2006

Research and boosting science learning: Diagnosis and potential solutions

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Student interest in science: The problem, possible solutions, and constraints

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In this paper I want to draw on relevant research to address the theme of this year's conference in three ways:

1. The nature of the problem
2. Possible solutions
3. Constraints on these possible solutions

Part 1: The nature of the problem

The quantitative decline in enrolments in the senior secondary sciences and in university, science, particularly higher achieving students, has been well publicised in Australia and, across the OECD and beyond.

I shall therefore focus on research that adds qualitative detail to the issues associated with lack of interest in science among students.

The place of science within the curriculum of schooling

Since 1950, the opportunities not to choose science study in senior schooling have markedly increased.

In a parallel but inverse manner, the unification of the university sector in 1989 has given students many more opportunities, in both the new and older universities, to choose courses other than science, and without the prerequisite constraints the science-related faculties still demand.

Employment opportunities

A recent study at Macquarie University indicates that there are good employment prospects, but that science graduates lack skills that Science and Technology (S&T) positions require in the new Knowledge Society. Declining enrolments in the sciences are associated with the perception that science study is too difficult compared to other subjects, as well as an ignorance of these career prospects.

In 2005, the Deans of Science commissioned a study that found that quite large percentages of teachers had not completed a major three-year sequence of undergraduate studies in the science subject area for which they were responsible. This study did not address the issue of the inadequacies of even a three-year major in science for a teaching career – raised 15 years earlier in the National Review of Science Teacher Education.

Being a science student

Independent studies of students' experience of science in secondary school have been reported by Lindahl in Sweden, Simon and Osborne in England and Lyons in Australia (see Lyons, 2006). These studies present remarkably concordant descriptions of school science as:

- Transmission of knowledge from the teacher or the textbook to the students (our opinions are not involved);
- About content that is irrelevant and boring to our lives; and
- Difficult to learn in comparison with other subjects

The Australian study only involved high achieving students, but most of these concluded *that further science studies should be avoided unless they were needed for some career purpose*. Intrinsic interest, in contrast to other subjects, was low.

The extent of this sense of irrelevance in Japan emerged from a nationwide survey of students in Years 6–9 in 2002. All subjects suffered from a steady decline in interest, but only science and mathematics remained in decline, when the intrinsic worth was considered (Ogura, 2003).

Large scale reviews of students in Australia by Goodrum, Hackling and Rennie (2001) and by TIMSS (ACER/IEA, 2003) found, respectively, that well over half of secondary students did not agree that the science at school: *was relevant to my present or future, or helps me make decisions about my health, and that 62 and 65 % of females and males in Year 4 like science, but by Year 8 only 26 and 33 % did so*.

Part 2: Possible solutions

Guaranteed employment at higher than usual salaries would probably attract more students to stay with the enabling sciences in Years 11 and 12, and to undertake science-based university studies, especially if science was promoted like sport by the Australian media.

If Physics and/or Chemistry were made compulsory for all students to Year 12, more students may find them to their liking, and continue with them, although the experience of countries like Japan rather belies this.

These conditions, outside or inside schooling, are so unlikely, that I focus on what can be changed, with sufficient will and commitment, namely, how science is presented in schooling.

What research do we have about students' interests in science and science education?

Inspired teachers

Before discussing this research, I want to acknowledge the existence of inspiring teachers of science and of supportive school environments. Together they can produce positive interest in science their students, whatever the curriculum. However, we would not be meeting on this theme, if the extension of such inspiration across whole systems were a simple matter.

Students' interests

Focal questions

Beginning in the 1980s, Svein Sjoberg, in the **Science and Scientists (SAS)** project explored the reaction of 13-year-olds in a number of countries to different ways of focusing the learning of the same science content. A purposeful and relevant focal question heightened students' interest in science learning. For example, learning about:

> Sound < How musical instruments make sounds < How animals communicate with sounds

Focal questions were introduced in the initial form of VCE Chemistry in 1991, but their intended use was thwarted by the examiners' total disregard of them.

Questions and topics

The **Relevance of Science Education (ROSE)** project (Svein Sjøberg, Oslo) grew out of the SAS project. To date, the ROSE project has data from 15–16-year-olds in more than 30 countries (Australia still collecting). Students have responded to long lists of science topics they might like to learn, interspersed with items about their personal and societal aspects of relevance to S&T.

Students in industrialised countries have shown great similarity of interest in ways that contrast with those of students in developing countries. The former are more interested in topics that rarely occur in school science, whereas the latter favour more traditional topics. Since Australian students are more like the former, I will use the report from England (Jenkins & Pell, 2006) to illustrate the findings.

- Most students agree that S&T are important for society.
- A lower level of agreement the science benefits outweigh possible harmful effects.
- Most students do not like science compared with other subjects.
- Most do not agree that school science has made them more critical and skeptical and more appreciative of nature.

The ten most popular topics for boys and girls are listed in Table 4.1 and the ten least popular ones in Table 4.2 of the English Report.

Curricular responses

In a his recent book, *Science Education for Everyday Life*, Glen Aikenhead (2005) has provided positive research evidence concerning a number of innovative science curricula that can he describes as Humanistic Science Education. Humanistic Science Education has a number of characteristics that contrasted with those of Traditional Science Education, by including the persons of the learners and of science.

Common features in these positively received approaches to science education are:

- Science as a Story involving persons, situations, action
- Real-world situations of S&T that students can engage with
- Focal questions that attract interest
- Contexts as the source and power of concepts in science
- Clearly presented science – related issues of personal and social significance
- Personally engaging, open problems for investigation.

Further evidence of positive student responses to science education with these features comes from the OECD's Programme for International Student Achievement (PISA). In the Science domain of this project, most if not all of these features have been incorporated into its assessment instrument for 15-year-olds in more than 30 countries in 2000 and 2003 for the scientific literacies (clearly defined as competencies) that this project deemed important for life in the 21st Century (OECD, 2001).

The units in the test instrument consist of a 'real-life Science & Technology situation' about which a set of questions reflecting different competencies are asked. The real-life situations are reports or descriptions (sometimes stories of actual situations) somewhere in today's world that involve science. The real-life situations do not have to reflect the school curriculum for science. They are typical of science's place in 21st century society. In the 2000 testing, Australian students performed relatively well. While the performances overall were not particularly high, they were considerably better than the pessimists had predicted on this very novel test. The very substantial reading involved in the S&T situations had been of particular concern. In the testing of the Reading domain of PISA, girls in every one of the 32 countries outperformed boys, often very significantly. In the Science test, heavily dependent on reading, there were no gender differences among the same students in 26 of the 32 participating countries (repeated in 2003).

These remarkable findings can only be explained, I believe, in terms of the level of interest and engagement that both boys and girls had with these accounts of S&T-based situations. They certainly encourage the changing the school science curriculum to emphasise these features.

New curricula

21st Century Science is a new set of science courses for Years 10 and 11 in England that has included many of these features. It has also recognised that science education needs different courses at the same level if it is to meet the diverse needs and interests of students (Roberts, 1988). Its particular relevance for Australia since that it is a direct consequence of the major rethinking of the role of science in compulsory schooling in England, the country most influential on science curricula in Australia in the 1990s.

The three subjects making up 21st Century Science began in 2004.

1. Core Science, a mandatory study for all students – a terminal study that can be summarized as Science for Citizenship
2. General Science, an optional study involving biology, chemistry and physics for students planning specialised study of these sciences in Years 12 and 13
3. Applied Science, another optional subject, to arouse students' interest in applications of science in modern society.

The rapid progress in enrolments and the interest of schools in this radical approach to school science warrant Australia giving serious consideration to it - especially the way it deals with students' needs and interests among the purposes for school science in the compulsory years.

Part 3: Constraints to solutions

With such an apparently rich set of positive options for improving the in-school response to the issue of lack of interest in science, what constraints stand in the way of implementing science curricula with these attractive possibilities? I refer to three major sources of constraint – science teachers, academic science, and systemic competing demands.

Science teachers

Informal investigations with science teachers in Australia, have made me aware that, however weak or strong their background in science studies, many of them are seriously deficient in ***having any science stories to tell***, in *communicating within and from science*, in *knowing science as a way of thinking*, and in *applying science in real-world applications*. None of these aspects of science as a human endeavour had been emphasised in their school or undergraduate science studies.

In theory, these could all be rectified, but they would require very comprehensive and continuing professional development, involving partnerships between organisations with practising scientists and the education system. The 10-year investment behind the new National Science Learning Centre in England is a model for the scale needed.

Academic science

Academic science in Australia has been reluctant to endorse changes in science curricula with Aikenhead's humanistic characteristics. For academic science, the sciences in schooling were preparatory and prerequisite for science-based study at university. Academic science has exercised control to maintain this situation directly, or indirectly through well socialised disciples among the teaching force. Undergraduate studies in the sciences have in turn been primarily introductory to careers in scientific research, leaving graduates for other careers, such as school teaching, deficient in aspects other than foundational conceptual knowledge.

Hitherto, there has been little pressure for academic science to alter its stance, but the current falling enrolments and failure to attract Science's share of higher achieving students means the scene has changed. It is a good time for academic science to give support and attention to the new roles that school science and undergraduate science might play.

Systemic competing demands

At this very time, two very different curriculum scenarios are being played out. Neither has taken seriously into account the crisis in interest that is our theme at this conference. Both, for different reasons, are unlikely to promote humanistic, contextual learning of science – our best understanding of how to engage more students enthusiastically with science. Indeed, it seems likely that in their own way they may cement in place the view of science that, I am arguing, needs to be replaced.

The first scenario can be found in Tasmania, Victoria and Queensland (and in New Zealand). In each case, decisions have been made to rethink the whole curriculum so that it reflects the demands on education for skill learning, that arise from the changing nature of work and from the revolution in information, the Knowledge Society.

To make room for a number of these new learnings, the customary content of a subject like science has been paired down to a smaller set, graced with the title 'Essentials' (although without clear criteria of essentialness). This is not to say that science teachers are excluded from contributing to the teaching/learning of the new priority skills, that in each of these new versions of the curriculum for schooling, appear in terms like Thinking, Communicating, Rich Tasks, Higher Order Reasoning and Problem Solving. These are like foreign language terms to science teachers, whose forte has been transmitting Established Knowledge (with just a dash of Science as Doing).

The second scenario is the National Consistency Project of the Commonwealth Government to which the states have been coerced to join to be eligible for federal funding. In this project, science is one of five areas in which a core of knowledge is being specified for teaching in a sequence that has checks for learning at Years 3, 5, 7 and 9. This project seems to ignore completely the new skills of first scenario, and has chosen conceptual scientific knowledge as its core content for emphasis. By not prescribing phenomena or contexts to be commonly studied, the Consistency Project misses the fundamental characteristic of scientific concepts, namely, that they only exist because they have phenomenal (contextual) meaning. It also misses what could be a very justifiable and more engaging approach to consistency, namely, that all young Australians should study science-based issues (contexts) that impinge strongly on their lives as they move through the compulsory years, such as obesity, water availability, energy conservation, biological, chemical and nuclear weapons of mass destruction, and safe sex are just four of these key issues in Australia, with genetic engineering, nano-technologies, communication technologies also of significance.

My final concern about these systemic constraints is that should they become the basis for state-wide or national assessment, they will destroy the chance PISA has now shown us about making assessment, at last, authentic to science curricula that are aimed at increasing student interest in science and in the careers that science involves.

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