Science Education International
Vol. 25, Issue 2 (Special Issue), 2014, 78-96

The PROFILES Project Promoting Science Teaching in a Foreign Language

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ABSTRACT: School subjects can provide a good context for learning a second language. This is especially true for science as it can involve a range of student centred activities, which involve students in collaborative communication related to a range of different competences. This paper reflects on one approach to learning in a second language, using the approach promoted by the PROFILES project. It illustrates how the PROFILES approach can realise greater potential for student language development, focusing on learning about carbon dioxide in an inquiry learning format, permitting experimentation and interpretation of the outcomes. The approach is via a scenario providing a familiar setting for the learning and, following experimentation, the approach moves to decision making where the focus of carbon dioxide is on being a greenhouse gas and effecting global warming, this leading to a debate on acceptable levels of carbon dioxide and the effect of deforestation. The latter involves the use of argumentation skills in a socio-scientific setting allowing the utilisation of a second language in a different dimension to that of providing scientific explanations.

KEY WORDS: science teaching, foreign language, PROFILES project

INTRODUCTION

(a) CLIL

In France it is possible for students to study science in a CLIL (Contact and Language Integrated Learning) class. In the CLIL class, students study science subjects - Chemistry, Physics, Biology and Mathematics - in a foreign language. The foreign language is often English, but it is not necessarily the case in all schools. The focus is on communication and not simply on the acquisition of new knowledge. Usually the students have already gained, or will acquire, major scientific skills in French and so the

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* ICASE- MICE1, France; ICASE- MICE refers to a group of French science teachers interested in exploring PROFILES ideas under the patronage of ICASE. ICASE is the international council of associations for science education, a non-governmental organisation linking national and sub-national organisations. MICE relates to motivational inquiry-based science education.
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CLIL class is seen as a good opportunity to develop additional, inquiry learning skills and to practice the foreign language in an authentic setting.

(b) PROFILES Project

The intention of the PROFILES project is to promote motivational learning through science education and thus promote the gaining of important educational skills. It strives to achieve this through raising the self-efficacy of science teachers towards taking ownership of more effective ways of teaching students in science lessons (Bolte, Holbrook & Rauch, 2012). The PROFILES project places much stress on student centred learning, while the teaching approach places much importance on the relevance of student learning (ED, 2007). This is seen as a huge challenge, given the many classroom constraints faced by teachers and the widely accepted practice that science education is the passive acquisition of curriculum content. The PROFILES approach thus goes beyond promoting meaningful inquiry-based science education (IBSE) as a teaching and learning construct and strives to address:

1. the perceived gap between the outcomes of science education research and the practices adopted by many teachers, partly a result of science education research being qualitative in nature and hence limited in direct applicability, partly a result of limited teacher competence in the field of education with little by way of partnerships established between researchers and teachers (Anderson, 2007; Davis, 2007; Korthagen, 2007; Nuthall, 2002);
2. the accountability of teachers for the success of their students. Unfortunately, all too often, this is measured using assessment strategies and instruments, which are often at odds with evidence-based best practice (Torrance, 1995; Harrison et al., 2008). This impinges on the teacher’s self-efficacy in trying out new ideas and approaches that do not fit the standard assessment patterns. Work package 6 within PROFILES strives towards greater teacher ownership of the intended teaching and by recognising the need for strong student motivation, especially intrinsic motivation, and the reactions of stakeholders to this, gaps between accountability and best practice can be minimised;
3. science education being considered a branch of science, rather than a branch of education. This has led to stress being placed on acquiring science content (and associated ‘passive’ conceptual learning). In turn, this has given the impression that content is the only component of importance, which in turn, inhibits inclusion of more modern science which is more linked to the everyday world as this new science content (more interdisciplinary) is not in the textbooks (NRC, 1996). In PROFILES, work package 5, through the training and

support for classroom intervention, seeks to address issues associated with the goals of education and the goals of science education in particular, within the frame of 'education for all.' Student centred approaches are strongly promoted;

4. science in school usually being compulsory, or a core subject for all students, yet the content continues to reflect scientists' expectations, or scientists' views of science learning (EC, 2004). School science practice rarely reflects issues and concerns in society. Society expectations are considered often through the 'eyes of scientists' and hence seen as one and the same. As a result, motivation suffers as many students do not see being a scientist as a career target, but do appreciate learning for their future needs (Fensham, 2008; Osborne & Dillon, 2008);
5. the science education literature (e.g. Osborne et al., 2003) pointing to success of school science in meeting interest needs at the primary school level, but at the same time, the interest of young adults in learning science is largely not sustained and motivation decreases at the 13-16 age level (the beginning of adolescent) (EC, 2004; 2007). Past philosophies about the Nature of Science Education and Inquiry based Scientific Teaching Approaches take too little account of this (Holbrook & Rannikmae, 2007);
6. teachers being exposed to a range of teaching ideas, but often being unaware of appropriate teaching strategies to use. However it is one thing to be aware of more appropriate strategies to teach science, but it is another to be able, or willing, to put them into practice in the classroom; (Ridlon, 2009);
7. assessment being a constraining issue for many teachers, especially while many external examinations focus on surrogate measures of student learning which concentrate on knowledge transmission, poorly conductive to promoting inquiry-based teaching processes or other life skills and competencies (e.g. in argumentation and/or informed decision making processes esp. in the field of socio-scientific related problems and dilemma) (Holbrook 2008a; 2008b).

Using PROFILES modules as a tool to make more sense to language learning

Science education in a foreign language can address English as a communication tool and not as a direct object of study. Science here is the support, the pretext for learning a foreign language, and making sense to it. The associated hypothesis is that in a context where the teacher is not an expert, students express themselves more easily and gain confidence in greater levels of self-efficacy. Also in technological settings, English quickly became a necessity (technical manuals, technical journals, reports, not to mention verbal exchanges). The PROFILES modules can be a major source of inspiration, and can be adapted to be less scientific and provide a greater focus on enhancing language requirements.

Using the PROFILES approach in teaching science in a foreign language as a tool for a better understanding of the sciences

Having an explicit concept in another language required the teacher and students to put it differently, and as a result, clarifies their thinking. Sometimes, the word can be imaged in one language more than in another. According to cultures, presentation and examples vary and thus they propose a different perspective which sometimes improves understanding.

An AEDE study (*http://www.aede-france.org/langues-savoirs.html*) performed on 20 DNL (DNL = Discipline Non Linguistique – any kind of subject taught in a foreign language) for 2 years showed that, because of language difficulties, the teacher is required to ensure each student has understood. In particular, an individual validation in the reformulation, both written and oral, is more common. As there is no program in these sections, there is less pressure on time management; groups may be less crowded, and the goals are more focused on written and spoken communication than the acquisition of scientific knowledge.

Using PROFILES modules, taught in a foreign language, as a tool to educate through the sciences.

About advantages of teaching in a foreign language is that the educational structure of DNL often creates more relaxed relationship between students and teacher. The non-expert Professor makes it more accessible, and can help the students to change the way they look at teachers, as to their own learning process.

- Virtual international projects invite to a multicultural approach and face pupils (and teachers) with different requirements and can help them to relativize "the level", and their "capacities”.
- International exchanges, create strong relationships, and can get to know themselves, to build themselves into togetherness.

On the other hand, the natural opening to international development and the fact of not being constrained by a program, help to develop a broader scientific culture.

- Simple search and use of resources in the native language opens a window to other perspectives.
- Documentary projects can be an opportunity to realize that, from time immemorial, the development of knowledge and technological advances have required multiple exchanges between different peoples. And international collaborations of scientists to pursue

together a unique and often exciting joint project (eg CERN, Antarctica, Aerospace, ...), give a more optimistic view of reality, a salutary vision of human solidarity, an awareness that humans are united by some universal issues.

- Finally, if the wealth of a plurality of points of view seems obvious, the diversity of cultures also highlights their common base, and our belonging to the same entity, (Europe, for example, …) or humanity.

Using PROFILES modules to motivate CLIL teachers in the use of IBSE and Education through Science.

PROFILES modules, which offer turn-key (ready to use) tools, and which permits and even encourages teachers to adapt this to the situation, allow a greater degree of ownership by high school teachers. They have the potential to reactivate the interest to devote the time necessary to re-invigorate teachers towards IBSE as a priority axis in teaching.

If IBSE develops a scientific approach with its doubts and questions, it offers a learning environment well beyond a 'scientific' education (EC, 2007). Following an idea with enough conviction to move forward, but be constantly listening to the confrontation with reality, with experimental results, along with other proposals, even if changing ones lines of research is needed, induces a state of openness, humility and adaptability. And that can be a real asset in society, as well as in one's own personal journey. Accept living doubt as a source of non-confinement, a doubt experienced not as an obstacle or as a lack of confidence, but as a positive and constructive attitude. So our work is about /covers life skills (Choi et al., 2011; Holbrook & Rannikmae, 2007).

The most significant value of PROFILES modules is the issue announced in the scenario that is expected to lead to a socio-scientific decision making situation. This last step, often overlooked, because less explicitly expressed in the school curriculum, and difficult to enact due to lack of training, invites us to step back and provide space for students to consolidate their learning in a society setting. It involves placing hierarchical and related knowledge, acquired during the investigation phase, in a familiar setting in order to achieve a synthesis and the making of a decision. The fact that it is based on hard data, solid knowledge, and that the work was carried out as a team, can give students self-confidence, especially if they don't have the art of rhetoric.

If this final phase involves a debate, it is not the simple exchange of opinions, more or less unjustified, which are expected, but the exchanges argued against science knowledge gained during a study conducted with rigour. It can also be particularly constructive, if followed through to a collective decision, requiring compromise and final consensus. Thus, it develops listening skills, as well as tolerance and respect for the views of others found to be relevant, though (sic) contrary to one's own.

In this way students are led to perceive that science has strong links with economics, social, political, religious and philosophical issues. The challenge is not just intellectual; it is to help students develop as citizens, citizens who influence choices with sometimes serious and long-term consequences. Develop critical thinking is essential, and a solid scientific training can help. However, it would be sad to see science reduced to solely a decision-making tool, yet at the same time to think school science and science lessons focus only on intellectual curiosity, is equally simplistic. The one and the other are not antithetical. This third stage in PROFILES modules thus reminds us of our own function not only in education of the sciences, but education through science (Holbrook & Rannikmae, 2007; 2010).

The question thus put forward is how can an innovative project like PROFILES play a meaningful role in the development of CLIL, as well as introduce more meaningful science teaching and learning?

This paper explores the following questions:

1. In what ways can PROFILES lend itself to CLIL teaching?
2. Does the use of PROFILES, in a CLIL class, support learning?

THEORETICAL BACKGROUND

(a) IBSE

An inquiry-based approach to science teaching (IBSE) is not new. It has been especially promoted in France since 1996, when Georges Charpak, the 1992 physics Nobel Prize winner, created the programme 'Le Main à la Pâte' (http://www.fondation-lamap.org/fr/page/91/presentation). His idea was that good science education should be based on inquiry, a conviction he held after finding out about the American programme 'Hands on' (http://www.handsonnetwork.org). La main à la pâte is a Foundation that aims at renewing and expanding science teaching in school, in France and beyond. Its action focuses on supporting and training teachers in science and:

- produces and disseminates pedagogical and scientific resources;
- contributes to the training of teachers and trainers;
- develops an international cooperation around science education;
- favours equal opportunities;
- involves scientists and industrialists in the development of science education.

The above is in line with the goals of PROFILES. Nevertheless, rather than involve scientists and industrialists directly, in its work package 3, PROFILES strives to seek scientists/industrialists views via a Delphi study (Adler and Ziglio, 1996) and to interpret this in determining the scope of the CPD.

An EC report (2007) had an impact on promoting IBSE in Europe and further oriented French science curricula towards promoted such approaches for use in regular science classes, but even more in other school activities or courses related to science, such as an optional 1,5 hours a week course for 10th grade students called 'Scientific Methods and Practices,' or another optional course 'European Section,' where science subjects are taught in a foreign language. IBSE methods are also widely used by students of the 11th or 12th grade to conduct a 6 months research project, based on a scientific problem which the students set out to solve. In technological schools, the importance of those projects is heavily stressed and these projects count for about 30% marks for the final examination.

Junior high and primary school teachers receive in-service training on IBSE to varying extents, although it can be meaningfully claimed that every single science teacher in France has at least heard about IBSE, most have received training in this area, and the large majority are convinced that the IBSE method is a good tool to motivate students. Science textbooks suggest inquiry activities for students, presented prior to summaries of lesson intentions. Also several websites available for teachers, present a wide range of ISBE activities.

What is IBSE?

Unfortunately no simple answer is possible. And to complicate matters, inquiry-based science education (IBSE) can relate to both the term inquiry learning and inquiry teaching in the field of science (Anderson, 2002). Inquiry learning is important as this implies that the student is being considered and thus learning through science lessons is clearly the focus. But as it is recognised that teaching is to support the learner to learn, the term inquiry learning would suggest it can cover both teaching and learning and thus have a wide implication (Anderson, 2002). Inquiry learning in science lessons can be considered as scientific inquiry and refer to "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996). It suggests student cognitive involvement, as well as hands-on activity.

On the other hand, inquiry teaching can imply that it is how the teacher goes about promoting scientific inquiry by students (Anderson, 1996; NRC, 2010; Capps &Crawford, 2013). It is thus not surprising to suggest that there is no single way this is, or need be, achieved. Nevertheless, it is common for inquiry teaching to promote student learning related to:

a. identifying scientific questions,
b. seeking evidence to answer such questions, and
c. exploring the interpretation of the evidence to seek answers to the initial questions.

Thus “in the teaching context, inquiry seems to be used in a variety of ways without careful distinction as to the differences. It is seen both as a characteristic of a desired form of teaching and as a certain kind of activity” (Anderson, 2002). Alas, ‘inquiry teaching’ does not necessarily lead to ‘inquiry learning.’

It is perhaps important to recognise that non-inquiry teaching can, does and may even be required to, exist. If for no other reasons, teacher reinforcement of inquiry gains, teacher clarification through guidance instruction, ensuring safety concerns are recognised, or presentations made by visitors such as scientists, all provide examples where teaching is not fitting the inquiry pattern and hence serve to illustrate that scientific inquiry is not the only approach to student learning within science lessons. Nor is it suggested to be the only approach that usefully promotes CLIL in science lessons

Issues associated with IBSE

Perhaps the single most widespread reason for a lack of inquiry teaching is the widespread belief by teachers of the need to follow a textbook approach (Anderson, 1996). For various reasons, it seems teachers take the textbook to actually express the curriculum, even though, in numerous situations, the curriculum developers are not the textbook writers. And, in this sense, the textbook are mere personal interpretations of the curriculum in the eyes of the authors. A further key aspect to bear in mind is that the science curriculum can rarely be used solely in a print (or even in an e-book) format. Science in school is best conceived as science education, thus differing from science in a variety of ways (Holbrook & Rannikmae, 2007); for example, learning to collaborate with others, to communicate in meaningful ways, to acquire techniques, or to learn employability skills. And within this education, considerations related to aspects such as authentic problem solving, or decision making in a familiar social setting are inclusion in most school science curricula today, inevitably make textbooks support resources at best and insufficient as sole curriculum providers.

A second valid reason for a lack of inquiry teaching can be the teacher frustration and the difficult problems encountered in implementing inquiry teaching as intended (Capps & Crawford. 2013). There is the feeling that in trying something new, we are not likely to be good at it – at least not at the beginning. And thus there are feelings that, if we receive no encouragement, or no support, why persist with what ‘does not work’!

In general, it has been suggested that barriers and dilemmas to the inclusion of meaningful inquiry learning can be clustered within three dimensions - a technical dimension, a political dimension and a cultural dimension (Anderson, 1996).

a. While the technical dimension includes limited teacher ability for such a new role and perceptions of textbook dominance, assessment challenges and the lack of guidance e.g. inadequate in-service education, or opportunities for networking with other teachers (such as within activities provided by profession science teacher association) fall in this category.
b. The political dimension includes limited teacher support from the school, other teachers, the community and in particular parents, the perceived lack of resources and coping with a ‘freer’ student environment.
c. The cultural dimension—possibly the most important, because beliefs and values are so central to it,—include the teacher views e.g. role of the textbook, the meaning of learning, views on assessment and perhaps most damaging of all, an overriding commitment to feeling that all student learning comes from teachers and hence teachers are the ones who need to ensure they enact coverage of the whole curriculum (and never mind if the students don’t understand the teaching as a consequence!).

The above suggests that teacher beliefs and values, coupled with the teacher preparedness to face challenge to their understanding in the face of the unknown (what students may ask, make comments on and value), are of critical importance in the process of willing teachers to utilise meaningful inquiry approaches in teaching. Nevertheless, one should not expect to address change in isolation from the practical context in which teachers operate and hence one should not expect that change can be addressed directly as mental constructs. Nor should one expect that teachers feel they are to cope in isolation and that change is not a collaborative undertaking.

But still many high school teachers seem to hesitate to use IBSE, often because they suggest such an approach is time consuming. Yet by considering the range of attributes associated with IBSE in the table below, the multiple variations in student involvement indicate there are many ways to include IBSE associated with the multitude of topics included in a science curriculum (EC, 2007; Osborne & Dillon, 2008; Fensham, 2008).

Table 1. Essential features of IBSE and suggested variations possible (NRC, 2002)

Essential Feature *Students…*	*Students…*	**Variations**		
engage in scientifically oriented questions	pose a question	select among questions, poses new questions	sharpen or clarify a question provided by the teacher, materials, or other source	engage in a question provided by the teacher, materials, or other source
give priority to evidence in responding to questions	learner determines what constitutes evidence and collects it	directed to collect certain data	given data and asked to analyse	given data and told how to analyse
formulate explanations from evidence	formulate explanations after summarizing evidence	guided in process of formulating explanations from evidence	given possible ways to use evidence to formulate explanation	provided with evidence
connect explanations to scientific knowledge	independently examine other resources and form links to explanations	directed toward areas and sources of scientific knowledge	given possible connections	
communicate and justify explanations	form reasonable and logical argument to communicate explanation	coached in development of communication	provided broad guidelines to use to sharpen communication	given steps and procedures for communication

More ◄——— Amount of Learner Self-Direction ———

Less ◄——— Amount of Direction from Teacher or Material ———

But perhaps of greatest concern (Anderson, 2002) is the fact that many teachers believe they are teaching science and promoting inquiry learning, but this is not necessarily the case in reality. It suggests that teacher self-reporting alone may not provide an accurate picture of what teachers are actually doing in their classrooms related to inquiry (Capps & Crawford, 2013). This would suggest evidence of inquiry teaching needs to be obtained from sources beyond the teacher, perhaps from observation by other teachers (onsite or via videotape/podcasts), perhaps from student reflections or perhaps through a portfolio illustrating teacher approaches and students' work.

It seems also, there are a number of misconceptions which are guiding the wide-spread misuse of IBSE (Llewellyn, 2002). At one extreme, teachers believe they are practicing inquiry by posing questions to their students and guiding them towards answers. At the other extreme, teachers feel they are not practicing inquiry unless they allow their students to engage in a lengthy open-ended process that directly mimics scientific research. Given these two extremes, it is not surprising that misconceptions about inquiry-based instruction abound. The mistaken notions about inquiry, listed below, serve to deter efforts to reform science education.

Table 2 Identified misconceptions about IBSE (Llewellyn, 2002)

	Misconception about inquiry-based teaching
1	Inquiry-based teaching is the application of the "scientific method."
2	Inquiry-based teaching requires that students generate and pursue their own questions.
3	Inquiry-based teaching can take place without attention to science concepts.
4	All science should be taught through inquiry-based teaching.
5	Inquiry-based teaching can be easily implemented through use of hands-on activities.

METHODOLOGY

A PROFILES module on Carbon Dioxide was used as an illustration of how teaching a class of grade 12 CLIL students can proceed. The module is a modification of that developed in a project called PARSEL (www.parsel.eu). PROFILES modules are designed for the teacher, although they include a section for students which teachers can utilise in the classroom situation.

Each module provides a suitable format for classroom use, based on the following best practice expectation: (Holbrook & Rannikmae, 2012b)

- Cognitive or intellectual development of students, especially with reference to higher order skills.
- Emphasis on moving science teaching towards promoting student thinking - (analysis, synthesis, evaluation based on Bloom's taxonomy, 1956), or relational and extended abstract thinking (based on the SOLO taxonomy by Biggs and Collins, 1982), or aspects such as creative thinking, problem solving thinking, argumentation skills,

or justified decision making. Holbrook & Rannikmae, 2007; Choi et al., 2011)
- Promoting an appreciation, by students, of the Nature of Science ("What is Science?") and an ability to use scientific process skills in association with cognitive thinking (McComas, Clough & Almazroa, 1998).
- Development of students' personal skills; these being seen as attitudinal, aptitude (e.g.
- perseverance, safe working, initiative, ingenuity) and the range of communication abilities (written, oral, graphical, tabular, symbolic) (Holbrook & Rannikmae, 2007).
- Development of social skills; these being seen as cooperative or collaborative learning, gaining of social values and the ability to make justifiable socio-scientific decisions (Holbrook & Rannikmae, 2007).
- Each module is geared to promoting learning for responsible citizenry (Education through Science) as indicated by the stated specific learning objectives/competencies (Holbrook & Rannikmae, 2007).
- Module are designed to be seen as relevant and meaningful for students.
- The title of each module has a society oriented focus, using words/situations familiar to students (unfamiliar science words are not included).
- Modules are structured (especially in the student section) such that 'student ownership through participation' is anticipated to be high.
- The expectation and potential for teacher ownership, through appropriate teacher modifications of any module is high.
- Experimentation/modelling by students is extensively included thus ensuring high student gains in cognitive and process skills and in student cooperation and collaboration competences.

Suggested formative assessment approaches are given, encouraging student involvement.

MODULE TITLE CARBON DIOXIDE – A LIFE SAVER OR A MAJOR CONCERN?

Based on the PROFILES teaching approach, this module is taught using the PROFILES 3 stage model (Holbrook & Rannikmae, 2010; 2012). The teaching begins with a scenario.

Stage 1 - The Scenario

The intention is that students read, or are presented with a scenario. This is intended to raise student awareness about carbon dioxide and to bring to the attention of students that it is a 'life-safer,' as well as a matter of concern. But rather than allow the teacher to explain, the scenario provides the teacher with the opportunity to find out what the students already know about carbon dioxide (it is not very interesting to explain what the students already know and it is clear the scenario assumes students are already aware that carbon dioxide is needed for photosynthesis and that people breathe out carbon dioxide). Also the scenario strives to make the topic relevant to students and by raising awareness among the students that the topic affected them personally, the goal is to arouse the intrinsic motivation of students.

The scenario suggested is:

Two students were walking home through the park, when one of them said to the other "Did you know that plants use up carbon dioxide from the air to make food?" "Yes" said the other "It is called photosynthesis. Our lives depend on this." The first student, however, was not thinking about the process of photosynthesis; he continued "So if it is bad that there is too much carbon dioxide in the air, we should grow more plants! We could grow more plants in this park. There is plenty of space."

The other student was somewhat surprised by these statements. She said "But the cause of the 'too much' carbon dioxide is not so simple. It is not just from people and animals breathing out. We need to identify the cause of the extra carbon dioxide in the air and whether this is bad." (This student, of course, was assuming that the carbon dioxide was a gas and that it was included in the air with the other gases present). "Oh dear," said the first student "What do we do?" It seems carbon dioxide is both very important, but also very bad." "I guess, if you are concerned, we should ask our science teacher if we can find out more about carbon dioxide" said the second student.

Operationalising PROFILES in stage 1

If the scenario fulfils its function of motivating students, it is expected student will wish to suggest to other students that there is a need to find out more about carbon dioxide (and that, of course, is exactly in line with the intention of the school science curriculum for these students). But how should the teacher go about this? Does the teacher give worksheets to the students so that they can find out sources of carbon dioxide experimentally? Or are there alternatives which the teacher can choose? The answer largely depends on how the students respond, with perhaps teacher probing, so as to deepen discussion based on the students' prior knowledge.

Determining prior knowledge is important in a constructivist setting, because it provides an understanding of the base from which the learning begins. It is expected students will be aware that carbon dioxide is a component of air breathed out and that it is a product of burning carbon and carbon compounds. Students can also be expected to point out that carbon dioxide is an important ingredient for photosynthesis to take place.

Moving towards PROFILES stage 2

With the students expected to be familiar with photosynthesis, the presence of carbon dioxide in the air and that people and animals need oxygen to live while they breathe out unwanted carbon dioxide, the question that is likely to concern the teacher is 'how far do students appreciate that the use of most common fuels produce carbon dioxide and that the increased use of this is a matter of concern?' Here the teacher, in probing further, trying to guide the students to come up with investigatory scientific questions (which students can then solve), related to ways to produce carbon dioxide. For example, it is probably a fairly simple step to explore the name of carbon dioxide and then, depending on student familiarity with elements and compounds, to try to establish that to produce carbon dioxide requires a carbon source and an oxide (oxygen) source. And, assuming students are familiar with oxygen aiding combustion (burning), it is anticipated to be a relatively simple step to indicate burning substances are a probable source of carbon dioxide. And from this students can suggest substances that could be tested.

Profiles Stage 2

A step beyond the above is to establish the test for carbon dioxide (using limewater) and then to embark on checking which substances, during burning, give off carbon dioxide and thus show that these substances are carbon compounds. Also, it is useful to explore gases in our lives and which of these are carbon dioxide. This probably establishes that carbon dioxide has uses besides allowing plants to grow (i.e. used in fizzy drinks, fermentation processes and even cooking and bread formation). From here it is but a small step to explore ways of making carbon dioxide, other than by burning.

All of the above is, of course, far from the initial concern in the scenario. However, the learning was triggered by the need to know more about carbon dioxide and its sources. The learning has shifted from the science in the society, initiated in the scenario, to a scientific investigation. It is triggered by the question 'how do we find out more about carbon dioxide?' (and especially its sources and uses). In the above, it is suggested this question can come from the students, and if so, this enables students to play a role in determine the first step in inquiry-based learning – identifying the scientific question. But, if the students do not volunteer such a question, then clearly the teacher steps in and poses the question in an appropriate manner. This enables further inquiry steps to begin – prediction (students putting forward a hypothesis insofar as they can), planning (students putting forward ideas (guided by the teacher as necessary) on how to undertake the experimentation, actually doing the experiments and observing (recording) outcomes and, then, interpretation of the outcomes. The greater the student involvement in these various steps, the greater the degree of open inquiry and the more students illustrate that they are able to undertake science and learn from the scientific experience.

Inquiry-based learning (through direct experimentation in this case) is stage 2 in the PROFILES approach, whereas the scenario and its subsequent discussion leading to the establishment of prior background is stage 1. The stage 2 experimental aspect of the inquiry learning can involve all, or some, of the following - burning a candle, kerosene (or other similar liquids e.g. methylated spirits, vegetable oils in a kerosene/spirit burner), using animal fat (lard) and also other methods of carbon dioxide production e.g. extracting the gas from fizzy drinks, adding acid (or applying heat) to carbonates/hydrogencarbonates) such as limestone, sodium hydrogen carbonate (bicarbonate of soda), seashells, or examining the adding of water to fizzy mixtures (alkaseltzer, etc.), plus the fermentation process.

The end result is that students establish that carbon-containing substance can give carbon dioxide if they (a) burn, (b) react with acids, (c) decompose on heating, (d) are involved in a fermentation process. Added to this, students can include the carbon dioxide production by people and animals (utilizing/breaking down foodstuffs) and also the role of carbon dioxide in photosynthesis (building up foodstuffs).

Moving from PROFILES stage 2 to stage 3

By now it is expected that the students have built up a strong background related to the production and use of carbon dioxide. This is the purpose of PROFILES stage 2. This stage 2 is not simply inquiry teaching, but inquiry learning so as to enable student to acquire meaningful science. Whereas in stage 1 the students were involved in using language to convey their prior learning, in stage 2, language plays a major role in intra-group discussions consolidating the conceptual science and also inter-group discussions to exchange findings within the class (especially of value of student groups undertake different experiments).

But the learning is somewhat isolated from everyday life. We don't test for carbon dioxide in our daily lives and if we do, we would use special instrumentation for the process. And the learning is far from the initial discussions between the two students in the park. It is now important to utilise the science gained and re-focus on the discussion started in the scenario. And whereas, before, students were learning in a scientific way, there is now a need to think in a more social way. So if there is too ‘much carbon’ dioxide, why is this? How it being produced? And does it really matter? And surely we can, as one student said in the scenario, grow more plants.

Profiles Stage 3

This next phase, stage 3, engages in a meaningful role for learning conceptual science and at the same time it engages students into further language learning. As we enter the social setting, so simple problem-solving techniques no longer apply and we are into making decisions, based on both the science and the social components. We need to discuss, by reasoning out the way forward, to put forward justified arguments and even to refute the arguments put forward by others. The language component becomes more interactive and deals with an area of uncertainty. The goal is to determine whether carbon dioxide is a life-safer, or is its increase a major concern?

At this point, the carbon dioxide story needs to widen, as the production of carbon dioxide is not, in itself, the concern. The role of carbon dioxide as a greenhouse gas, leading to global warming and to the impact of this, is the concern. This can take us into another stage 2 inquiry learning phase (this time probably making much use of the internet as we find out about the greenhouse effect) and reflecting on why the oceans are not seen as playing a major equalising role. After all, carbon dioxide dissolves in water to some degree and this carbon dioxide is the much needed source of the production of seashells by many forms of sea-life. Or perhaps it leads to a role-play activity, whereby students take on different perspectives (using the internet to help identify the role) and argue the case. Language learning is now heightened through evaluative reading of text on the internet as well as developing argumentation skills.

CONCLUSIONS

Of major interest is the usefulness of PROFILES as an approach to CLIL teaching and linked to this, the value of shared outcomes with the community of CLIL teachers, not only in France, but worldwide.

The need for relevance (Teppo & Rannikmae, 2006; Fensham, 2004), as seen through the eyes of students, places stress on high intrinsic motivation of students (Ryan & Deci, 2000) as a major focus for the PROFILES teaching modules. The teaching is thus triggered from the students ‘world’ and is not an introduction through unfamiliar science terminology. Not only is this seen as aiding learning, but provides a meaningful setting for developing language learning.

Inquiry based-learning is a powerful approach to student involvement in the learning process, but to put this into effect is not so easy. The learning requires conceptualisation and a degree of student involvement. For this, student relevance and student intrinsic motivation are powerful additions to the learning process. Through student involvement in both the thinking and doing components of IBSE, PROFILES supports meaningful student learning and at the same time aids the development of language in the reading of text, interaction with others and putting forward presentations on the experimental outcomes.

The PROFILES 3rd stage process recognises the need to reflect on the socio-scientific aspects of the learning and to discuss the issues and establish a justified decision. This also encourages a focus on language learning as the argumentation requires spoken and listening interaction with others and the need to develop a record of the way the decision making led to a consensus view.

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