The Curriculum of School Science

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Abstract

In the 1960s school curriculum development took on a quite new form. Particularly for science education, many large projects were established to produce what usually turned out to be a 'package' of curriculum to be implemented by teachers in the classroom. There is currently another reform of science curriculum in progress internationally. The notions of how to effect curriculum change have altered substantially and less emphasis is now being given to the production of 'packages'. Five sources of influence concerned science teachers, academic scientists, political and economic comparisons, theories of teaching and learning and philosophical ideas about science and science education are obvious in both periods although their concerns and directions for reform have changed.

Introduction

Science education and particularly the way its curriculum was conceived underwent a very major reformation in the period from the late 1950s to the early 1970s. The early initiatives of what was to become an unprecedented concentration of human and other resources on curriculum development began in the U.S., largely under sponsorship of the National Science Foundation, and in Britain where the Nuffield Foundation played a similar role.

Many other countries followed these leads, sometimes slavishly, by simply importing these curricula under a new form of educational imperialism. In most cases they have, some years later, developed indigenous responses to their own particular national demands for up-to-date and better science education in school.

The 1970s was a quiescent period as far as curriculum development in science was concerned, and indeed increasingly became a decade of malaise and disappointment as evidence accumulated that many or most of the hopes and good intentions of the reformers were not being achieved in schools. Beginning in New Zealand in 1979 and spreading to more and more countries as the 1980s proceeded, there is now a new wave of science curriculum reform. While not on quite the same profligate scale as the previous reforms, the resources being put into the current interest in school science are sufficiently large for it to be compared with the earlier efforts.

Sources of Curriculum Influence

Five sources of influence on the curriculum reforms of the 1960s have been identified. All of these have reappeared in the current situation although they now present quite new messages and exert different pressures. In addition, at least six new sources of influence are now discernible.These influences are :

1960s and Present	**Present**
Concerned Science Teachers	Science educator and their research
Academic scientists	Evaluation of the 1950s/60s curricula
Political and economic comparisons	Historical and sociological analyses of curriculum
Theories of teaching and learning	New groups of learners
Philosophical ideas about science and science education	Measurements of educational achievement
	Community and internal movements

This paper considers the five common sources and identifies the nature of their influence on the curriculum of school science.

In the 1950/60s the five influences were generally seen to be co-operative. This spirit of partnership can be summarised in a somewhat simplistic way as follows. The concern of science teachers for the state of the school curriculum gained support from the political and economic comparisons so that decisions for serious reform were made. Academic scientists provided prestige and interest to the curriculum projects and worked with science teachers (usually the more academically well-qualified) to produce new curriculum materials.

The nature of science and its contemporary forms of expression in academic disciplinary science became the intended learning content of these new materials, and it was presented in ways that tried to be faithful to ideas about how learning occurs.

Slowly, as contradictions and disappointments about the implementation of the 1960s sciences mounted, a new view of these influences has developed among informed science educators. If there are, as has just been indicated, a number of different societal interests about the science education that schools provide, it would be surprising if all will be equally well met. Indeed the probability is that the curriculum of a science education that meets one or several of these interests will not serve the others. Recognition of this probability, unfortunately, is still quite rare in the official reports and public policies of the 1980s as it was in the 1960s. Without it, some critical implications for science curriculum are likely to be missed in decision-making for the current reforms in science education, just as they so largely were in the development and implementations of the 1960s reforms. Hodson (1987) has suggested that each proposal should be subjected to a scrutiny that reveals the underlying socio-political motivation of the interest groups. Whose views of science, whose interests, and whose view of society are being advanced?

Concerned Science Teachers

In the earlier reforms the leaders in the science teaching profession and those teachers who had been more recently trained in universities were very conscious of how 'out-of-date' school science curricula were. In the current case it is not so much the 'out-of-dateness' of today's science curricula that concerns leaders in the science teaching profession (science teachers associations). Rather their concern is the inappropriateness of these curricula if science at school is to be a worthwhile educational experience for all students (Science for All) and not just an education that serves a minority of students only. Many science teachers do, however, take a more conservative view of their subjects and are comfortable with the existing curricula and their elite groups of students in the upper secondary levels. These curricula are essentially still of the 1960s type with some very minor changes that recognise applications of science. They are consistent with the conceptual sciences these teachers studied in higher education.

Academic Scientists

Prominent university scientists played a leading and encouraging role in the 1960s projects. They exerted a crucial influence on the sort of science content that was included as worthy of learning. They were important legitimators of what topics and what sort of account of them were appropriate for school science. Their exercise of this role did vary in relation to different sciences (Fensham 1980) and was more constraining in the physical science than in the biological and earth sciences. In all cases, however, it turned out that the school curricula were brought more up to date with the conceptual emphases of post war first year teaching in universities than they were with the frontier topics and questions of the sciences in the 1960s.

Although they were more directly concerned with the curriculum for the later years of secondary schooling, the strong sequential assumptions about scientific knowledge and the preparatory role, which one year of schooling plays for the next, ensured that this influence had effect at all levels of science curriculum.

The most general concerns expressed by university scientists in the 1980s have been quantitative ones. There is concern that not enough students are coming forth from schools to continue advanced studies in scientific and technological fields. There is concern that fewer of the high achievers in school science are choosing to continue studies in science. There is concern that the proposals to reshape and redefine the science curricula in schools in ways that suit Science for All will mean that less time is devoted to traditional topics in chemistry and physics. These sorts of concerns, on the whole, have acted as brakes on reform of science curricula rather than spurs for it.

Some academic voices have been critical of the content of school chemistry and physics. Gillespie (1976) in Canada and Bucat and Cole (1988) in Australia are typical of one set of these voices. However, they are not calling for the inclusion of the many exciting new sorts of substances chemists have made and discovered in recent years. They are concerned about the emphasis the 1960s reforms put on general concepts and abstract principles to the exclusion of familiarity with chemical reactions, and with field and laboratory experiences. They do encourage knowledge and experience of the role of chemicals in applied areas like foods, building materials, and consumer products, but on the whole they seem to conceive of these applications in terms of simple and basic chemicals that have long been part of school chemistry rather than in terms of newer substances with quite novel properties.

A few exceptions can be noted to the claim above that there are examples in the current reforms of the scientific community of a coherent voice calling for new approaches to science education. The Royal Society (1985) in Britain produced a short and startling manifesto, *Science is for Everybody*, in a report on the public understanding of science. A proper science education at school, it states, must provide the basis for an adequate understanding of science which is then to be added to throughout life. This understanding includes not just facts but the methods of science and its limitations as well as an appreciation of the practical and social implications. The manifesto claims that some understanding of statistics including ideas of risk, uncertainty, ratios and variability are so intrinsic to the method of science and to understanding many personal and public issues, that they should be goals of all science curricula. This manifesto calls for a very different sort of curriculum for the whole of the school population. It thus gives strong support for Science for All.

Political and Economic Comparisons

The onset of the reforms of the 1950/60s in the U.S. and in Britain is often ascribed to the cold war and the launching of the first Sputnik by the U.S.S.R. in 1957. In fact, the significant lobbying for the reforms had already occurred, so that it was more general aspects of international comparisons that were influential in the decision to reform. Nevertheless, the belief by politicians, military leaders, business and other societal leaders that scientific progress and technological development, in some senses, was ahead in other competing countries (politically and economically) contributed to the level of support that these reforms enjoyed. Inter-country comparisons at these same levels of political and economic leadership have likewise fueled the current reforms.

In country after country, the 1980s have been punctuated by statements by prominent societal spokespersons and by reports on the state of the nation that urge for more and better science education. These reports almost always now refer to some research findings that present new comparative data or a reworking of existing data on science participation and achievement. In this sense they differ from the more polemical comparative statements in the 1950/60s. The research the reports present or represent are, however, constrained by the terms of reference of the review and or the biases of those responsible. To command attention these reports often make use of sweeping rhetoric: "Our children could be stragglers in a world of technology in which technological skills and sophistication are the basic capital of tomorrow's society" (National Science Board 1983), is a typical example.

The two broad aims that were referred to in the curriculum reforms of the 1950/60s - a scientifically based work force and a scientifically literate citizenry, are both now regular targets for these reports. The former tends to be assessed as having been met with varying degrees of quantitative success. The *quantity* of the technological work force is now, however, seen as a necessary but not sufficient condition for a healthy society. Equally important and not being achieved is the *quality* of this work force's ability to address problems of national significance, and to incorporate science and technology into the life of society without destroying its culture. The second target is assessed as having been addressed only incidentally thus far and accordingly, these reports now give it a much greater priority than it had in the 1960s.

Psychological Theories of Teaching and Learning

Conceptions of teaching and learning as psychological processes have been recurrent influences on curriculum reforms. They were certainly prominent in the projects of the 1950/60s. Piaget's name can be associated with a number of the British projects and with some elementary school projects in the U.S. Gagne's more behaviorist views were overtly influential in other American elementary and junior high school projects, and in Britain's School Council Integrated Science Project, while Bruner's ideas of discovery learning, generalising concepts, and readiness to learn were espoused by a number of senior secondary projects.

It is interesting to note that the translation of such general theories of teaching and learning into curriculum materials for the teaching of science always resulted in considerable slippage. Between the theory and the preparation of materials for learning there were many opportunities for the influence to weaken, and even more between the materials and classroom practice. These theories were also developed largely from experimental studies in psychology that were divorced both from social contexts like classrooms and from the content of science.

Of the theories that were influential in the 1950/60s only that of Piaget still has much explicit currency. In the sense of the association between thinking and experience, the idea of emphasizing concrete, hands-on experiences with younger learners has widespread recognition in science curricula and in its practice. In the sense of how these experiences can be used to develop logical thinking about natural phenomena, only a few curricula are consistently maintaining and exploiting this emphasis.

The most conspicious psychological influence on curriculum thinking in science since 1980 has been the constructivist view of learning. In the 1970s, research studies in science education began from several different directions to explore how students at school conceived of various scientific phenomena and of concepts such as force, life, electric current and solution, that science uses to describe and explain them. Studies of how students viewed science teaching and learning followed and now there is great interest in teaching approaches that (a) take seriously the conceptions students already hold about the phenomena and concepts of school science topics and (b) encourage the construction via a reconstruction by the students themselves of new meaning via reorganisation and linkage to what they already know. Interest in these and other metacognitive processes are now also finding expression in science classrooms along with many novel constructivist pedagogies.

Philosophical Ideas of Science and Science Education

Philosophical influences were prominent in the 1960s. In Britain the heuristic ideas of Armstrong at the turn of the century were often referred to in the Nuffield projects (Jenkins 1979). Dewey's ideas of "learning by doing" had a parallel historical influence in North America. Especially in relation to the successful biology projects, Schwab (1962) provided a direct and powerful input from the philosophy of science to the project teams of the Biological Sciences Curriculum Study (BSCS). He argued that the nature of science itself is a process of enquiry - a search for cause and effect. To teach science as inquiry, he suggested that two changes were needed in the role of the laboratory. Firstly, a substantial part of the laboratory work should be made to lead rather than lag the classroom phase of science teaching. Secondly, the demonstration function of the laboratory should be subordinated to two other functions, namely, to provide a tangible experience of some of the problems of acquiring data dealt with in science, and to provide occasions for an invitation to conduct miniature but exemplary programs of enquiry.

A different influence from the philosophy of science, was the definition of a set of science processes as objectives for learning (i.e. as the things to be learnt) in school science. The so-called, "process approach to science", with its atomised components of the investigative methods scientists employ, became very strongly associated with elementary or primary education. Initially, and in Bruner's (1965) recommendations in *The Process of Education*, they had been advocated as essential components of the content of science to complement and to give a dynamic thrust to the otherwise potentially sterile body of facts and conceptual knowledge that was now being seen as appropriate for school learners. Bruner also advocated that engagement in these processes was a good way to learn science.

In the struggle, however, to apportion the new ideas about what the content of school science might be between its traditional place in secondary education, and the pressure for it also to be part of the curriculum of the earlier years, a quite unphilosophical dissection occurred. Stated a little crudely but without much exaggeration, the elementary or primary curriculum got the processes and the secondary curriculum retained the content of science which was now much more conceptual and less factual and descriptive.

Different philosophical perspectives are now challenging the way these earlier ideas should influence the science curriculum. For example, Hodson (1988) has refined Schwab's earlier work on *Science as Enquiry* by pointing out differences among the enquiries in science. Each one arises in relation to specific subject matter and the essence lies in the sorts of concepts, data and questions that are employed. Millar and Driver (1987) have also pointed to this interweaving of phenomenon, concept and process. Lybeck (1981), in his study of the teaching and learning of Archimedes principle, has provided a splendid example of the point Hodson is making. In an earlier paper Hodson (1985) used a philosophical basis to identify a number of distinct learnings in science education. If these distinctions are not to be blurred or lost, he argues that each needs a definite "space" in the curriculum so that students recognise it for what it is and have enough practice with it. Horwood (1982) uses Robert's (1982) idea of *curriculum emphasis*, to argue for a similar approach, if coherent messages are to be received by students about the nature of science that many curricula do intend to be taught. Jenkins et al. (1988) in their STSC Chemistry set out to provide this sort of curriculum space for each of their emphases: "science, technology, society and communication".

Millar and Driver argue that current understandings of the philosophy of science deny a special connection between the primary science processes and science. They are concerned about the predominant place many junior science curricula have given to science processes compared with science knowledge content. They also point out that the process view does not correspond with the way science knowledge is learned and stored in the minds of students or of scientists.

In a subsequent paper I would like to discuss the new influences on science curricula and how these interact with the ones that have been described here.

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