless approach to the 'right answer.'

11. THE MODULES

Modules used for promoting the PROFILES philosophy and approach heavily relate to the earlier components described in this guide. However they may not explicitly indicate the various stages, often so as not to convey to teachers and students that the learning is intended to be compartmentalised. The stages are put forward, not to compartmentalise science education, but to promote student motivation and relevance as key factors in science learning. Students are nto expected to be aware of the 3 stages. The following sub-sections explain further the structure of the modules as they actually appear.

STRUCTURE OF THE MODULES

While the structure of these modules is not to be taken as an absolute, the following components are seen as important for the general approach to the development of modules: a frontpage; student activities or tasks; teacher's guide; assessment; background teacher notes (in science and pedagogy). They are further elaborated here to guide CPD providers in appreciating their value and allow the CPD providers to guide teachers in how best to make appropriate use of modules. Each component is described in turn.

THE FRONTPAGE

This is a double sided cover, attractively laid out to draw attention to the **module title,** a summary of the science content, as well as elaboration of the 'education through science' learning portrayed in the **form of competencies** to be developed through the teaching using the module.

The competencies are important as they indicate the intended learning and hence the components that are to be assessed during the learning. As they are related to 'education through science', the competencies go beyond knowledge and encompass skills, attitudes and value, relevant to the situation and the intended learning. In some modules these competencies may be grouped into the 3 stages to assist teachers in appreciating the intended learning.

STUDENT ACTIVITIES

In setting out the student activities, it is important to realise that this section is designed for the students. It directly involves the students in constructing their learning. Yet at the same time, it is not intended to take over from the teacher and dictate to the teacher how this aspect should be undertaken.

With the recognition that the teacher needs to determine how the teaching should be conducted, the student activities are **not divided** between the 3 stages, although the scenario is given. Also, although the student activities are listed, they are usually **not explicitly** supported by worksheets (worksheets, if provided, are purposely included in the teacher notes so that the teacher has the option of deciding whether they are appropriate for use or not).

TEACHER'S GUIDE

CPD providers need to ensure teachers recognise this as an important section in the module. It sets out to guide the teacher in appreciating the situation put forward by designers of the module and the manner in which they intend the learning to develop. Nevertheless, the guidance given **is advisory** and it is expected that it can be overridden by the teacher, as and when the teacher feels appropriate. Teacher modifications can be in terms of suggested activities, in the time allocation put forward, or in the sequencing being suggested for student-constructed learning. Clearly the indicated freedom for the teacher is important, as the intention is to utilise 'relevance to the students' as a motivational factor and also to develop the learning in a constructivist fashion, based on the students' actual prior knowledge.

ASSESSMENT

In an 'education through science' setting, not all competencies can be determined by using a pencil and paper assessment strategy. Furthermore, in new situations, it is valuable to determine and support student progress. This lends itself to formative assessment strategies and hence this section is intended to guide the teacher to develop this area. Once again, however, the suggestions are for guidance to suit the circumstances and not for the teacher to follow without modification. This the suggestions put forward are not intended to be prescriptive, but purely examples covering aspects from which the teacher may wish to choose. It is important for CPD providers to be aware of the difficulty teachers had with formative assessment ideas during the PARSEL project and this aspect may need to introduced to teachers slowly over much time and teachers being permitted to discuss among themselves at length.

TEACHER NOTES

This section, which may or may not be present, is for additional supporting material that can be offered to the teacher to assist the teaching. Noting the inter-disciplinarity of modules, this section can provide notes on the wider science content which may be unfamiliar to the teacher, suggested worksheets for students, provide answers to questions raised in the student activities, or detail experimental and safety aspects.

12. PROFILES TEACHING IN ACTION

The PROFILES approach is very much guided by the modules and the thrust is very much associated with the PROFILES philosophy of: from familiar to unfamiliar; social to scientific, social relevance to scientific conceptualisation. Student attitudes are thus of much importance and ensuring teachers do identify that motivation is being promoted and prolonged is a key PROFILES component. With this in mind, CPD providers are required to guide teachers to pay attention to the following components:

DETERMINING STUDENT GAINS

Before students are first taught, based on the PROFILES approach, it is valuable to determine their attitude and aptitudes towards science teaching. For this, PROFILES has developed pre-learning instruments. The CPD provider needs to be aware of these and to convince teachers that it is important they implement these before the PROFILES teaching takes place so that it is possible, at a later stage, to determine student gains.

Student gains are explicitly related to attitude. While the PROFILES hypothesis is that motivation will drive conceptual learning and hence conceptual gains are to be expected, the competencies are heavily directed towards transfer of learning to new situations and hence not comparable with cognitive gains of textbook knowledge. However, of special importance is the gains in motivation itself and hence in attributes that relate to this, such as self efficacy and problem solving abilities. It is expected that teachers will determine student attitudes following the use of each PROFILES module.

EVALUATING TEACHER'S SELF EFFICACY

A stated goal of PROFILES is to raise the self efficacy of teachers to teach using the PROFILES approach. The PROFILES questionnaire related to teacher needs, administered to teachers before embarking on CPD, can be used as a base for seeking measures of teacher self-efficacy in terms of competence and confidence to teach the PROFILES way. It can also be used to seek gains in teachers self efficacy following the CPD.

Besides classroom observation (which CPD providers can contemplate undertaking using appropriate instruments), self reporting by the teacher themselves and collective reflections with peers (during interactive discussion sessions) can also give a strong indication of the progress of teachers in using the PROFLES approach and appreciating the value of the PROFILES philosophy. These are all to be

encouraged within the CPD programme, provide they CPD providers are seen to be working with, and not evaluating, the PROFILES teachers.

Where the teachers believe in their own expertise and are willing to take note of the motivation and involvement of their students, the PROFILES philosophy hypothesises that student gains will be heavy, in terms to student self-determination and hence in areas of higher cognitive learning and in student self-learning. CPD providers are guided to identify evidence of this. Teachers who positively related to PROFILES are expected to be asked to continue their development under PROFILES for a second year when the intended target shifts to teacher ownership of PROFILES and teachers can embark on greater reflection of their teaching with a view to be better placed to guide others in the PROFILES direction.

A FOOTNOTE

CPD providers must be prepared for teachers to comment during the CPD:

- The pace of learning through the use of PROFILES modules is too slow, or
- There is no time for PROFILES modules because it is necessary to cover the curriculum, or
- Students need to pass the examination (modules are a distraction).

In all cases teachers are showing they do not appreciate 'education through science.' Key aspects of education are self-determination, or self-initiation or peer-peer interaction, support and collaboration. All take time to establish, but once gained, enable the teacher to play a subordinate role in the student learning. Students need to determine the pace of learning (not the curriculum or even the teacher). Students determine how far coverage of the curriculum is meaningful for them. Really, in the end, the students are responsible for ensuring they pass the examination (provided it is appropriate for the students). The teacher's role is thus one of promoting students' self-determination, not reading the textbook, encouraging students' self-initiation, not presenting facts. In other words, the teacher is a 'facilitator, not a dictator'.

Maybe the above is seen as utopia, but it is direction in which PROFILES strives. Only then, can students' intrinsic motivation thrive, interests develop and flourish and meaningful 'education through science' learning (learning that is not memorisation for an exam and then forgotten) take place.

REFERENCES

Bybee, R.W. (1997). Toward an understanding of scientific literacy. In: W. Gräber & C. Bolte (Eds.). *Scientific literacy: An international symposium* (pp. 37-68). Kiel, Germany: IPN.

European Commission (EC). (2007). *Science Education Now: A renewed pedagogy for the Future of Europe.* Brussels: Author.

Herron, M.D. (1971). The nature of scientific enquiry. *School Review, 79*(2), 171- 212.

Holbrook, J., & Rannikmäe, M. (2010). Contextualisation, de-contextualisation, re-contextualisation – A science teaching approach to enhance meaningful learning for scientific literacy. In I. Eilks & B. Ralle (eds.), *Contemporary Science Education* (pp. 69-82). Aachen, Germany: Shaker.

Holbrook, Jack & Rannikmae, Miia. 2009. The Meaning of Scientific Literacy. *International Journal of Environmental and Science Education,* 4(3) 275-288.

Holbrook, J. & Rannikmäe, M. (2007). The Nature of Science Education for Enhancing Scientific Literacy, *International Journal of Science Education*, 29(11), 1347-1362.

Novak, J.D. & Gowin, D.B., (1984). *Learning How to Learn.* Cambridge: Cambridge University Press.

Smith, C. (2011). Scientific Thinking. ICASE newsletter April 2011. Accessed online: www.icaseonline.net/news.html

Appendix 1

A Model Illustrating the Planning and Operation of the CPD Team

(in the case of Estonia)

Overview of the CPD team

CPD Leader			
CPD Provider (Region/Network) A	CPD Provider (Region/Network) B	CPD Provider (Region/Network) C	CPD Provider (Region/Network) D
Secretary/coordinator for the CPD team			

Step 1

CPD provider team meeting

Choosing
(a) modules/translate;
(b) teacher needs questionnaire format.

Step 2

Teacher's meeting (pre-CPD)
for 30 teachers covering:

Project expectations, Modules to use, Complete teacher needs questionnaire

Module adaptation/translation; Completed teacher questionnaire

Modules translation check

CPD provider's workshop (2 days)
- planning the programme discussions, timelines, post try-out reflections by teachers. Operation of networking

CPD workshop plans for 2011-2012 (workshops for all teachers and regional group meetings)

August 2011

Teacher workshop I (2 days)

(1st CPD involving all providers – how and when to use module/pre-test student gains)

Sept – Nov 2011

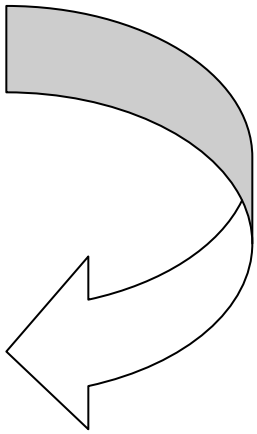
Regional follow-up A

Regional follow-up B

Regional follow-up C

Regional follow-up D

Teacher workshop II , III and IV – each two days
Nov 2011; Feb/Mar 2012; May 2012



Appendix 2
WHAT TO LEARN AND INCORPORATE INTO THE CPD PROGRAMME FROM THE TEACHER NEEDS QUESTIONNAIRE

The number of PROFILES continuous professional development sessions offered under PROFILES per partner depends on the teachers' interest and their wish to be more self-confident and effective in the teaching using PROFILES modules (*teaching the PROFILES way*).

The **TEACHER NEEDS QUESTIONNAIRE** is intended to be invaluable in being a guide to the wishes of the teachers. Besides the recognises need to give teachers insights into aspects of PROFILES related to science teaching, outcomes for the questionnaire enables the CPD provider(s) to gain important prior insights into the teacher areas of 'need.'

The teacher need questionnaire is divided into 9 sections, but these are not intended to be sequenced in any priority order. The sections are:

Nature of Science

If the promoting of scientific literacy is to be a serious target, then appreciating 'what science is', 'its important contributions to society' and the 'limitations of science in explaining phenomena' are obviously important and need to be incorporated into science teaching. Teachers should become aware of the care needed, if they are not portray science as - the 'truth' - it is composed of fact which are not to be challenged; observations are always viewed the same way whatever the cultural and society background. The questionnaire gives an indicator of how far the teachers welcome the opportunity to discuss in this area, especially in its implications for teaching in their classrooms.

STL

PROFILES sees this as 'the' goal of science teaching and thus teachers need to gain a clear idea of what is intended. A discussion on STL is expected to be an important consideration.

Goals of Education/Science Education

The STL intention becomes clearer if a closer relationship is realised between the goals of education as a whole and the goals of science. How far are teachers prepared to consider them as the same? Any discussion on this will challenge memorisation in science teaching. Why memorise yesterday's ideas when career orientations focus on being creative, self-reliant and possessing good interpersonal skills. PROFILES and 'Education through Science' focus on the real learning in science lessons.

IBSE

Science is heavily associated with knowledge, but what to do with this knowledge (when called upon to do so) requires much wider skills that memorisation, or simply understanding of isolated facts. It is

strongly expected that teachers will want to discuss IBSE teaching and what this means when undertaking PROFILES modules. While it is expected to be a real challenge to teachers, it is also expected that students will strongly welcome IBSE teaching. The teacher needs questionnaire can be a guide to how far teachers need support in developing their teaching in this area – crucial if PROFILES is to impact on making science teaching interest and relevant for students.

Classroom learning environment

If the PROFILES way stands for motivating student, then PROFILES also stands for enhancing student motivation by ensuring the atmosphere in the classroom plays a strong role by the teaching supporting the learning. It is in this area that good teachers excel. If teachers are not confident of undertaking student-centred teaching, CPD providers will need to put much effort into convincing teachers to move in this direction. For PROFILES to succeed, it is a must.

Student Motivation

PROFILES heavily stresses the need to promote student motivation. This is put forward as a key factor to enhance meaningful science learning. Where learning is student- driven, student-constructed the PROFILES hypothesis is that science achievement will be heavily increased. CPD providers must place great effort in this area if the teacher questionnaire does not indicate positive teacher beliefs.

Assessment

Assessment can kill or heighten student motivation and is thus an important component of science teaching. In PROFILES the emphasis is on promoting '*student progress'* and also allowing students to see and be aware of their learning. This takes the learning away from factual gains and into a wider 'education through science' arena in which personal skill development, social skills development and above all the transference of the learning to new situations are encouraged to flourish. Again if teachers are not confident in this area, the CPD provider must take time to promote this vision.

Education Theories

PROFILES is not intended to be an isolated approach devoid from evidence. It is in fact heavily dependent on education theories and teachers may feel that they would be better placed in their teaching if they become more aware of the more important ideas driving teaching in the 21st century.

Self Reflection

If a teacher is to develop the confidence and self-efficacy for which PROFILES strives, it is important the teacher is willing and able to gain from self-reflection. The teachers need to reflect on the manner in which they are able to involve the students and promote intrinsic and extrinsic motivation in students. CPD providers are expected to give much emphasis to self reflection and to collective reflection by teachers meeting as a small group.