Symposium:
Research in science education: Enlarging the vision

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This symposium, to which this paper is the first contribution, is an attempt to review science education as a field of research, to identify its principal features, strengths and weaknesses, and to examine its relationships with educational policy and practice. It will argue that science education as a field of research has been understood in terms that are too narrow and that a broader, enlarged vision is needed.

This paper will review the research that has been done in science education during the past 30 or so years. It will examine work published in a number of leading international journals and attempt to assess the impact of some of this work on educational practice. It will argue that, while the emphasis that has been placed on the development of students’ understanding of scientific concepts is understandable, such emphasis has had a number of undesirable consequences. For example, it has led to the relative neglect of other fields of research in science education and, arguably, done much to ‘define’ science education research in terms that are narrow and unhelpful. It may also have led, in some contexts, to an over-hasty attempt to translate findings into reformed practice.

The ‘definition’ of science education as a research field is important for several reasons. It affects the status of the field, its appeal to prospective researchers and the research training and support offered to them, and its relationship with other fields of research, most obviously science itself. It must accommodate tensions between different research paradigms and can, all too readily, exclude from conversation and dialogue researchers who would not regard themselves as science educators although their research is important to those whose professional responsibilities are with teaching and learning. A further point is that the kind of research undertaken in science education shows strong historical, cultural and institutional influences. These various issues and influences need to be better understood if research in science education is to develop a truly European dimension.

Finally, this paper will suggest some of the dimensions of a broader perspective on science education research, and, in so doing, serve as an introduction to the remaining papers to be presented in the symposium.
Policy-related research has many forms. I propose to take a very particular section through it. One of the key strands in policies towards science education is curricular definition. I will focus on this issue from broadly three perspectives:

- how ought the science curriculum be delineated at a national level?
- what ought the curriculum to contain?
- how do such questions relate to the professional authority of teachers.

My first theme is significant because of the relative lack of attention given to it. How should curricula be specified: by outcomes? by detailed ‘schemes of work’? by licensing of textbooks? What are the consequences of such decisions? It seems to me that little is known at a comparative level about these issues. Certainly the ‘technology’ of curricular specification in England and Wales was developed (and altered) more or less at random. Yet the forms it took were highly significant for the meaning of the curriculum and the implementation of policy, and the social relations of science teaching. We have a here a technology of control which merits greater attention.

To describe some of the writing on my second theme as ‘research’ is perhaps mistaken, though there is certainly a lot of it, evaluating what is and considering what out to be. Such writing is essentially ‘theoretical’ and a priori, though demonstrating some consensus around what the key issues: rationalizing content, giving attention to the large majority of pupils who will not become professional scientists and providing tools to engage with the controversial and problematic in the contemporary practice of science. By contrast, TIMSS and associated work (such as that funded by the OECD) has produced a range of research findings sceptical of what has been achieved in the drive to address these and associated issues. Change and how to promote it is the guiding theme. The underlying position which is adopted is commonly that, while change is not merely desirable but essential, the history of attempts to change the curriculum shows limited success. (Cuban, 1993; Black and Atkin, 1996; Raizen and Britton, 1997a and b; Schmidt, McKnight and Raizen, 1997) Work on attempts at reform in the UK present a related picture, though with a different emphasis. (Donnelly, Buchan, Jenkins, Laws and Welford, 1996) This brings me to my third strand.

Teachers occupy a somewhat uncomfortable position in such writing, and the policy processes which it aspires to influence. Teachers constitute (do they not?) the key location of professional expertise. Yet they are also construed as a major barrier to change and the target of reform efforts. Here is a not unrepresentative statement of the reform project.

Teachers must learn about constructivist learning and identify teaching strategies which encourage real learning. They must turn their teaching into a science where questions are raised and answers sought. (Yager and Weld, 1999, 175)

However one judges the aims, the tone is authoritarian.
Teachers are perhaps the single most important vehicle by which the emphasis on pre-professional scientific training is maintained, because what they have primarily experienced is such training. Writing which acknowledges seriously (rather than sentimentally) the authority and expertise of science teachers and its relationship to agendas of change is rare indeed. (Olson, 1991)

My three themes interpenetrate and my ultimate questions are: when will ‘we’ (by which I mean those who undertake research into teaching) come to terms with honestly understanding the practice of science teaching as it is commonly practised, before attempting to change or control it? What theoretical tools are available for this purpose? And what is the legitimate relationship between science teachers and those who research their work and would change their practice?

References.
Challenges for science education in Europe.  
Or: Why do they turn their backs to us? 

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The meagre grasp of the meaning of scientific concepts among pupils as well as the general public has been well documented. Many science educators define this as the most important questions that science educators should address -- and they do so, often from a cognitive psychological point of view. But maybe the observed 'ignorance' is a mere surface phenomenon, and that other questions need to be addressed. In the paper, I will try to outline some of these challenges and suggest tentative ways of looking at them. The challenges may be described in terms of some well-known paradoxes:

We live in a society that is driven by S&T, and permeated with S&T-based artefacts and processes. Young people seem to have an extreme (and uncritical?) willingness to use (and over-use) the new technologies (pc's, internet, cellular phones, digital sound and video etc.) The paradox is that -- at the same time -- we experience a lack of interest in science subjects in schools, and a falling recruitment to tertiary studies in many S&T related areas. We want to use the new science-based technologies -- but there seems to be an unwillingness to study, probe, and understand the science behind the development. How do we understand and face this paradox?

In spite of the openness towards using new technologies, there is a growing distrust in science and technology -- and a parallel growth in the belief in 'alternative' ways of seeing and interpreting the world. What are the reasons behind the distrust? Is the distrust and scepticism grounded in ignorance -- or is the distrust well founded, based on an understanding of the 'real nature' of how R&D operate in its 'post-academic' phase?

Critics inside science as well as from the outside has in recent decades raised serious questions about science as an activity as well as scientific knowledge in itself. Sociologists, feminists and a host of post-modern critics have raised serious questions about the objectivity and neutrality of science. The theories as well as the ideals and values of science are being questioned. To which degree has this critique of science become part of the public 'understanding' of a possibly changing 'nature of science'? How is this challenge met by the science education community? How is the recent criticism of science faced in textbooks and curricula?

Science is under attack and criticism from many positions and different perspectives. How do we as science educators face these challenges? What kind of critique do we accept and incorporate -- and where do we have to defend science and fight back? These are important debates -- neglecting them is dangerous and damaging.

Modern science and technology also challenge the limits of what many people see as legitimate questions for science to deal with. Physicists have the ambition to develop a "Theory of Everything" -- and biologists are seen as "Playing God" in their research on gene manipulation. Many people react to these and other trends in modern science. They react emotionally and morally towards these trends -- and they do not feel comfortable with the often arrogant way the scientific community meets these challenges.
In the past, the perceived proud history of science attracted many young people. Science was seen as antiauthoritarian. The scientists could be seen as radical people who challenged myths, religion and authorities and who replaced superstition with human dignity and rational thought -- often at great risk. Science was seen as liberating, both at the intellectual level and at the material level through its use to develop new technologies, medicines etc.

But this public image of science is changing. Rather few hold on to these images of an objective, positive and neutral scientist who acts to the benefit of mankind. Many see present science not as antiauthoritarian, but rather as an authority itself. And not as a challenger of power, but as allied with the power, be it the State, The Military or Industry. They also find that S&T produce more problems than solutions.

Modern science has lost its positive and unproblematic image -- although many textbooks and curricula try to hold on to it. Can we restore the lost heroic image of science -- or is the emerging new image based on a real understanding of the new role of science in modern society? What is the real role and function of contemporary science -- and how should it be reflected in a modern science curriculum?

The above dilemmas and challenges may be faced or considered in many ways. By reflection and debate -- and of course informed by empirical research (enrolment patterns, attitude research etc.)

Comparative, international studies may shed light on this and provide new insights. What are the causes, and what are the possible remedies? To what degree are the challenges common to many countries, to which degree are they different? Is this an unavoidable consequence of scientific and technological ‘progress’?

Many comparative studies like the large-scale IEA projects (TIMSS) provide rich empirical data, although the emphasis is on academic achievement measured by means of a universal standard. Such studies should be complemented by more interpretative, discursive approaches.

From a European perspective, this may be an interesting field. Europe is small in size, but rich in cultural variation. But an even wider perspective is necessary: Asian countries, Africa and other developing countries should be included to contrast eastern and western, rich and poor countries. There is evidence that the perceived or public image of science is very different in different countries. Will science in poor or emerging countries lose its high status when people see the fruits of ‘development’ -- like we have seen in the North?
Breaking the Spell: Science Education for a Free Society

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The problem. In the past, science education has been under the spell of scientists. Science educators and science teachers have subserviently done the job that scientists wanted them to: reproducing a sorting system and existing inequalities (Roth & McGinn, 1998). This spell is especially evident if we look at the science education from another domain interested in how scientists work and how they construct new knowledge: science studies. Sociologists, anthropologists, feminists, ethnomethodologists and others interested in science have shown both the ordinariness of scientific practices and, at the same time, the rhetoric and politics of scientific communities that attempt to reserve themselves special places in society and a maximum of financial resources (Fuller, 1997).

Despite all the curriculum reforms over the past four decades, science education has, at its core, remained the same. Few people come to know science in the scientists’ way (Fuller, 1997). This despite science educator’s central goals of inculcating scientists’ science to future generations. There “bare facts” (in Canada and US) are that 25% of students never complete high school—rising in some areas such as Newfoundland to nearly 50%. Of those who complete high school, a certain number continues on to college and university. Only a small number, about 5% actually enter careers in which they need to know scientists’ science to a lesser or greater degree. Few people ever come to appreciate or like this form of science which is taught in ways elitist, destined to shake people out of the system, and almost as a career preparation in science itself. Furthermore, many people develop little understanding of or about science. That is, all our efforts in teaching science were wasted—thinking otherwise is an illusion which readers can easily found when they begin to ask around in their neighborhoods to find out what people generally know about scientific knowledge, literacy, and the nature of science.

The questions. I therefore raise some serious questions such as, “Is this the kind of science we want to teach?,” “Do we want to continue to use science education as a career selection mechanism or do we want science for all?,” and “What would be an appropriate science for all?”

The argument. I draw on four different kind of discursive resources in support of my argument that we need a different kind of science education, a science education as/for sociopolitical action that has as central goal the betterment of the world for example, via a philosophy-of-wisdom inquiry in which the discourses of music, literature, drama, politics, science, religion, and philosophy are treated at the same level (e.g., Maxwell, 1992).

First, research on everyday cognition shows that there is more to knowing than facts and skills (e.g., Lave, 1988). A much more appropriate ontology of everyday cognition includes: standard practices, material resources, linguistic resources, breakdowns, and on-going concerns. A comparison of examples from each of these categories with traditional science education shows that it is concerned only with some, linguistic (but decontextualized) resources and perhaps some standard (but so highly routinized as to be laughable) standard practices. Students never get to
know about the on-going concerns, and never engage linguistic resources in the service of some authentic goal to be achieved, and never get to engage in the practices of scientists or any other science-related field.

Second, research in science studies shows that people who identify with some genuine cause—activists for various causes such as environment, AIDS, medical treatments—engage science such as to change its very nature (e.g., Epstein, 1996). That is, the nature of scientific experiments, who is to participate as subject, how controls are to be instituted, and so on is negotiated between scientists and activists, often in the forum of legal courts. That is, without scientific training (indoctrination?), these groups engage science in a socio-political process and thereby shape what science is and how it is done.

Third, my research on students’ interpretive resources rallied to underpin their epistemological, ontological, and sociological claims about science and knowledge more generally showed that there is much to be gained by engaging students in epistemology as practice (e.g., Désautels & Roth, in press). Those students who begin to reflect on the nature of knowledge, how it is represented, and who investigate the nature of science textbooks, develop a critical attitude toward the unreflective and indoctrinatory presentation of science in schools (“Textbooks are like the bible. You have to believe in the truth of their basic assumptions” [TA]). It is not that these students begin considering science as useless, but they begin to question its status in the society, the nature of its claims, and the texts it uses to reproduce itself.

Fourth, our on-going research in a local community where environmental activists, farmers, local residents, school children (middle, high school) each take an interest in one of the watersheds in which their community is located (Lee, Roth, & Bowen, 1999). Our research shows how people enact science education in and out-of schools, they learn science not for its own sake, but because they are interested in the goal of making the community a better (ecological) place to live, and to preserve (and restore) the watershed so that it can survive as an ecological whole.

The resolution. Drawing on these four areas as interpretive resources, I will argue for a science education as/for sociopolitical action which constitutes a further development of arguments made earlier (e.g., McGinn & Roth, in press; Roth & McGinn, 1997; Roth, 1998). Rather than thinking about science education in terms of scientific knowledge worthwhile on its own, I propose that we think in terms of worthwhile purposes which we, as science educators and science teachers, pursue with the school children in our care. These purposes cannot be argued for from within science, but are related to the values we hold. Values are matters of choice rather than logic. Concomitant with these new goals for science education, teachers need to be concerned with engaging students in epistemology as practice. In this effort, then, science is an exemplar of solidarity rather than one of rationality and objectivity (Rorty, 1991). Such a new and differently conceived science education provides a context for educating future generations in a society free from the spell of science, but which nevertheless draws on science to deal with the ecological and technological challenges it will face. Scientific literacy might then be defined in terms of knowing about the right use of specialists, scientific blackboxes, simple models, interdisciplinary models, metaphors, standardized knowledge, and translations, negotiations, and knowledge transfer (Fourez, 1997).
References.