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Introduction to the Special Issue of Science Education International Devoted to PARSEL

JACK HOLBROOK (jack@ut.ee), Centre for Science Education, University of Tartu, Estonia

This special issue is devoted to an approach to the teaching of science, which is intended to stimulate both an *interest* in the subject and to gain student acceptance that science lessons are *important and useful* for them as members of society. It is timely, as the teaching of science is problematic in many countries, as illustrated in research articles and more general documents discussed later. All too often, students report that science lessons are boring and that science lessons are irrelevant for them (EC, 2004).

Not surprisingly, the key to interesting and meaningful teaching is seen as 'how to motivate' the students. A European project called PARSEL, involving a consortium of partners from 8 European Universities plus ICASE, has developed or adapted a series of teaching/learning modules in the area of science (Biology, Chemistry, and Physics) at various secondary grade levels (grades 7-12). The modules are fully operational and in English reside on the PARSEL website – www.parsel.eu. The modules are specifically targeted at teachers (rather than students), but can be directly used by teachers with their classes if they so choose.

The PARSEL acronym stands for Popularity And Relevance (of) Science Education (for scientific) Literacy. The project explores ideas for making the learning of science subjects, from grade 7 upwards, better appreciated by students. It tries to do so by taking an approach that differs from the often tried *'extrinsic motivation'* approach, in which the teacher tries to stimulate student interest in the learning, despite a curriculum largely isolated from issues in the society.

The PARSEL approach, introduced in this special issue, is 'promoting popularity and relevance.' These words probably say little to the reader without further explanation and do not portray why such an approach is being suggested. Thus, the introduction:

(a) explains the 'popularity and relevance' approach;
(b) addresses some myths in teaching, which have inhibited this teaching direction in the past;
(c) highlights how PARSEL ideas are seen as useful for the problems identified in the teaching of science eluded to earlier;
(d) introduces the PARSEL approach and the format of PARSEL modules.

The introduction concludes by commenting on the links between the various articles in this special issue and how these introduce different facets of PARSEL, and, at the same time, show adherence to the PARSEL model.

The Popularity and Relevance Approach

PARSEL is an easily remembered acronym and brings science teaching into the fantasy world of Harry Potter. But, it is difficult to give a precise meaning to the words 'popular' and 'relevant.' Both are important and often used by teachers, although trying to separate them may be unimportant for many teachers (and perhaps may even be unnecessary).

By popular is meant – liked by all or most students in the class; the learning is enjoyable. However, it is more than watching an interesting video, seeing an attractive computer animation, watching an exciting demonstration, or participating in a class competition. It is about making the *learning* interesting and enjoyable. It is the popularity of the learning that is emphasized. It is about student saying "I like to learn in science lessons." As such, it arouses an emotional response by students and gives a feeling of liking the science lessons.

So what about relevance? Ensuring relevance is a very common expression used by teachers, parents, and many other stakeholders. Students often relate to this in the negative, and they clearly state that 'science is irrelevant; science is boring.' Relevance is about the usefulness of the learning and about engaging students in meaningful learning. Relevant science learning is seen by students as important, but the usefulness, meaningfulness, or importance is something internal to the student. It is *intrinsic* usefulness, *intrinsic* meaningfulness, or *intrinsic* importance. PARSEL materials are thus designed to promote student's 'intrinsic relevance' (the student sees the need to learn about the science being offered). This suggests that the teaching approach is "*identifying science learning, which has intrinsic relevance for students, so as to stimulate intrinsic motivat*ion."

The PARSEL learning approach is based on students perceiving the learning as relevant, and triggering 'motivation for learning.' Of course, the teacher still plays a very important role (good teaching is still essential), but the PARSEL emphasis is on promoting 'intrinsic motivation.' The teacher reinforces this with 'extrinsic' (coming from the teacher) motivation. This does not describe all PARSEL ideas. For example, sustaining motivation and determining the learning to be achieved are additional and important PARSEL features. But, these do not illustrate the reason for the acronym PARSEL and the importance of expanding the manner in which science learning is approached. The examples given in this special issue are closely linked to such an approach.

Addressing Some Myths Inhibiting Science Teaching

1. *The Scientist's View of Learning Science in School Is the Only View for Determining what Constitutes Science Education.*

A scientist's view is perceived as approaching science learning through building from basic ideas and acquiring the so-called 'fundamental' conceptual blocks, which can then be used to construct a logical structure of learning within a science perspective. This is a 'basic to complex,' or 'simple first to more difficult second' approach. But, unfortunately, it suffers, because the basic is multifaceted and often not so simple, and it is largely unrelated to everyday life. This approach delays the 'going beyond the basics' until the base is in place, and means that the more familiar, socially related aspects are in the latter parts of the course, or are omitted completely. Furthermore, the science that is experienced in everyday life is largely complex, interdisciplinary, and diverse. For students, the basics have little appeal and, as a consequence, the patterns on which science learning depends are not attained.

Adopting an alternative societal approach, whereby the science is experienced within a society frame, has the potential advantage of promoting greater relevance in the eyes of students. Thus, students have some familiarity with the topics being taught, which are designed particularly to meet a perceived need for students to learn more about themselves or their society. While the science is complex, it can, in the hands of an experienced teacher, be broken down to expose the underlying conceptual ideas. This context-based approach has been extensively tried with varying degrees of success in stimulating interest in science.

2. *Science Education Is Learning Scientist's Science.*

If enhancing scientific literacy is a major goal for the teaching of science, the teaching approach should depend on the meaning attached to the term 'scientific literacy.' Scientist's science, or the acquisition of scientific concepts, considers scientific literacy as being associated with understanding specific fundamentals of science. These are often referred to as the 'big ideas,' as if they are culturally independent and have equal status in terms of importance.

A more significant view of scientific literacy, and a view gaining in popularity and forming the focus of such studies as PISA, perceives functionality within society as the goal, and hence processes and dealing with social interactions are considered as the key elements. The approach recognizes that facts can be looked up as and when needed, and that understanding is constructed by the process of embedding conceptualizations in context and developing relevant process skills to help elucidate conceptual understanding.

3. *Science Education Is Special and Somehow Separate from Learning in Other School Subject Areas; It Is Outside the Realm of General Education.*

Students go to school to be educated, while education helps them to formulate interests in careers. Why should science in school be the only subject to have a special function in preparation for a career related to science? Science in school is part of education and hence can be expected to play its role in helping to develop attributes for *all careers*, whether this is in the field of technology, social services, or business. Science in school is within education and hence alongside all school subjects.

By taking a stronger educational view and recognizing colleagues teaching other subject areas can be part of a team, where all play their part to guide the students, then greater cooperative teaching and teamwork can be incorporated, and help to reduce potentially confusing double learning (e.g., electricity is electron flow in a chemistry context, but current flow from a physics perspective).

4. *School Science Cannot Be Socio-scientific, i.e., Society-driven.*

An often used expression is that science and technology are developing at a faster and faster pace within society. This strongly suggests that science is playing a role within society and perhaps will play an even greater role in the future. Yet, this science in society cannot act in a vacuum, and, thus, it interacts with the general social arena, and issues are discussed as such. These issues can be described as socio-scientific. Scientific conceptual understanding has a bearing on the manner in which social issues are discussed and decisions are made, but so do other factors, such as, environmental concerns, aesthetics, social employment, and economics. Science education is thus more than acquiring conceptual science, which then leads to ways of using science in society. It is rather an intention to guide students to interact with science ideas and be able to develop skills and to transfer these for making justified socio-scientific decisions.

5. *If School Science Is Linked to Society, then It Is Specifically to Meet the Public Understanding of Science Expectation of 'How Things Work or Behave.'*

Determining 'how things work' is dependent on practical experiences as well as conceptual understanding. While the basic science ideas can be acquired, and this can be interesting and stimulating to some, the 'technology' in society is increasingly complex and the science ideas well hidden behind aesthetic designs, miniaturization, and electronic triggers. Knowing that a washing machine is driven by a motor, or that it cleans by using motion to remove dirt particles, is fine, but to appreciate the materials used, the strength of the motor, or the quantity of washing power, is moving science into a technological enterprise and is thus stretching the basics too far.

Many issues in society have a science underpinning. Through gaining skills in decision making and the attributes that are associated with this, students and adults can utilize their science to determine which technology is more appropriate for the society. Science understanding in this manner is less about 'how things work' and more about determining the appropriateness of the science for a given situation within society. It is about relating to the issues facing a democratic society, rather than a specific feeding of a potential career need for knowing the workings, or the nature, of technology in specific situations.

Documents Associated with Learning 'Popular and Relevant' Science in School.

Europe Needs More Scientists (EC, 2004)

This report by a high level commission focused heavily on increasing human resources for science and technology in Europe. It has this to say about science education in aspects seen as particularly related to PARSEL:

> *Unfortunately science education has developed its own subculture to a certain degree. In particular at the secondary (and more so at the upper secondary level), many SET (science, engineering, technology) teachers regard the teaching of science not as an area of general educational development of the student,*

> *but as an area for the pursuit of* ***expertise in the subject matter*** *of their discipline.... This may function well for the few students who already see themselves as future SET specialists, but this is only a very small minority. The great majority of students are likely to be turned off by the hidden messages conveyed by the attitudes of those SET teachers with this orientation (p. ix).*
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> *Science education suffers badly in this respect (attractiveness of school in the face of society distractions at secondary level). Not only it is trying to cope with this image of 'becoming a scientist,' but it is also fighting to relate to society. And yet it is being bound by an old-fashioned view that it must develop the 'fundamentals' of science, which, all too often, are abstract, even microscopic, and far from the science ideas underpinning the technological advances within society, which form the focus of debate and divide public opinion. It can be argued that science education in schools lives in a world of its own. It seems unsophisticated, because it is unable to compete with advances within the scientific fields. It is abstract, because it is trying to put forward fundamental ideas, most of which were developed in the 19th century, without sufficient experimental data, observations, and interpretational background, without showing sufficient understanding of their implications, and without giving students the opportunity of a cumulative development of understanding and interest. It is heavily in danger of being excessively content-based.... No wonder society tries to reject science education as irrelevant and only useful for training to be 'scientists.' No wonder students have a perception of science education as irrelevant and difficult. No wonder science teachers have little idea of society's expectations and the directions that they are anticipated to take (p. x).*

Science Education Now: A Renewed Pedagogy for the Future of Europe (EC, 2007)

Two of the four key recommendations from this booklet (EU, 2007), which have particular relevance to PARSEL are:

> *A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science (p. 2).*
>
> *Teachers are key players in the renewal of science education. Among other methods, being part of a network allows them to improve the quality of their teaching and supports their motivation (p. 3).*

Science Education Policy: Eleven Emerging Issues (UNESCO, 2008)

This publication covers eleven issues that are essential for the direction of science education. It makes recommendations that policy makers should reflect on a number of issues, some of which PARSEL is attempting to address. Recommendations in this publication address to policy makers and which address explicit issues of PARSEL are:

- consider what are the education purposes that science and technology education can best provide for students, as they move through the stages of schooling (p. 5);
- make the issue of personal and societal interest about science the reference point from which curriculum decisions about learning in science and technology relating to content, pedagogy, and assessment are made (p. 6);

- consider mandating that science education should move progressively towards a real world 'context-based' approach to the teaching and learning of school science at all levels of the school curriculum (p. 7);
- consider changing the assessment procedures, as critical curriculum factors, in ways that will encourage higher levels of learning as the intended outcomes of school science and technology (p. 8);
- consider how the intentions of the science curriculum for students' learning can be more authentically assessed, both with schools and externally, by the use of a wider variety of assessment tools (p. 9).

***Science Education in Europe: Critical Reflections (A Report to the Nuffield* Foundation (Osborne & Dillon, 2008)**

Recommendations Related to PARSEL:

> *More attempts at innovative curricula and ways of organizing the teaching of science that address the issue of low student motivation are required. These innovations need to be evaluated. In particular, a physical science curriculum that specifically focuses on developing an understanding of science in contexts that are known to interest girls should be developed and tested within the EU'* (p. 8).
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> *Developing and extending the ways in which science is taught is essential for improving student engagement. Transforming teacher practice across the EU is a long-term project, and will require significant and sustained investment in continuous professional development* (p. 9).

Introducing the PARSEL Approach

Each module is conceived in three stages:

Stage 1: This is the introduction to a social issue, as reflected in the title of the module. Relevance is enhanced by linking the title to a society situation rather than attempting to introduce unfamiliar scientific terms. This means that the initial teaching concerns the social aspect and it is put into an appropriate context by means of a 'scenario' – a story, a situation, an elaboration of the title or other such triggers to initiate discussion. Based on the considerations in stage 1, students are led to realize that they lack the scientific ideas, which are important for a more in-depth discussion. This realization forms the basis for Stage 2.

Stage 2: The scientific ideas, the scientific problems to be solved, and the associated process skills, personal and social attributes, are now incorporated into the teaching. By following on from Stage 1, the relevance of the scientific learning is clearly established. The approach within Stage 2 should be familiar to teachers and the module take this opportunity to guide teachers towards guided- or open-inquiry style learning and maximizing student involvement in the learning process.

Stage 2 is the major component of the module and inevitably takes the majority of the teaching time. The extent to which scientific ideas are explored or scientific problems are solved will depend on the scientific learning deemed necessary for an appreciation of the socio-scientific issues introduced in Stage 1. Stage 2 is, in substance, purely scientific, although educational skills, such as, cooperative learning, scientific communication, and the development of perseverance, initiate, ingenuity, or safe working, are also intended.

Stage 3: This stage is perhaps the most important. Here, the students consolidate their science learning by transferring the learning to the socio-scientific issue introduced in Stage 1 and, through discussion and reasoning, arrive at a socio-scientific decision. In this process, the actual decision made is of less importance than the reasoning put forward, and the degree to which the scientific component is included in a conceptually correct manner. This stage involves argumentation skills, leadership skills, the ability to reason using sound science ideas, and balancing these against other considerations, such as, ethical, environmental, social, political and, of course, financial.

Special Features of PARSEL Modules

A Front-page: This section allows the teacher to be both familiar with the title, but also the intended curriculum topic at a given grade level. An abstract on the front page gives a brief description of the modules and the areas of learning. The learning is further specified by means of a list of educational competencies to be attained. The front-page ends by specifying other files in the module, which relate to the topic.

A Student Guide: This file provides the 'scenario' with which the students will interact and the tasks the students are expected to undertake. Where instructions are required for the students, these are included in the student guide (allowing the students to appreciate the tasks), or the instructions may appear in a separate file that is called teacher notes, so that the teacher is able to decide the degree to which students need guidance and hence control the learning accordingly.

A Teacher Guide: This file is intended to support the teacher in using the module. It provides guidance on how to teach the module and the sequencing related to this. It is not intended to indicate that the given approach is the only way in which the module can be taught, but to illustrate the thinking of the authors of the module in developing this PARSEL module. Of importance to the teacher is the need to consider the competencies to be gained during the teaching and learning process within this module.

Assessment File: This is included to provide suggestions to the teacher on the manner in which formative assessment strategies can be utilized, so as to determine the degree to which students are attaining the competencies that are put forward for the learning within this module.

Teacher Notes: This is an optional file designed to provide the teacher with further information or other materials.

Articles in this Special Issue

The first article describes outcomes from the teaching of one PARSEL module in one school in Portugal. This module tries to link the problems of food preservation at the time of Magellan with issues of food preservation today. The authors considered that science education should aim at not only teaching scientific facts, but also at making students aware of social and technological scientific issues. However, the teacher found that there was a tension between what (s)he thought science education ought to be and several constraints from his/her daily practice at school. This dilemma created difficulties which the teacher found difficult to manage. Thus, while student reactions were very positive, there was always the issue of time constraints – an issue which will confront all teachers who conceptualize science education in a similar manner, as this specific teacher (and the PARSEL consortium partners).

The second article considers the PARSEL modules as a potential answer to the concerns with science teaching in German schools, and that PARSEL is very much aligned with the German science education standards that were introduced in 2004. The article recognizes the PARSEL objectives of going beyond cognitive learning, and developing the interactions between students and society. The importance of students being guided to raise questions, to put forward opinions, and to learn how to share ideas is expounded. The article points out that, through interviews, student reactions were found to be very positive. The authors suggest that interviewing students should be undertaken far more frequently, as an approach to an assessment of student learning and as a mechanism to learn more about the development of students' social values.

The third paper describes a "bottom-up" adapting process, which allows teachers to gain ownership of both the module and the PARSEL philosophy. During an intervention, the teachers were introduced to PARSEL modules and invited to modify these to fit their teaching. At a first stage, it was found that teachers often made changes, which moved the module away from the PARSEL philosophy. The instructors took this opportunity to further guide the teachers to take ownership of the philosophy as well as the content. In this way, in subsequent stages, the teachers gradually took ownership of the modules and remained aligned with the PARSEL philosophy. This 'bottom-up' approach helped the teachers to accept the philosophy and the teaching approach of the PARSEL project. At the same time, the teachers adapted the modules to their own needs, their schools, and their students, and maintained their own professional identity. Students for their part found the modules to be popular and interesting, and they also recognized that the key ideas underlying the PARSEL project were relevance for science learning. The students' reactions indicated that the PARSEL teachers did maintain the PARSEL philosophy while teaching the modules.

The fourth article highlights students' responses, collected by means of a questionnaire, related to one or more PARSEL modules. The instrument used was being tested to determine students' reactions to the modules, and, at the same time, to determine whether students could distinguish between the two aspects, namely, 'popularity' and 'relevance' with respect to science teaching. The findings indicate that students were very positive towards the gaining of the various competencies included in the PARSEL modules, and that the students enjoyed the change of approach and did not express any concerns about the lessons being a waste of time, the lessons being boring, or that they did not consider that the lessons were not preparing them sufficiently for existing external examinations. However, the instrument was insufficiently sensitive to determine whether students could distinguish popularity from relevance. Significant correlations were found between questions irrespective of whether the terms 'interest' and 'enjoyment' (being used as indicators of popularity), or the terms 'important' and 'meaningful' (being used as surrogates for relevance) were used. More research is clearly needed if teachers will finally recognize that 'fun' or 'enjoyment' per se are not key elements in science lessons, or that while fun might be important, it is insufficient. Teachers need to clearly recognize that the inclusion of the students' sense of relevance of science lessons to their lives is crucial and that, if lessons are presented in an interesting manner, these can have important implications for student learning.

The next (firth) article moves away from a direct consideration of PARSEL and focuses on the need for in-service intervention, if teachers are to make appropriate use of PARSEL modules. The article thus focuses on the type of in-service intervention that should be provided and considers a one-year master's program as being sufficient. Using the '*Science Teachers of the Future* project' as an indicator, which involved teachers as key partners in the development of the master's program, teachers were involved in trying out and taking ownership of the sequences developed in the program. This was shown to lead to positive gains. The challenge to the approach, as pointed out by the authors, is to maintain the collaborative partnership established through the teachers' participation in the research context, when trying out PARSEL modules and taking ownership of the underlying ideas.

Using PARSEL modules to contextualize the States-Of-Matter Approach to introductory chemistry (SOMA) is the topic of the next (sixth) article. Reconceptualizing a higher secondary course in chemistry has long been seen as important, and utilizing the concept of solids, liquids, and gases is certainly an idea that can be considered, as argued in this article. PARSEL modules, insofar as they include a state of matter theoretical chemistry frame, can be used to develop the teaching approach in a popular and relevant manner. In fact, PARSEL modules can provide the scope of the program, if relevance to social issues is considered as a guiding principle in determining which conceptual chemistry to be included.

The last article describes an alternative approach to a conceptual frame from that adopted by PARSEL, where the unpopularity of science was considered as a barrier to supporting more young people towards science and technology careers (EC, 2004). Similarly, the lack of relevance was also considered as an additional barrier, as indicated in a High Level Commission report (EC, 2004). This article tries to answer the questions: why is chemistry unpopular and which topics covered in chemistry classes are not considered relevant by students? The article, via a Delphi study, attempted to provide answers to three alternative hypotheses - the lack of popularity is due to a gap between science education expectations and students' educational interests; there is a conflict between education expectations of the older generation and today's students, and there is an imbalance between chemistry curriculum intentions and that implemented in school chemistry classes. Findings from the study see the PARSEL project as moving in the right direction.

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