**Science in Schools**

This edited collection considers science teaching at all levels in secondary schools and the implications for schools of the nature of science and science activity, including its place in the curriculum and its relationship to technology. The book is divided into six main sections.
*Science and Scientific Activity* examines the nature of science from the perspectives of scientists such as Einstein and Medawar and of philosophers and historians of science such as Popper and Kuhn. *Science in a Technological Society* ranges from C.P. Snow to Steven Rose; and *Science in Education* from Layton to Ziman. *Science in the Curriculum* discusses general objectives of science teaching and issues such as why the science curriculum changes and what is the meaning of interdisciplinarity or integration in the science curriculum. *Teaching Methods in Science*, features the work of, amongst others, Driver and Gilbert; and, finally *Review and Evaluation* looks at how we should evaluate science teaching and curriculum innovations.

Science teachers and trainee science teachers will find this an invaluable resource which brings together the current thinking and trends in science education.

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EXPLORING THE CURRIC

# SCIENCE IN SCHOOLS

1986

*Science for the 13–16 Age Group* (another ASE report published in 1973) describes the scope of science for this age group in three sections. This is an attempt 'to achieve a balance between three aspects of science education'. The first section on basic principles is called 'Science for the Inquiring Mind'. Then comes 'Science in Action', suggesting pupils should have 'a basic knowledge of themselves, their physical and biological environments and the interrelationships between them'. Thirdly, 'Science for Citizenship' concerns knowledge needed for making personal and collective decisions. The purpose of courses based on these principles is specified by means of a list of aims for teachers. Included in this list are relating science to life, developing manipulative skills and caring for things, teaching for understanding rather than recall, the methods of science, encouraging communication, imagination, and inventiveness, as well as providing training for decision-making. Science is to be seen, the report states, as a human activity 'offering both promise and threat' (p. 8).

Having surveyed the changes in the aims of science teaching, and briefly sketched in some of the influences responsible for change, a number of important points stand out. The last twenty years have seen the most rapid and radical changes in science curricula and the approach to science teaching. Views on the nature and purpose of practical work have swung back and forth over the years, though ideas on what the teaching of science involves have grown, ranging from a factual knowledge of single subjects to an understanding of aspects of several sciences, together with related moral and social issues. The intellectual demands of what is taught have increased from rote learning in the nineteenth century to the sophisticated abilities and attitudes expected in recent years. Factors influencing change are difficult to quantify, often resulting from the aspirations or constraints of the times. However, with a background of these various changes, it is possible to consider current and future developments in science education in a truer perspective.

## NOTES AND REFERENCES


1. See, for example, Layton, D., *Science for the People* (George Allen and Unwin, 1973).
2. Wilson's essay appears in Farrar, F. W., *ed.*, *Essays on Liberal Education* (Macmillan, 1867).
3. There is much background material in Brock, W. H., *ed.*, *H. E. Armstrong and the Teaching of Science* (Cambridge University Press, 1973) and Armstrong, H. E., *The Teaching of Scientific Method* (Macmillan, 1903).
4. Reprinted in *School Science Review* 1926, 6, **2**, 203.


# 16 Why the science curriculum changes – evolution or social control?

● D. Hodson and R. B. Prophet

*Hodson and Prophet seek to provide an explanation of the shifts in the aims and practice of school science detailed by Uzzell (Chapter 15). They suggest that social Darwinist explanations, emphasizing the failure of certain modes of teaching, are inadequate: it is more pertinent to examine the interests of those who control the curriculum in order to explain the abandonment of certain practices. Although they reject the idea that all knowledge is socially constructed, they use the theoretical framework of the 'new sociologists' to show that school science is so constructed in that it is the product of particular sets of choices made by particular groups of people at particular times.*

Peter Uzzell[1] has traced the changing aims of science education from the early days of school science in the nineteenth century through to the Nuffield projects of the 1960s and the more recent Schools Council project in integrated science (SCISP). What is absent from this admirable article and from other works dealing with the history and development of the science curriculum (such as Jenkins[2], Layton[3] and Turner[4]) is any convincing account of *why* the curriculum changed in the particular way that it did. In a later article exploring the changing status of science in the curriculum as reflected in official reports, Uzzell concludes:

> . . . What is taught, the manner of teaching and the resources for teaching are of crucial importance, as are the needs of children and our country. *Who will decide and on what grounds?*[5] (our italics)

This chapter speculates on these questions by taking a historical perspective, in the belief that some light may be shed on the question 'Who *will* decide curriculum issues?' by attempting to ascertain who decided them in the past – for example, in the period so carefully documented by Uzzell and others.

Underpinning the curricular arguments concerning the relative importance of 'content' or 'method', the role of practical work, the issue of separate versus combined (or integrated) science, which concerned the attention of teachers throughout this period, is the perception of 'science', and of 'school science' in particular, held by curriculum writers, teachers of science and scientists. Just as the science curriculum has changed, so too has the prevailing view of what is appropriate 'school science'. Layton[3] provides a most interesting and useful account of the process leading to the establishment of one particular conception of school science, that of *pure laboratory science*. It is this view which has provided the basic framework of school science in modern times. Layton argues that this particular view of science emerged in preference to alternative approaches because the alternatives had become 'casualties in a process of natural selection as the educational environment had become progressively more sharply defined'.[6] In our opinion, social Darwinist explanations of this kind are inadequate and must be replaced by a more radical historiographic account. They are inadequate because they treat the social processes of decision making as though they are *natural* processes, and because they ignore the motives and interests of the decision makers.

In the mid-nineteenth century at least two alternative conceptions of school science were available to teachers: 'the Science of Common Things' and 'pure laboratory science'. That the latter became established as the *correct* view is not disputed in this article. However, Layton's explanation of *why* the latter view became established ('survival of the fittest') *is* challenged, and two important questions concerning the science curriculum are raised:

1 How does the selection of what is to count as worthwhile knowledge take place?
2 How is this *selected* knowledge presented to the learner?

Answers to these questions may lie in the dispute surrounding the nature of knowledge. Basically, there are two opposing views concerning the nature of knowledge. One view assumes a direct correspondence between reality and knowledge, and asserts that knowledge is *discovered*, the other claims that knowledge is *socially constructed* and may be understood only by reference to the social, cultural and historical context in which it arose.



## THE FORMS OF KNOWLEDGE

There have been many attempts of late to derive a theory of knowledge to aid curriculum design.[7,8] Perhaps the best known is that advanced by Paul Hirst,[9] who claims that all human knowledge may be differentiated into a number of 'logically distinct' *Forms* on the basis of four criteria.

1 The characteristic basic concepts.
2 The characteristic structures by which these concepts are related.
3 The characteristic ways by which knowledge statements are tested.
4 The characteristic techniques and skills for exploring experience.

Using these criteria, Hirst identifies about *seven* Forms of Knowledge:

Mathematics and formal logic
The physical sciences
The human sciences, including history
Moral understanding
The religious form of knowledge
Philosophy
Fine arts

For Hirst, the central aim of education is the development of mind, so that a curriculum organized on the basis of the Forms of Knowledge represents the most appropriate way of achieving that goal – because it introduces children to the *various ways of knowing*.

A number of distinguished educationists have argued that an effective teaching strategy requires that learning experiences should be designed in such a way that they reflect and illustrate the conceptual and methodological structure of the disciplines. Jerome Bruner may be taken as representative of this tradition of curriculum design.

> The curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to that subject. Teaching specific topics or skills without making clear their context in the broader fundamental structure of a field of knowledge . . . makes it exceedingly difficult for the student to generalize from what he has learned to what he will encounter later . . . has little reward in terms of intellectual excitement . . . (and produces knowledge) that is likely to be forgotten.[10]

## SOCIALLY-CONSTRUCTED KNOWLEDGE

Directly opposed to Hirst's theory is the view that knowledge is the product of the interaction of individual minds with experiences, resulting in a highly *personal* system of interpretations and rationalizations. On this theory, knowledge develops through social processes, as individuals categorize experience and infer meanings. Thus, the status of knowledge as an *objective* entity is severely questioned. Statements about curriculum content are then seen not as statements about objective entities, but as particular views of the world advanced by particular groups of individuals, or (as Blum puts it) as 'products of the informal understandings negotiated among members of an organized intellectual collectivity'.[11]

The sociology of knowledge has a long history. In *History and Class Consciousness*, published in 1923, Lukàcs asserted that consciousness, and consequently knowledge of all kinds, is the product of interaction between men, reality and *interest*. This third variable is just as powerful as the other two in limiting and determining the kind of knowledge that different groups in society acquire. Lukàcs believed that 'under ideal conditions' reality *is* accessible to man's rational appraisal, but that in practice *both* classes in society (the 'dominant' and the 'oppressed') will, because of their different *interests*, attain only a partial understanding of reality (a 'false consciousness', as he calls it). In *Ideology and Utopia* (1936), Mannheim reasserted this theory of the social construction of knowledge, but he exempted scientific knowledge, which he regarded as 'disinterested knowledge' unrelated to its context of production and capable of a direct relationship with reality. Writers in the modern tradition of the so-called 'new sociology' – especially Keddie,[12] Esland[13] and Young[14] – deny special status to scientific knowledge and reject the distinction between academic knowledge and common-sense knowledge drawn by philosophers such as Karl Popper.[15] They argue that *all* knowledge is socially constructed, that we do not know the world as it really is, but only as mediated through the conceptual framework we have. This framework is a human construction, which could have been different and is relative to the social system. Clearly, the way we see the world is partly influenced by the way we have been brought up ('socialized'), by our language and by our experiences, but these writers suggest that it is *totally* determined by these factors and that all knowledge and all kinds of truth are simply 'institutionalized conventions'. Thus, they lead us to a theory of 'cultural relativity' in which a particular view of reality is neither right nor wrong. In other words, 'truth is as you see it!' They refuse to allow limiting features in the nature of reality: the validity of arguments, the truth of statements, and the correct application of concepts to experience are to be explained *only* in terms of the socially dominant group. Hence, different groups could legitimate different standards of validity, truth and correctness. It is only a short step from suggesting that all knowledge is socially constructed, and therefore arbitrary, to suggesting that the *criteria* by which we decide on truth and falsehood are also socially constructed and could, therefore, be altered. Thus, rationality itself becomes merely a convention and the rules of logic and argument are shaped and selected in accordance with the purpose of the argument or the intentions of the arguer. C. W. Mills had argued in similar vein when he asserted that 'the rules of the game change with a shift of interest'. Zones of knowledge (as he called them), because they are human constructs, have 'careers' in which *the norms of truth change*.



> Criteria, or observational and verificatory models are not transcendental. There have been, and are, diverse canons and criteria of validity and truth, and these criteria, upon which determination of the truthfulness of propositions at any time depend, are themselves, in their persistence and change, open to socio-historical relativization.[16]

At the other extreme is Phenix's view that the disciplines are perfected, *absolute* forms of knowledge, existing independently of man.

> The structure of things is revealed, not invented, and it is the business of enquiry to open that structure to general understanding through formation of appropriate concepts and theories. Truth is rich and varied, but it is not arbitrary. The nature of things is given, not chosen.[17]

Whilst not wishing to accept Phenix's proposition that 'the nature of things is *given*', we believe that there is a point at which it makes no sense to ask if things could be conceived otherwise. There *are* limiting features in the world. There *are* events in the world subject to cause and effect. There *is* some degree of stability and order. If there were not, we couldn't perceive it. The way we discriminate and explain must be *partly* due to stable features in our environment and *partly* due to cultural influences. Richard Pring sums this up quite succinctly when he says that choosing to distinguish between cats and dogs may be a consequence of our particular cultural environment, but *being able* to distinguish between them says something about cats and dogs.[17]

## SOCIAL CONTROL

Whilst rejecting the extreme position advocated by the 'new sociologists', it is still possible to use the theoretical framework of socially-constructed knowledge and the notion of *social control* as an explanation for *why* the science curriculum changes in a particular way.

Sociologists of knowledge assert that all groups in society attempt to legitimate and disseminate the knowledge which best suits their interests. As Karl Marx reminds us, the groups with the most power, the ruling groups, are in a better position to succeed in establishing their particular version of reality.

> The ideas of the ruling class are in every epoch the ruling ideas: i.e. the class which is the ruling material force of society, is at the same time its ruling intellectual force. The class which has the means of material production at its disposal, has control at the same time over the means of mental production . . . hence among other things (they) rule also as thinkers, as producers of ideas, and regulate the production and distribution of the ideas of their age; thus their ideas are the ruling ideas of the epoch.[18]

However, to suggest that the imposition of a particular view of the world by a ruling group implies both a huge conspiracy of manipulation on the one hand, and large scale human subservience and passive acceptance on the other hand, is to grossly over-simplify the complex interactions in society. We are all born into a specific social and historical context, with its already existing ideas and interactions; we live within an 'ideological matrix' which influences and determines our whole consciousness, so that we acquire a set of beliefs, values and practices which we accept as 'common sense'. This view of society is then reinforced and stabilized through institutions such as schools, so that it appears to be the only way the world *can* be. Thus, the education system may be an important aspect of the social control mechanism.[19] It is inappropriate to enter into a discussion of the concept of social control here, but it is worth noting (as Donajgrodzki[20] points out) that the identification of social control processes at work does *not* imply that the control element is the major or the only factor, or that the 'controllers' and 'controlled' are aware of the process. A particular interest group may, of course, make a conscious and cynical use of education, or any other social structure or institution, but that group is just as likely to have a genuine passion for its cause and to assign itself motives for its actions, which only later appear to have been false. This would appear to be the state of affairs at the time of the great changes in the school science curriculum in the mid-nineteenth century. It may also be happening now!

## THE SCIENCE OF COMMON THINGS

The earliest attempt to include science in the curriculum seems to have been Charles and Elizabeth Mayo's *Object Lessons*, designed for 'the cultivation of habits of accurate observation, correct description, and right judgement upon the things of nature and art'.[21] Following the publication of textbooks written by the Mayos (*Lessons and Objects*, 1831, and *Lessons on Shells*, (1832)) and backing from the Home and Colonial Infant



School society, Object Lessons quickly became established as the basis of science lessons in the early years of a child's elementary schooling. In the 1840s a small but influential group of clerics existed, who saw the teaching of science as essential for the moral and religious salvation of the labouring classes. Notable among them was the Rev. Richard Dawes, who became Rector of Kings Somborne in 1837 and, with the help of a government grant, opened a National Society school there in October 1842.[22] This village school soon achieved remarkable educational results, in large measure attributable to the use of secular reading books with a large scientific content and to the teaching of science as applied to 'the understanding of common things'. The first favourable reports from HM Inspectorate appeared in 1845[23] and, in 1848, the Minutes of the Committee of Council on Education contained a long account of the organization and teaching of the Science of Common Things by the Rev Henry Moseley.[24] From this time, Dawes found a staunch ally in Moseley, who applied himself to the diffusion of Dawes' curriculum scheme.

In the early 1850s more well-defined support for the teaching of science in elementary schools became apparent, possibly due to the Great Exhibition of 1851, when it was realized that British manufacturers compared unfavourably with those from overseas. Layton[3] describes how the supporters of the movement for science education recognized three priorities if science were to be firmly established in the curriculum: well-designed and inexpensive apparatus and books; suitably trained teachers; and a sound administrative framework. A government grant scheme for the purchase of school science apparatus and books, promoted by Moseley, went some way to meeting this first priority. Moseley's influence was also crucial in meeting the second priority, when he was instrumental in establishing the requirement that all students in training schools should study science. Additionally, grants were made available to supplement the salaries of lecturers who showed skill in adapting topics in science for elementary instruction. The third essential resource for the establishment of science in the curriculum was a sound administrative framework. Much of the basic groundwork had, of course, already been done by Moseley through his work for the Committee of Council. Further impetus was supplied in 1853 by the creation of the Department of Science and Art, with Dr Lyon Playfair as Head of Science. Playfair strongly endorsed the view that science should be introduced into elementary education, and early signs were that much fruitful work would be done in cooperation with the Committee of Council on Education.

By 1854, with the three essential resources necessary for the development of Dawes' scheme reasonably satisfied, the movement seemed poised for success. Journals such as *Educational Expositor* carried many articles discussing and suggesting further developments for the scheme.

Suddenly, in mid-decade, when all seemed set for a significant advance, several crucial changes occurred. Dawes was moved to the Deanery of Hereford where, even though he retained his interest in education, much of his time was taken up with his new duties. In 1855, a year after influencing grant regulations favourable to science and introducing a large amount of physical science into the examinations of training schools, Moseley was appointed resident Canon of Bristol Cathedral, being replaced as Inspector with special responsibility for the Church Training Colleges by the Rev Frederick Temple, who within two years had revised the scheme of examinations for students, reducing the amount of mechanics and demoting physical science from its prime position to one of several *optional* subjects. By 1859 mechanics had disappeared as an examination subject and the number of teachers able to claim grant aid for scientific apparatus had been drastically reduced. The most vital resource of all for the continued success of the science of common things movement, the supply of trained teachers, had been virtually halted. In the administrative sphere a significant change of priority was apparent. Playfair, a strong supporter of the Dawes schemes in the early years of the decade, shifted his ground significantly regarding the most appropriate kind of science for the elementary school curriculum. The aims and objectives of science education were moved firmly into the affective domain, with prime place being afforded to 'love of nature', for which natural history and the 'sciences of observation' were regarded as the most appropriate vehicles. In 1858 Playfair left the Department of Science and Art to resume his academic career as professor of chemistry in the University of Edinburgh. By 1859, with a new and very limited system of claiming grant aid for science teaching, the role of science in the curriculum had been severely curtailed. With the Revised Code of 1862, following the Report of the Newcastle Commission, all financial assistance towards science in elementary schools was withdrawn. It is worth noting that in assessing the state of popular education the Commissioners rather surprisingly, did *not* seek the views of Dawes or Moseley. The result of these new regulations was that science disappeared from the elementary school curriculum, and did not reappear until 1882.

The question of particular interest in this article is *why* this change should have come about. The 'social Darwinist' explanation given by Layton – that better and more acceptable alternatives had become available, may appear reasonable from a common-sense viewpoint, but does not stand up well to close historical scrutiny. Rather than failing, the experiment with the Science of Common Things was showing signs of marked success, children were successfully learning science! Hence it would be more correct to say that it was *abandoned* rather than it failed, and that its abandonment represents an attempt at social control. It is reasonable to ask, therefore, *to whom* the new science curriculum alternative of *pure laboratory science* was 'more acceptable'? It is reasonable to ask *whose interests* were furthered by the introduction of this alternative and why this group's interest was being threatened by the success of the Science of Common Things?



## THE EMERGENCE OF PURE SCIENCE

During the early 1850s the traditional orthodox conception of a classics-based liberal education, which set apart the aristocracy and gentry from the rest and restricted the entry of the emergent middle class to the ruling order, was beginning to come under attack. An important and forceful essay by Herbert Spencer[25] on the relative merits of various branches of knowledge directly questioned some of the basic assumptions of this classical education, and put forward a case for the inclusion of *science* in the curriculum. He suggested four main 'areas' in which scientific knowledge had a greater 'worth' than any other form of knowledge.

1 It cultivated a superior type of memory.
2 It was superior in cultivating judgement.
3 It was superior in instilling moral discipline, through its appeal to reason.
4 It was essential for developing a religious culture – science could not be separated from religion without harmful effects to both.

Spencer and Hershel[26] were adamant that the science promoted in schools should be 'practically useful' in various professions, manufactures and businesses, but such an emphasis was roundly condemned by Whewell, who considered that it would inhibit scientists in moving towards 'laws of a more exalted generality and higher speculative beauty'.[27] Such an attitude is representative of the increasingly prominent advocates of education in *pure abstract science*. Robert Hunt, Secretary to the Society of Arts, argued that whilst the practical aspect of science was of 'some importance', it is the study of *abstract science* that 'refined and elevated human feelings'. He claimed that any idea of measuring the value of science in terms of its utility was degrading it from its 'far higher and holier ends'. By training the young to 'estimate truth by its money value' and by seeking scientific knowledge for 'purely mercenary ends' we would ensure that scientific knowledge advanced no further. He suggested, instead, 'more noble' ends for science education:

> I would venture to impress upon all teachers of the young, not to attempt to teach science in all its details, but to excite curiosity, stimulate inquiry and quicken the powers of observation.[28]

His concluding words presented a view of science designed to advance it for serious consideration as a component of a liberal education:

> . . . by allowing the young mind to expand itself over the fields of nature 'like a wild bird of the wilderness', to embrace within its flight the whole truth in its illustration of creation's great phenomena, by ascending from practical science to the high poetry of science, we shall produce a nobler being.[28]

The opposition to the teaching of the Science of Common Things and the promotion of Pure Abstract Science for inclusion in the curriculum for liberal education of the upper classes merged with the movement for the improved status of natural history. In this context the work of Henslow[29] and T. H. Huxley are particularly important. The views of many eminent scientists of the time were represented in a report presented to the British Association by its Parliamentary Committee.[30] Under the chairmanship of Lord Wrottesley, this committee undertook a survey of opinion among scientists on what they saw as the most effective measures to be adopted in improving the position of science. On the basis of the report (presented in 1857), Wrottesley drew up twelve resolutions to be submitted to Parliament. Implicit in the resolutions was the value of *pure science* – prestige for abstract science was deemed to be essential for the progress of science. Of the four resolutions directly concerned with education, none was concerned with science at the elementary school level. It may be assumed from this that Wrottesley and his committee either (i) considered science at the elementary level to be unimportant, or (ii) considered that developments at this level were already satisfactory and needed no further comment. It is *our* view that the report implicitly reflected a growing awareness of a serious problem: that developments in science at the elementary level were not only 'satisfactory' as far as science *learning* was concerned, but were highly *successful*, and that social hierarchy was being threatened because there was no corresponding development for the higher orders. Giving the labouring poor access to a particular form of knowledge, seen as a very important resource, and at the same time denying this resource to their superiors was coming to be regarded as a very dangerous state of affairs. Wrottesley himself expressed his concern over elementary school science in a section of his book on the 'present condition of England'. He comments on the impressive grasp of scientific principles in schools for the labouring poor compared with the lack of any science in the curriculum of grammar and public schools, and describes in detail an incident in a pauper school where he asked a class for the explanation of the principle of a pump:

> . . . a poor boy hobbled forth to give a reply; he was lame and hump-backed, and his wan emaciated face told only too clearly the tale of poverty and its consequences, unwholesome and scanty diet in early years; but he gave forthwith so lucid and intelligent a reply to the question put to him that there arose a feeling of admiration for the child's talents combined with a sense of shame that more information should be found in some of the lowest of our lowest classes on matters of general interest than in those far above them in the world by station.[31]



Wrottesley's conclusion confirms the worst fears of the upper classes concerning the education of the lower orders:

> It would be an unwholesome and vicious state of society in which those who are comparatively unblessed with nature's gifts should be generally superior in intellectual attainments to those above them in station.[31]

Similar views, showing the depth of the disquiet, were expressed by many other influential individuals. In an article in the *Edinburgh Review*, A. C. Tait (who followed Arnold at Rugby and later became Archbishop of Canterbury) expressed concern that the education of the poor was making such good progress that the higher orders were being left behind. Consequently it was 'absolutely necessary for government to attend to education of the rich'. He predicted a complete overturn of the social order if 'the son of a labourer possesses better knowledge than the son of the squire'. It is interesting to note that he also makes direct reference to Dawes at Kings Somborne and to the undesirability of the children of labourers, being educated with the sons of the higher orders.

The principal goal of the Science of Common Things was intellectual development of children, the acquisition of scientific knowledge and the provision of experiences for the exercise of reason, speculation and imagination. Improvements in the moral and religious condition of the children of the poor were assumed to follow as a matter of course once self-confidence and integrity of thought had been achieved. By giving a prominent place in the curriculum to applied sciences such as mechanics and agricultural chemistry, education could be related to a culture which was familiar to the labouring classes. Furthermore, the restricted linguistic experiences of so many elementary school children need no longer be an insuperable obstacle to the growth of rationality. As Layton remarks:

> Here was no crumb of upper-class education charitably dispensed to the children of the labouring poor. Instruction was related to a culture which was familiar to them and provided opportunities for the use of reason and speculation by drawing upon observations which pertained to everyday life. *Understanding and the exercise of thought were not the prerogative of the upper and middle classes.*[3] (our italics)

As a consequence, the upper classes felt threatened. Influential scientists of the day, men such as Owen, Hooker, Lyell and Faraday, advanced the view that the ruling class was in danger of losing its position through lack of scientific knowledge. These views are evident in the *Report of the Public School Commission* set up in 1861.

> In a political point of view, it is not only an unhealthy but also a dangerous state of things in some respects, that the material world should be very

much better known by the middle classes of society than by the upper classes.[32]

If it was considered such a 'dangerous state of things' that the new middle class had access to a form of knowledge denied to the upper class, how much more serious must have seemed the 'state of things' when the *lower* orders were seen to be becoming superior in scientific 'intellectual attainments to those above them in station'. By the middle and late 1850s a campaign backed by the *Times* newspaper had been mounted on two levels. On the one hand it advocated the merits of *pure science* as a component of the liberal education of the higher orders, on the other it advocated a *halt* in the scientific education of the lower orders, whom it saw as being 'over-educated'. The higher orders had realized that those below them in the social hierarchy were gaining access to scientific knowledge which might be used as a resource in future socially undesirable activity. Since, however, the continuing insistence of the higher orders on a classics-based liberal education excluded science to a large degree, it was in their interests to exclude science from the education of the poor. It is suggested that this, and *not* the appearance of 'better alternatives', was the reason behind the abandonment of the Science of Common Things. From this perspective it is possible to speculate that the Revised Code of 1862, which finally removed science from the elementary school curriculum, was the institutionalization of these beliefs legitimated on administrative and financial grounds. The curriculum proposed for the elementary schools was a watered-down classics curriculum, containing *no science*. Clearly, a curriculum based on 'general training' offered the possibility of more direct control. Prominent amongst the advocates of this 'new' curriculum was Joshua Fitch, appointed Principal of the British and Foreign School Society Training College in 1854, and promoted to the Inspectorate in 1863. His Elementary School curriculum comprised reading and writing, arithmetic, English grammar (the 'classics of the poor'), a little geography and history. A knowledge of common things was not to be obtained by the direct study of science, but through 'country walks, star gazing and domestic experiences'.

> If children go into the world ignorant of common things, it is not for the want of technical instruction about them; but either because their daily life has been confined to a narrow and unlovely world, their homes are wretched, and God's fairest works kept far out of their sight (circumstances over which we have but small control), or else because their powers of observation and of thoughtfulness have been insufficiently developed; and this is a defect which I believe would be more truly corrected by the good and sound teaching of arithmetic, geography, grammar, history and the Holy Scriptures, than by all the catechisms and manuals of miscellaneous information ever written.[33]



When science eventually reappeared in the curriculum of the elementary schools, some twenty years later, it was in a very different form from that advocated by the liberal reformers. Objectives were now firmly in the affective domain: the principal goal was 'love of nature', which was considered necessary for ensuring success in later stages of a scientific education. Pure science had become accepted as the *correct* view. This marks the start of the conception of science education as it is known today. The 'new' view was described in some detail by Professor Roscoe in an address to commemorate the opening of new buildings at Owens College, Manchester. He argued for 'the educational value of original research', which he saw as 'personal communication with nature for its own sake'. Through this type of scientific enquiry, which was value-free and disinterested, 'habits of independent thought and ideas of free enquiry are thus at once inculcated'. In claiming that the purpose of science education is to select and supply future scientists of talent to the universities, he described the teaching of science in schools as 'the means of sifting out of the great mass of the people those golden grains of genius which are now too often lost amongst the sands of mediocrity'.[34] This new view of science was designed to develop an elite who conformed to the image of the 'pure scientist' rationalized by the higher orders. Science had been allowed into the curriculum once more, but only on terms which effectively excluded the mass of the population from any meaningful scientific education. In this way it was ensured that the resource, available to all in theory but only accessible to the higher orders in practice, no longer posed a threat to the social hierarchy. As far as the elementary schools were concerned, the science component was to be natural history. As long ago as 1854, T. H. Huxley had defined scientific method as 'extended and applied common sense'.

> Science is nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit.[35]

For Huxley, biology was the experimental science which best exemplified scientific method and was ideally suited to the disciplining of the mind. Moreover, biology was ideally suited to the promotion of 'a love of nature'.

## THE CURRENT SITUATION

The major thesis of this article is that the way in which school science is perceived today is *not* the end result of 'inevitable progress' in the disinterested search for truth. Rather, it is *socially constructed*, being the product of particular sets of choices made by particular groups of people at particular times. Its final form represents the triumph of a particular interest group. In providing a way of understanding nature that by definition *excludes* knowledge of the natural world as it is experienced by the mass of the population, the conception of school science that we have today was not designed to achieve the full potential of the majority. Hence it is unsuited, in its present form, to a common curriculum in comprehensive schools.

Michael Young has argued that science teachers continue to see the main purpose of science education as the supply of future scientists, with the result that two very different kinds of school science courses have arisen: academic science and non-academic science – 'the former claiming credibility from the professional scientific community, and the latter through notions of 'relevance' and immediate interest for pupils'. Thus, 'relevance' and 'intellectual credibility' have come to be regarded as incompatible, and even mutually exclusive; O-level and A-level courses have become increasingly abstract whilst courses dealing with the outside world and the environment have been reserved for the non-examinable or, at best, for CSE. The inevitable consequence of this dual policy towards science education is the emergence of two classes of citizen: the scientifically literate and the scientifically illiterate. According to Young, curriculum decision-makers have social control motives in wishing to create a large scientifically illiterate workforce, 'who see themselves as dependent on experts in more and more aspects of their life'. He argues that those in power see it as desirable that 'except in the specific context of their work, and possibly in leisure pursuits such as car maintenance, our increasingly technologically dominated world remains for the majority as much a mystery as the theological mysteries of feudal times'.[36]

Jenkins[37] has attempted to discern some social control element in the nature study movement of the early twentieth century and Millar[38] claims to have detected similar concerns in the proposals of the Newsom Report and the influential Scottish Education Department's curriculum paper *Science for General Education*. Millar claims that these documents betray a concern with social control both *within* the classroom and outside (for example, in industrial relations), which determines both the content and the teaching methods employed.

> As soon as a course module is refined to the point where its use in the class keeps the pupils occupied, enables a satisfactory staff-pupil atmosphere to develop, and therefore permits the teacher to feel unthreatened by an incipient loss of control, it is endorsed as 'satisfactory'. . .
>
> The hope here is clearly that a 'scientific' attitude to information, characterized by a desire to consider all sides of a question, to keep an open mind, to hold a point-of-view subject to experimental verification, will be transferred to areas which are far removed from the school science area.[38]



It is tempting to look for social control mechanisms operating during other periods of significant change in the science curriculum. What motives lay behind the other important curriculum changes described by Uzzell,[1] Layton[3] and Jenkins[2]? Were there social control factors at work during the great changes brought about by the Nuffield courses in the 1960s? What lay behind the General Science movement in the mid-twentieth century and the more recent attempts to promote integrated science? Which interest groups are promoting the current drive to increase the number of girls taking up careers in science, and why? As we enter a new phase of curriculum development in science we need to ask two questions:

1. *Whose* view of school science is being adopted in the curriculum?
2. *Whose* interests are being promoted by the particular view of school science that is adopted?

All proposals present a *particular* view of science. For example, the Association for Science Education's *Alternatives for Science Education* includes the following statements:

> . . . a good science education should seek to develop a range of intellectual skills and cognitive patterns which would help youngsters to handle the problems of growing up in, and integrating with, a society that is heavily dependent on scientific and technological knowledge and its utilization . . . provide opportunities for explaining, and therefore understanding, the nature of advanced technological societies, the complex interaction between science and society, and the contribution science makes to our cultural heritage.[39]

The document goes on to urge teachers to 'provide opportunities whereby youngsters can gain a sense of social meaning and identity' and sets out six 'personal and social aims of science education for all'. Typical of these is the aim identified by the ASE as *science in the world of work*: 'The development of an understanding of the way in which scientific and technological ideas are used to maintain an economic surplus'. Similarly, one is tempted to look for social control intent in the ASE policy statement *Education through Science* when it sets out the aims of science education for *all* in the following terms:

> . . . the development of an appreciation and understanding of the ways in which science and technology contribute to the worlds of *work*, *citizenship*, *leisure* and *survival*. We would include under this heading an understanding of the way scientific and technological ideas are used to create and maintain an economic surplus, facilitate participation in democratic decision-making in a technological society, enrich and sustain a wide range of leisure activities and pursuits, and enable the individual to utilize scientific ideas and technological processes in the context of increasing self-sufficiency, the conservation of resources and the utilization of alternative technologies.[40]

At least three of the six aims of science education listed in *Education through Science* could be regarded as having a social control intent:

1 'The attainment of a perspective or way of looking at the world . . .'
2 'The attainment of a basic understanding of the nature of advanced technological societies, the interaction between science and society, and the contribution science makes to our cultural heritage.'
3 'The realization that scientific knowledge and experience is of some value in the process of establishing a sense of personal and social identity.'[40]

In view of the foregoing discussion one is tempted to ask:

1 *Whose* 'way of looking at the world' is being advanced?
2 *Whose interest* is being promoted by the curriculum?
3 *Whose* view of society is to be projected?

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# 17 The schooling of science

• M. F. D. Young

*Young is concerned about the gap between science teaching and what he sees as the proper role of science in society.*

*He reflects on a diminution in school science and the danger (described by Matthews) of trivializing science by overloading it with projects and social implications.*

*Young provides a few historical examples of unenlightened aims for science teaching and goes on to claim that 'relevance' is still downgraded, that 'academic' science cannot be achieved in comprehensive schools, that doing leads to learning, and that one should talk mainly about science itself, not only about its abuse.*

*At the end, the author claims that the postulated dichotomy between 'pure' and 'applied' science arises not only in schools but also in 'a society in which men have become increasingly separated from the products of their labour, mental and manual'. He concludes that 'the transformation of school science, and the separations that characterize it, then becomes a part of a much wider struggle for the realisation of a socialist society'.*

Despite a decade of unprecedented investment in curriculum innovation, school science displays many of the manifestations of a continuing 'crisis'. Closure of degree and teachers' certificate courses through lack of applicants, and further education colleges with science departments which only remain viable by accepting an overseas student intake of up to 90 per cent are but two examples. At the school level we have fears expressed that one outcome of comprehensive reorganization could be that 'the teaching of physics in schools may be a dying activity . . . the subject could even disappear'[1] and that 'the shortage of good physics teachers [would] not be quite so alarming . . . [were we to] concentrate our scarce manpower on the older secondary school pupils who could better appreciate the intellectual content'.[2] The price that we are being asked to pay for preserving school physics then is a withdrawal from most junior and middle school science, and therefore, in effect, from any science at all for many pupils.

Another aspect of this crisis is considered by Matthews, who reviews