# Proceedings

## Raising Questions: the Why? Who? What? & How? of Science. Why Should Science be part of the School Curriculum?

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Science is a human endeavour through which we try to make sense of the world. It can be a source of wonder and delight; it can provide the basis for a greater personal sense of competency in a world increasingly dominated by science and technology and can lead to more secure and abundant living.

Science is also used instrumentally, as a basis, together with associated technology, for national (or corporate) wealth and development. This can lead to 'choice for use' and to an élite, academic science for 'scientists' and a limited science for trades, with gender differentiation based on cultural expectations of males and females.

Science can also be used exploitatively. A new pre-university physics syllabus in Queensland, Australia, starts with preamble: 'Physics enables us to control the world'. In this we find the WHY of physics based in the greater power it affords to humans, to control and manipulate materials and events. This can lead to exploitation of the natural environment, the world becomes less safe, the powerful live more plentifully but the disadvantaged may suffer greater deprivation.

The WHY we have in mind when we design science curricula and present them for learning will inevitably influence the mind-set of our students. It is essential that we think through and can justify, morally and ethically, the WHY of science.

**WHO should participate in science education?**
If science is a human endeavour, and so part of our cultural heritage, we have no right to exclude anyone, by expectation or by curricular manipulation, from the delights and the greater sense of competence that its study can bring.

If science leads to skilled and relatively well-paid employment, again we have no right to exclude anyone by expectation or curricular manipulation.

**WHEN should science education begin?**
Science should have a secure place in the primary curriculum. Exploratory science fosters and develops the natural curiosity of the child. It contributes to the development, not only of skills useful in the study of science, but also of language in communication and mathematical skills of classification, ordering and pattern-making.

**WHEN should science education end?**
In a democratic society, where the culture is dominated by science and technology, it is essential that its citizens feel competent to contribute to decision-making about their uses. This requires facilities for adults constantly to update their understanding of science and technology. I have been working in the UK with COPUS (the Committee on the Public Understanding of Science) and the National Federation of Women's Institutes to break down barriers that separate most women from science. On September 10th, 1996 the new structure of Regional Science Coordinators and County Federation Science Representatives for Women's Institutes was launched at the British Association's Annual Meeting.

So-called cognitive tests from many parts of the world suggest that there is no built-in cognitive difference between males and females. This means that if there is gender bias to the male in the recruitment of scientists, science will be deprived of talent and a national economy will suffer. Moreover, a gendered society maps different characteristics and experiences on to females and males. The characteristics of nurturance and social responsibility ascribed to women will be largely absent from the pursuit of science.

The WHO of science as a human endeavour needs the whole range of human resources for its development, and requires the response 'SCIENCE FOR ALL (from the cradle to the grave!)'

**WHAT should go into the science curriculum?**
The content of a science curriculum in compulsory schooling depends on the objectives accepted for science education. I firmly believe these to be 4-fold:

1. to lay foundations across all the sciences on which life-long-learning may build;
2. to provide the challenging and rewarding experiences of exploring the natural and manufactured world that will lead to personal commitment to continued learning;
3. to develop skills, to expand and extend knowledge;
4. to reflect on the nature of science and its social implications.

The processes of practising science (such as observation, interpretation of data, data analysis, the design and evaluation of an investigation and how these vary from one science to another) should form an important element in the curriculum.

The question of the knowledge component in the foundations laid in schooling has to be negotiated. There is a tendency for the content of science curricula to expand at an alarming rate as knowledge extends. 'Pruning' has to take place within an understanding that what is presented is not exhaustive. To make sense of the world around us needs foundations in not only physics, chemistry and biology, but also earth science and astronomy. Real problems presented to the scientist know no subject boundaries. This leads me to support a broad and balanced science course for all throughout compulsory schooling. Later, the student may specialise with higher education or a trade in mind.

The WHAT of Science should recognise the vital role science plays in the world of today.

**HOW should science be presented for learning?**

To establish personal commitment to science it is important to demonstrate its relevance to the student's current interests and concerns.

The literature contains many accounts of successful learning in science. I will illustrate using examples from primary, secondary and post secondary education.

A 7 year old boy was 2 years behind in reading, but a perceptive teacher noticed he gravitated to the science table and played with batteries, wires and bulbs. On questioning him, it emerged that the boy's father worked as a technician with an electricity company. The teacher began to lace simple instruction cards by the equipment. It became important for the boy to read them. In 3 months he had caught up on reading and science was his favourite activity.

The students in a mixed secondary class were required to keep a science diary within an integrated science course. This enabled the teacher to identify the topics of main interest for each student. Individuals became recognised as 'experts' in their own topics. If a question arose in class it was referred to the 'expert' who researched it with support from the teacher. Girls as well as boys were listened to with respect by their peers.

A Level 1 BTEC physical science course (roughly equivalent to GCSE 'O' level) recruited young women returning to education with little science background. Eighty per cent dropped out of the traditionally taught class. A newly-appointed woman head of department reorganised the course around modules, each entered through a question relating to health care (e.g. Does it matter how high the drip-feed bottle is placed?). Responsibility was passed to the next intake of students to seek answers using references to the same standard textbooks used before. Collaborative and mutually supportive learning was encouraged. No students failed the module, although personal circumstances caused two students to withdraw from the course.

The Salter's Chemistry Course of the 1980's which was based on the everyday experiences (extended by the media) of young teenagers, has had phenomenal success. It has been followed by an A level course and a Salter's Science Course based on the English National Curriculum.

In the early 1980s also, assisted by graduate student teachers, I developed a 'Chemistry from Issues' course which started from issues where our use of materials (chemicals) hit the headlines. It generated considerable interest among local teachers in whose schools the students trialled the modules. (A workshop on this approach was presented later in the Forum).

The HOW of science will determine the level of personal commitment generated. It should start from where the student is.