J. CURRICULUM STUDIES, 1993, VOL. 25, NO. 1, 53–64

Academic influence on school science curricula

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Some years ago I interviewed a number of persons who had been involved in school curriculum development projects in the sciences in Australia, USA, Israel and Britain. One of my questions was: What ideas for science content and/or for teaching a topic did the project team have that they were subsequently discouraged or prevented from using? After this question was clarified, and after it was recognized as a serious research question, and not as a threat to national or team loyalties, in each case my respondents were able to instance a number of examples of what I had in mind. In this minor study I was not exploring the revisions that project teams make to their ideas and drafts as a result of trials in schools or in response to formative evaluations. Rather, I was seeking to see whether these project teams had had experience of academic reactions to their ideas which negated what otherwise might have been a fruitful development.

My interest in the question of academic influence stemmed from experiences I had had as part of a group developing *Physical Science–Man and the Physical World*, curriculum material for a new single-science subject for the final year of secondary education in the state of Victoria, Australia. We had encountered a considerable number of attempts at *academic control*. For example, although the existing physics and chemistry courses were already 10 years old, our attempts to introduce topics of contemporary interest, such as *efficiency in the use of energy*, *sound and music*, *structural and mechanical properties of alloys*, *ceramics and wood* were strongly restricted on the ground that they were not included in physics or chemistry, or that they were inappropriate because they were 'university level' topics.

About the same time I was aware of the emerging discussion and analysis of the political nature of curriculum. The work of scholars such as Young (1971), Layton (1973), and Waring (1979) in Britain, of Bourdieu and Passeron (1977) in France, of Gintis (1972) and Apple (1979) in the USA, and of Roberts (1982) in Canada provided frameworks for the observations of academic influence I, as both an academic chemist and a science educator, have been able to make during my years of participation in the Victorian scene. This paper reports some of these observations and my interpretation of them.

These data and their outcomes are quite often recorded in the minutes and working papers of the committees that have been responsible for various curriculum projects. At other times they are recorded in notes I made at the

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time, or are my memory of the events as a participant observer in them. (The validity of these second sorts of data could be established or refuted by checking with others who were present, since I am concerned here with public events and not private encounters.) The interpretations of the data are, of course, my own and there is no doubt a number of them would be corroborated by some witnesses and denied by others. The meaning of the events as socially constructed knowledge will vary from individual to individual.

The data for the discussion of academic influences in this paper are the contributions that academic scientists and academic teachers have made in the developments of curriculum for the study of the sciences in senior secondary schooling in the State of Victoria, Australia, and actions they have taken in response to these changes.

The scope for influence

Since 1966 in Victoria it is only the curricula of the last two years of schooling, Years 11 and 12, that still have been subject to structures that have formal influence state-wide on what happens in school science. In the Australian context this sort of influence is very substantial. The assessments of students' achievements in these curricula is the primary and often the only basis for their selection into universities. Most critically, they determine the very competitive admission to such attractive and prestigious professions as medicine, law, engineering, etc, which are studied in Australia as undergraduate programmes. Below Year 11, the official position concerning curriculum, since 1966, has been that this is the responsibility of individual school councils within very broad guidelines provided by the state ministry of education. This degree of decentralization for curriculum decisions is not uniform across the Australian states, a number of which still retain more of the centralism that was the pattern in all of them prior to 1966.

Although this paper is not concerned with academic influence on the science curricula in the lower secondary and primary years, it could be argued, I believe, that its effect is still very considerable although the mechanisms for its operation are less direct and more complex. To discuss these in any detail goes beyond the scope of this paper, but the assumption about the sequentiality of scientific knowledge (and hence the strong senses of 'preparation' or 'prerequisite knowledge' that lead to the influences here discussed) has obvious extensions downward from whatever is decided as the science to be learned in Years 11 and 12.

The sources of academic influence to which reference is being made here are academic scientists in universities and academic science teachers. By academic science teachers I am referring to those science teachers who have been so socialized by their own scientific studies in higher education that their conceptions of their subject for schooling conform to the knowledge content they were taught and learned in university or college. Since most science teachers in Victoria are recruited straight from higher education, many of them have had no opportunity to experience science other than through their undergraduate studies. Only a few teachers have research degrees and probably even fewer have worked as scientists outside education. Those who have often display quite different responses in curriculum debates and implementation.

Victoria happens to include some unusually strong groups of science education researchers. Their studies have made significant contributions over 20 years to (1) broadening the definition of science so that it might meet the needs of more students at school (gender-inclusive science and Science for All), (2) constructivist approaches to learning in science and (3) metacognition in science teaching and learning. As a consequence, ideas associated with these research groups have been commonly aired among Victorian science teachers for at least a decade. During this period also, science educators, together with teachers who have been influenced by them, have played an increasingly distinctive part in curriculum committees.

Victorian academic scientists were active instigators of the great changes that occurred in the state's senior secondary science curricula in the 1960s. Turner of the University of Melbourne played the leading role in the Australian Academy of Science sponsoring an adaptation of the BSCS *Green Version* which led to the highly successful *Web of Life*. Three faculty members of the University of Melbourne's Chemistry Department were the promoters and part of the writing team for *Chemistry: A Structural View*, a curriculum text that was influenced by CHEM Study; and academic physicists were influential in the decision to adopt PSSC *Physics* for use in Years 11 and 12. Similarly, they gave varying degrees of support to the evolutionary and rather minor changes in these subjects that occurred a decade later when teacher dissatisfaction and a declining student interest (proportionately) in chemistry and physics had become an established feature of what was a steadily increasing participation in these latter stages of secondary education (22% of the age cohort in 1965, 36% in 1975).

There was, however, strong opposition from senior academics at the University of Melbourne, and no obvious support from any of the other science professors in Victoria, for a novel subject at this level, *Physical Science*, which was developed in the mid-1970s. This subject had been naively planned to be a contribution to the problem of declining interest in the physical sciences mentioned above. If students were not willing to devote the great majority of their last two years at school to mathematics, physics and chemistry, the traditional preparation for the scientifically based faculties at Victorian universities – science, engineering and medicine – perhaps they would take a single subject that could somehow embody the essential learning of physics and chemistry.

The lively team charged with developing this new subject soon began to see their task rather differently. The education situation in Australia of the later 1970s (multiculturalism, rising school retention rates, a diverse tertiary scene with three sorts of institutions), and the world energy and environmental crises were very different from the context in which the science educational reformers of the 1960s worked. It was not surprising that the team's proposals for the science content of *Physical Science* and its incipient Science/Technology/Society (S–T–S) character were likewise very different from what had become established as senior secondary physics and chemistry in Victoria, following the developments of the 1960s.

These proposals quickly led to the evaporation of support for this development which could, it was recognized, just as well attract students *from* physics and chemistry as it could attract non-science students *to* study some physical science. Substantial hostility to the new course almost prevented its establishment as an accredited science subject. The universities then set up such other structural barriers to it that few schools chose to offer it in the period from 1976 until the current reforms, which, on a more universal scale, are changing the whole pattern of Victorian senior secondary education. (In 1990 the retention rate to Year 12 was almost 70%.)

An account of the academic debate and response to *Physical Science* has been given in an earlier paper (Fensham 1988). It was possible to summarize the directions for change in this science course that were seen by influential figures in the academic community in Victoria as threatening:

When a science course involving the physical sciences

- could compete in attractiveness with physics and chemistry;
- includes science topics or approaches and aspects of the physical sciences that are not included in existing physics and chemistry;
- includes as intended learning outcomes social, political and economic aspects of the interaction between the science content and society, as distinct from their presence merely for contextual or motivational purposes;
- seeks to compete with physics and chemistry for the status that is conferred by being counted in the basis for selection into socially prestigious university courses, such as medicine or engineering.

Grand-scale reform

With both support *and* constraint having been shown by Victorian academic scientists in relation to curriculum reform, the later 1980s provided a very significant context in which to observe the response of academic scientists to the science aspects of the major contemporary reform in Victoria of the whole curriculum of upper secondary education. The need for this reform was widely agreed in educational circles and in the community more generally. The reform followed a large-scale investigation and report on post-compulsory education in Victoria (Blackburn Report 1985). But as soon as proposals for its shape emerged, they were, not surprisingly, hotly debated. Nowhere was the curriculum debate stronger than in relation to science.

One proposal that was quickly squashed was the structural requirement that all students should undertake a breadth of studies that must include English, Australian Studies, Humanities, Science/Technology and Mathematics. This would have meant that the traditional concentration on maths/physics/chemistry (8 semester units of a total of 12 in Year 11 and 8 of 10 in Year 12) would no longer be possible. The structural requirement has now been reduced so that 16 semester units of physics (4)/chemistry (4)/mathematics (8) can still be included in the new total of 24 – maintaining the so-called 'golden 16', the traditional preparation for university science studies.

The present reform is largely concerned with integrating the many fragmentary strands that had emerged in upper secondary education since the mid-1970s. Very different groups of students were staying on at school for these years, and increasing numbers of adults were returning to study to undertake these critical years of education with their guardian roles for higher education and so many forms of desirable employment. Accordingly, the new committees that were established to plan these reforms in the broad curriculum categories known as 'subject fields' were far more representative of these needs and strands of secondary education than were the curriculum committees that had existed hitherto. The latter had had the much simpler task of designing studies for the final years in academic secondary schools to meet the needs of university courses that involved scientific studies.

Academic scientists and the academic science teachers from academically oriented high schools were, indeed, now in a minority on the new Science Committee. This has led to a number of incidents where, having failed to carry the vote in the Committee, academic influence has been exerted at other levels of the organization charged with the overall reform to reject a number of proposed innovations. Although science educators and teachers who were familiar with their research ideas also did not form a majority, their positions were closer to the representatives from the various alternative forms of secondary schooling.

It is not surprising, then, that the early drafts of the new study guides included various attempts to build these ideas into the curriculum statements. The opportunities to include them were quite substantial as the study guides are more than a statement of required and possible content to be covered. They also indicate in each unit a number of *Work Requirements*–learning tasks to be undertaken by students–that stem from a consensus view of what learning experiences are likely to develop in the students the intended aims and objectives of the unit. The multi-faceted assessments that will lead to the 'profile' of a student's learning are also to be based on these sorts of learning tasks.

As these early drafts were reviewed by various groups and tried out with teachers and classrooms, a number of these innovations have been eliminated. In general, the academic scientists have been sceptical or resistant to many of them although it is not always easy to be sure of the dominant negative influence that leads to the final decisions. However, a number of the innovations have survived. For example, *concept mapping* was, until 1985, probably only used in science education as a research tool. In the 1990s it will be a regular experience for all students in chemistry in Victoria.

Some examples of academic influence from the life of this Science Committee will now be described.

Disciplinary or trans-disciplinary science

When the Committee discussed the manner in which scientific studies should be available in the new stituation three alternatives were argued. A minority, including the academic scientists and some teachers, were in favour of disciplinary studies only: physics, chemistry, biology and geology.

Another slightly larger group, including teachers from alternative schools and teachers with feminist and environmental associations, were for no disciplinary studies. The largest group, but not a majority of the Committee, were for a compromise position in which an integrated form of science should be studied by all students in the first semester of Year 11, after which sequences of disciplinary studies would be offered in the other three semesters.

The Committee proceeded on the basis of the compromise – the only position that could command a majority. The compromise had a number of advantages in the local context. One of these was the fact that students would make decisions for chemistry, physics, biology, etc., after a semester of shared study in this now rather distinctive sector of their secondary schooling, and not on the basis of their past experiences of science studies in the earlier years of secondary schooling. It would also give teachers of physics and chemistry a more even chance of attracting students as they would share with biology teachers the teaching of this first semester subject. There was thus a real prospect in the compromise to break the pattern of gender bias whereby girls at the end of Year 10 frequently choose biology, and boys choose physics and chemistry.

It was not long before the academic scientists reasserted their control over this attempt by the wider science education community to tamper with the 'golden 16'. A resolution was pushed through the Board of the overall organization which required *all* studies seeking approval to have the possibility of being a sequence of *four* units. At the same time it was argued (as a sop?) that entry into the sequence should be possible at least to Unit 3 – a possibility never taken very seriously for physics and chemistry by the Science Committee.

The Science Committee was forced by this edict to revert to developing parallel studies of four units in Chemistry, Physics, Biology, Geology and 'Science'. The *Science* study, thus, once more merely occupied the unattractive niche that *Physical Science* had so precariously held since 1976. Indeed, this niche is now even less desirable since the University of Melbourne has taken the opportunity of the new reform to declare *Science* to be a 'non-subject' as far as students wishing to enter any of its faculties are concerned. It has been hard to get a clear statement of the criteria that were used to judge studies in this way, but all the disciplinary sciences were approved, including Psychology, a new study. It was promoted very strongly by the University of Melbourne and placed by the Board among the Science Committee's responsibilities against its own suggestion that it would be better placed with the Social Education or Personal Development committees.

Response to feminist initiative

Quite early in the reform, the McClintock Collective, a feminist group of science teachers who have done much to promote gender issues in science education and who have done a great deal of curriculum work with Victorian teachers and students (McClintock Collective 1988) presented a position paper to the Science Committee. In it they argued for the Committee to encourage the use of the numerous strategies that they and others have now found to be more gender-inclusive for science learning. They also argued for the content of the new courses to be so defined that they would be more inclusive. Some of the content characteristics they asked for were the co-operative nature of science, an explicit sensitivity and concern for people and the earth, a focus on career aspects, inclusive problem-solving activities, divergent aspects of science including creativity, etc. These proposals were unfamiliar to many on the Committee, but it was noticeable that it was the academic scientists and teachers who were most forthright in dismissing the suggestions that the content for science learning could be altered in the suggested ways. One of the academics said that 'what I hear you saying is simply about approaches to teaching'.

'Science for All' and 'Elite Science'

Developments in the science curriculum elsewhere in the last few years, and the strong press for 'Science for All' in Australia (Baklien Report 1987, Speedie *et al.* 1989, Dircks Report 1985) were major influences on the Committee's decision to adopt an S–T–S framework for its design of the new science courses. The particular S–T–S approach was one now being commonly referred to as *Concepts in Contexts*. This was an acceptance by the Committee that the content to be studied (or the knowledge of worth) would be made up of a set of scientific concepts and of aspects of socio-technological contexts that involved these concepts. This approach to *concepts in contexts* does not give as much status to the knowledge of the context as, for example, the PLON physics project in the Netherlands has with its *network of concepts in a network of contexts* (Eijkelhof and Kortland 1988). It did, however, enable a number of contextual concepts and other contextual knowledge to be listed in parallel to the traditional scientific concepts. For example, aspects of *pollution* and of the socio-technical phenomenon of *waste* were listed in the draft for Chemistry.

The revisions of these science drafts, primarily because of academic pressures, have steadily reduced the status of the contextual list. It is now doubtful whether the contexts have much more than motivational value. A number of teachers were interviewed late in 1989 about their perceptions of the changes in content being proposed, from the information about the new courses they had at that stage received. Most of them did not see the contexts in terms of essential knowledge but rather saw them as an approach to teaching.

Science as objective or personal knowledge

One of the innovations suggested by the science educators has been the subject of a continuing controversy. It is known as *Work Requirement* 7 and states:

> *Review*
>
> Purpose
> To assist students to appreciate the way in which their understanding of scienctific ideas has taken shape and the general nature of the development of scientific ideas.

Description
Students should prepare a brief statement explaining their understanding of a scientific concept or natural phenomenon before and after a period of study. The statement should include comment on influences which led to change in their original views.
This could involve

- listing knowledge and explanations before and after a period of investigation;
- commenting on the views of others which differ from the student's own;
- commenting on processes involved in changing the student's views, which are similar to or different from processes occurring in the development of scientific ideas;
- preparing concept maps of the student's ideas prior to and after completing the period of study;
- keeping a diary which notes significant changes in the student's understanding of the scientific concepts studied.

Students should provide an account of the effects of the learning activities on their original views.

Satisfactory completion
The student will

- undertake a review in accordance with the purpose and description above.

This work requirement is part of a fourth semester unit in the Science Study sequence, entitled *Changing Views of the Universe*. The introductory content of this unit is concerned with the way scientific thinking and understanding of the history of the earth and the history of life on earth have changed over time, and the evidence and influence that leads to such changes. These exemplary cases are followed by suggestions that other scientific topics such as

- the current view of earth's place in the galaxy/the view of the atom as consisting of an array arrangement of sub-atomic particles;
- the view of disease as being caused by a variety of microorganisms;
- the view of visible light as having a dual character of electromagnetic waves and photons;
- the idea of intelligence

could be explored for the changes in conceptions that have been part of their scientific 'history'. *Work Requirement 7* is the last in the set of learning experiences the students are required to undertake in this unit, most of the context of which has just been briefly outlined.

There have been a series of attempts to delete this work requirement. Some of the overt arguments made in favour and against in the committee are now presented.

Against:

It is too hard ('I couldn't do it', an academic scientist).
It is trivial. It will discredit the unit and subject in the eyes of the university.
It is not science. It is about learning science.
It is personal and hence not science.
It is unfamiliar to science teachers and they won't want it because they won't know how to teach it.
It is not related to the content of the unit and so is inappropriate.
It is metacognition not science.

For:

Science is about humans constructing views about natural phenomena. So, this provides practice at what may be the basic process of science.
The unit is about 'changing views' and so this work requirement is entirely appropriate. It is not about the details of a set of static positions scientists may have held about the history of the earth. All our work on 'children's science' and on learners' conceptions of scientific phenomena and concepts indicates students much younger than these do have views and do change them.
Many teachers in Victoria are now encouraging these sorts of learning activities in the study of science in the earlier years of schooling.
Other science units encourage and require practice at what are described as 'processes of science'; and these are readily accepted as science content of worth. 'Forming and articulating a view' is a process of science and subjecting it to empirical evidence or to other sources of information that provide second-hand evidence is another important scientific process.

Work Requirement 7 and the unit in which it occurs is, in a sense, the last remaining residue of an idea that captured the imagination of a significant group of the original members of the Science Committee in 1986 when it first met. This was that students in the last semester of high school should be encouraged to reflect on their learning of science throughout schooling. In this way it was hoped they would gain a sense of the importance of science in human affairs, and of its limitations as a social process, and of their own personal relation to it. Those with a constructivist view of science and of its learning and the feminists, with their sense of the personal and of the social manipulation of science, were particularly keen on the idea. As the nitty-gritty work of development occurred, under the constraining academic influences, to which reference has been made, the vision of this idea dimmed except for the residue that *Work Requirement* 7 provided.

One consequence of these constraints has been that a number of those who were for this vision lost interest and left the committee. They were not replaced by like-minded persons, so that support for *Work Requirement* 7 has lessened in the committee itself. It has survived but at a price, although it is most unlikely that its removal would have lessened the penalty the university scientists from the University of Melbourne have imposed on the *Science* studies in declaring them unacceptable as part of a student's background for *any* faculty. *Science*, like its predecessor *Physical Science*, was not disciplinary nor did it give primacy to traditional conceptual learning. These two grounds were sufficient to condemn it in these academic eyes.

Discussion

The examples that have been given involve complex actions and reactions by the various pressure groups who are now involved in the definition and implementation of science curricula in Victoria. It is not possible to do more than point to some aspects of this complexity. The dominant academic response to the current curricular reforms (and to those in the 1960s) is consistent with a strong sense of science education at schools as 'preparatory'. Thus, the content and knowledge of worth for the senior secondary sciences is to be determined by the knowledge and expression of it that is now well established as the content of freshman science courses in physics, chemistry and biology. It is as if these academic scientists ask the question used to construct Gagné-type learning hierarchies: 'What knowledge and skills do the learners need to have if they are to acquire this new piece of knowledge?' In the 1960s, by which time university science had recovered from the Second World War and freshman classes were agog with a much more theoretical and conceptual approach, the answer was that there was a great discontinuity with senior school science. The conceptual revolutions that the National Science Foundation and the Nuffield Foundation, on the two sides of the Atlantic, enabled in the content for school science had great academic support.

In the 1980s and 1990s freshman studies in physics and chemistry in particular have only changed slightly from the 1960s despite the major changes in these sciences as a whole in this period. The concerns of academic scientists about school science curricular are presently to *prevent* them deviating from the smooth continuity their now traditional content provides. Their anxiety is not now with the content or knowledge of worth of school science but that not enough students study this content and are prepared to continue into science studies at university.

Layton (1984) has described this academic attitude and influence on school curriculum as one of 'subject maintenance'. The definition of the subject content to be maintained is provided by undergraduate science courses. The research questions that excite academic scientists about their subject, and the new knowledge and contemporary experiences of it that they use in their discourse together, are not part of this definition and so have no place in the essential knowledge for school courses.

The curriculum reformers of the 1980s and 1990s are saying, on the other hand, that unless school science is radically redefined it will not attract the students the academics wish were studying it. It needs, they argue, to be more explicitly human, more socially relevant, more exciting in its discoveries and applications, more technological in its language, and more honest about its strengths and weaknesses as a human and social endeavour. As these emphases are included in the content of school science, there will be discontinuities between school science and the scientific studies that lie beyond. Students at school will not study less science. Indeed, many more could study just as much science, but it would be science content that is defined in different ways from those which now prevail because of the worth or value that Australian academe confers on it.

Kass and Fensham (1989) interviewed a number of academic chemists and high school chemistry teachers about 'theory in chemistry'. A content analysis of these data revealed a number of conceptions of chemical theory: theory as *speculative* or even as *explanatory* were *not* among the conceptions held by the teacher group. They were also rarely given by the academic chemists when they were talking about their teaching but were common about their research. *Non-empirical* was the most commonly shared conception.

These data also revealed the passivity into which the academic chemists cast students in their lecture classes (a number of whom, of course, become high school teachers) compared with their own active relation to the knowledge being taught. The high school chemistry teachers also presented themselves as passive in relation to chemical knowledge, but for pedagogical purposes did use more active expressions for how their students in school should relate to it (Marton *et al.* 1990).

There is a consistency in all these academic responses with the sense of 'preparatory' which the academic scientists maintain so strongly about school science education, and that academic science teachers in schools so readily accept and provide. Influential academic scientists in the most prestigious Australian universities also have little experience of teaching about *contexts*. The closest they get is in teaching chemistry or physics to medical, engineering or another vocationally specific group of students. Usually, however, even this takes the form of what Holman (1987) has described as the simplest or most primitive form of S–T–S teaching. That is, the traditional science concepts of the discipline concerned are taught *with applications* being identified rather than *the science of the application* being taught.

A recent national review (Speedy *et al.* 1989) found no examples in universities of freshman or other undergraduate units in chemistry or physics (in contrast to geology and biology) that set out to give an overview of the subject as a scientific field of inquiry with contemporary frontier interests, both pure and applied. This means that teachers studying these subject areas prior to teaching them gain much established knowledge but are unfamiliar with the process of its establishment and its relation to technological applications in industry, the home and society generally.

Of course not all academic scientists propound views that are consistent with the constraints that have been described. McBryde (1991), a Canadian academic chemist, for example, recently advocated that the scientific community should seriously try to upgrade scientific literacy. 'To do so, the material we teach should probably be rather different from what it has been. It is a healthy sign that significant increases are taking place in interdisciplinary studies'. Among Australia's academic scientists, similar views would be found, albeit less prominently or eloquently expressed. But what is lacking, certainly in Australia, are real changes in the structural conditions that would encourage, rather than constrain, the reformist ideas of these individual academics in school science.

The social context for school science education in most countries is different now in many respects from what it was in the 1960s. There are also new societal demands for successful science education in schooling. The aspiration for further academic studies is, however, still very important among these demands. As we have found in Victoria, academic scientists will continue to exert very major influences on what happens in school science.

Notes

1. The compulsory age for school education in Victoria is still 15 although it is many years since significant numbers left school at this age. 'Post-compulsory' has come to mean the final two years of secondary education (students' ages are usually 16–18) and the transitional overlaps between them and the various forms of tertiary education.

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