Nuffield Coordinated Sciences - aims and history

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Nuffield Coordinated Sciences—aims and history

Geoffrey Dorling

It is now widely acknowledged that all school children are entitled to receive, between the ages of five and 16, a broadly balanced education in science. This view was encapsulated in the DES (1985) publication '*Science 5–16: A Statement of Policy*.' In presenting the case of 'science for all' this document says 'There was however a considerable measure of agreement that the only way the claims of a broad and balanced science education, and a broad and balanced curriculum, could be reconciled was by a maximum allocation of about 20% of the curriculum time—8 or 9 periods in a 40-period week—in years four and five.' Such changes as were proposed in '*Science 5–16*' would require 'a radical reappraisal of current provision in years four and five [even so] it is also clear that no single means will meet the needs of all schools and all pupils'. *Nuffield Coordinated Sciences* was written in this context to fill one particular need, namely that for a broad and balanced science course that nevertheless preserved the identities of the separate sciences which were its component parts. This is made clear in the introduction to the Trust's (1988) submission to the Secondary Examinations Council (a draft syllabus):

'The course is designed to set the content, ideas, skills and processes of science in the broadest possible context. It sets out to make teachers and pupils continuously aware of the inter-relationships of the main areas of science while allowing schools to retain the separate identities of biology, chemistry and physics. This coordination is the feature that distinguishes this syllabus from independent, self-supporting courses in the separate sciences on the one hand and integrated science on the other.'

There is a wide measure of agreement about both the aims and basic content of a pre-16+ course in science and this new project was not intended to depart from them. Indeed, the existence of detailed National Criteria does not allow any substantial departure. The direction which *Nuffield Coordinated Sciences* has followed in its process of curriculum development is also made clear in the submission referred to above:

'*Aims of the course*
'It has not been the intention of *Nuffield Coordinated Sciences* to rewrite the now well established aims of a balanced science course. Rather it has been the intention to develop a strategy by which these aims can be achieved.'

In fact, in both aims and content, *Nuffield Coordinated Sciences* has been matched to the National Criteria for *The Sciences: Double Award*, a draft from the Joint Council for GCSE produced earlier this year (*Phys. Educ.* 1988 **23** 71).

In its development of ideas, *Nuffield Coordinated Sciences* has drawn heavily on earlier curriculum projects using 'tried and tested' teaching strategies wherever possible. Even so, the need to produce a course in science which was accessible to pupils of a wide range of interests and aptitudes, which emphasised the acquisition of skills and understanding processes as much as it did content, and which occupied only 20% of the curriculum time, has led to a Nuffield course which in appearance is very unlike its predecessors.

Content and coordination

Coordination of the work in the separate sciences is the feature of the course that has maintained the

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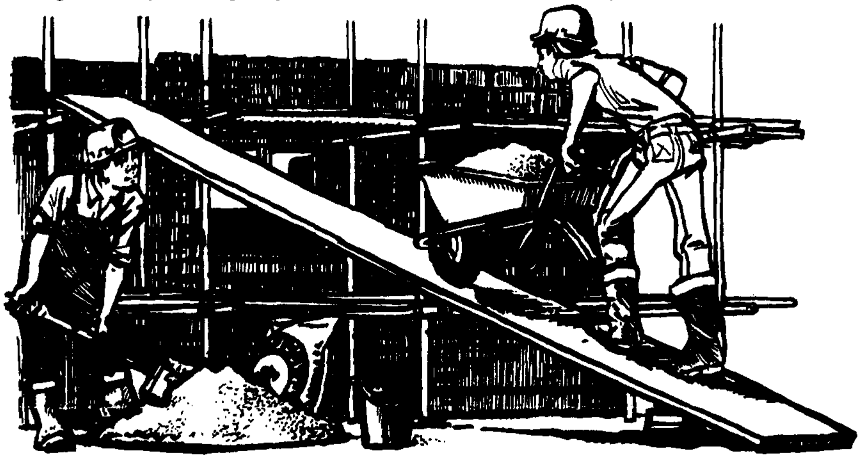
Worksheet P8B
Using a ramp

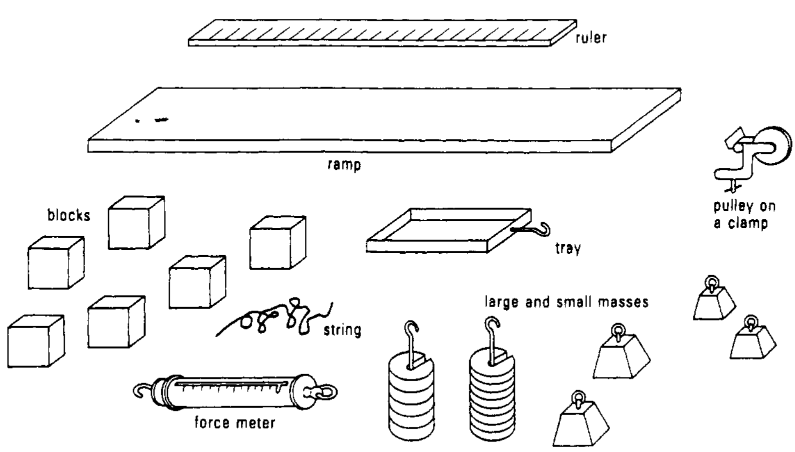
You are going to investigate the best way to use a ramp. A ramp is a machine for raising a load. The load can be put on a tray or board, or simply tugged up the ramp on its own.

When investigating the best way to use a ramp, remember that you do not want to use more force than necessary. On the other hand you do not want to waste more energy than necessary. You may not be able to achieve both these things with the same arrangement of your ramp, so you will have to find the best solution you can.



Investigation

a ● Plan and carry out an investigation into the best way to use a ramp. Your **Planning sheet** (P0) will help you do this. You may use some or all of the equipment shown here:



b ● What conclusions do you reach about the best way to use a ramp? You should back up your answer with measurements that you have made.

separate identity of the sciences, yet at the same time established a coherence between the components so that the pupil is presented with a science course rather than one which simply contains the elements of biology, chemistry and physics. The course was from the start planned as a whole. Consequently an overall similarity of approach and textual layout has been adopted for each of the sciences. All three components have also taken a common view of the skills and processes that underlie the performance of science and all have attempted to interweave the development of ideas with the processes which have led to them.

However, there is more to 'coordination' than this. In the first place, coordination proved fruitful in defining the essential content of each of the sciences. Also, by negotiation and by the elimination of overlaps between the sciences, the process has helped overcome the time constraints, i.e. teaching three established sciences in a smaller span of time than has been traditionally allotted.

In the first instance, the content of each of the sciences was defined by subject teams as representing the essential features of each particular science, bearing in mind the constraints imposed by the National Criteria, by time and by the need to give proper attention to skills and processes. This was an important initial step, since it ensured that the content of each science was appropriate to its particular needs rather than (as can be the danger in integrated courses) being selected for its global relevance.

We were considerably helped in this process by the responses to a questionnaire sent out to a wide range of schools. In this questionnaire, we broached the possibility of a coordinated sciences course. Recognising that this would mean extensive reductions in the traditional content of pre-16+ courses in the separate sciences, we asked schools for their own opinion of what was essential and what was inessential content. Returns from these questionnaires showed a broad measure of agreement in what was essential material and what could be removed. This helpful accord was (at least as far as physics was concerned) somewhat dashed by answers to the next question, about what material could be removed from conventional courses in the light of future needs (e.g. higher courses in physics). The answer to this seemed to be 'None at all'!

We were also, in these questionnaires, able to test out responses to half-formed ideas of our own. Again, to take an example from physics, we were already contemplating introducing some electronics in order to form a link between basic electrical ideas and this important area of technological innovation. The favourable response to this question gave us the confidence to proceed with something that we knew might be a contentious development. We were also able to find out something of the basis upon which current teaching was being developed—for example, to what extent teachers were already using previous Nuffield courses.

With this background the general editors were able, individually, to make proposals for a core of knowledge and understanding in each of the sciences which would form the pegs on which we could hang the course. However, no one science is independent of the work of others and at this point there was a prolonged period of negotiation in which, first of all, duplication of work was eliminated and then steps taken to see that the potential needs of each science were satisfied (if necessary) by the content of the others. This was not an easy stage and compromises were necessary. For example, physics accepted the responsibility for developing the underlying ideas involved in the use of the concept of energy, which were then taken up by the other sciences. However, chemistry ultimately accepted responsibility for developing ideas in electrolysis, which were important to it, rather than relying on work in physics. Coordination of content also resulted in some well established pieces of science falling more neatly into place than they did with a separate development of the sciences. An example of this is the inclusion of work on electric cells in chemistry, where it much more naturally belongs.

It was always a part of our policy to make the course materials as flexible in use as possible. However, because the ideas to be developed in each science depend to some extent on the prior development of ideas in other sciences, there are some constraints on the ordering of the content in each of the sciences. The example of energy has already been quoted. If physics is to be responsible for the foundation ideas, then clearly they must be taught before the other sciences have need of them. To help avoid pitfalls which might arise due to the coordination of the content, the *Teachers' Guide* contains some coordination charts which show the cross links between some major themes, such as energy.

Apart from imposing a degree of coherence on the sciences, coordination of content proved helpful in another way. It could be used to illuminate an idea in one science by appealing to a different, but not dissimilar, idea in another. One example of this is the development of the idea of the conservation of energy, in physics. The idea that energy is a quality whose measured totality never changes is a very strange one, which research has shown to be outside a youngster's natural comprehension. Physics in *Nuffield Coordinated Sciences* starts with the 'naturalistic' view that energy is 'used' to perform useful tasks and develops an idea of 'energy cost'. It is only when the processes of 'heating' and change in temperature are investigated that it becomes clear that maybe energy is not, in any sense, lost in a process of change. Rather it becomes less useable. Why should this be? It is here that we can turn helpfully to a parallel piece of work in chemistry, which concerns itself with the way the world is 'running short' of useful materials—such as copper for example. The world has probably not lost one copper atom (give or take the occasional 'atom-smashing experiment') in the past one hundred years, so how is it that we are 'running short' of this valuable commodity? The answer of course lies in the way it is being dispersed. For physics there is a valuable parallel with our use of energy resources. We are 'losing' energy because we are dispersing it. Once dispersed it is not readily reused. Just as with materials, we may be better off if we do not 'disperse' quite so much of it!

Presentation

Significance How then was the material to be presented? We decided that significance or 'relevance' must be at the centre of our presentation of the course to the pupil. In a core subject designed for all pupils, science must be meaningful to them in more ways than one. Science needs to be significant in several ways. It must be significant in terms of:

- its intrinsic interest;
- its relevance to the world in which the pupils live; and
- its meaning in relation to ideas the pupils already have.

Having said that, we nevertheless set ourselves the target of giving pupils some insight into the essential nature of biology, chemistry and physics. Thus in physics essential concepts are developed from application and social consequences, which we hope are intrinsically interesting, and not the other way round.

In the relevance of ideas we were much influenced by such work as that of the Children's Learning in Science Project (CLISP) at Leeds University. We tried to build ideas as far as possible on the ideas youngsters bring to science and to develop ideas in such a way that pupils are not confused by alternative useage in their day-to-day lives. The way ideas in energy are developed has already been described.

Process The content of the course was explicitly designed to aid the development of skills and the understanding of processes. Pupils should at all times be encouraged to see and understand the processes involved in 'doing science'. We looked for a common set of skills and processes, to be used in all the sciences, and decided to adopt those of the Assessment of Performance Unit (DES 1986).

We felt that it was not enough simply to give pupils the opportunity to use skills and processes, e.g. through the medium of open-ended investigation work: they should also *understand* that these same processes lead to the body of knowledge we call 'science'. To help in this, we devised a number of markers to highlight the use of important processes such as observation, measurement, interpretation, application and planning investigations. It was decided to adopt these flags in *all* the pupil texts, marking the use of each of the named skills and processes as it was used.

We did not want to undervalue the part played by opportunities for truly investigational work—indeed, we believe that great harm is done by putting pupils in a false investigational position (as when certain 'results' are required for deeper theoretical understanding). Nothing can be more harmful to the establishment of a proper understanding of processes in science than to give a youngster the idea that it is possible or sensible to ask, at the end of an investigation, whether she or he has 'got the right answer'! Consequently we have tried to encourage truly investigational work by relating it to topics whose outcome is not essential to the further understanding of core material—topics of broad generality, such as 'keeping warm'; topics that apply some newly learnt idea such as 'efficiency'; or topics which allow able pupils to extend ideas outside the 'core'.

Differentiation We decided to design a pupil-centred course. A pupil could be said to 'learn' science in several different ways, for example:

- by doing science;
- by reading about science;
- by talking about science—either with others or with a teacher;
- by applying scientific ideas in problem-solving situations.

Individually, we felt that pupils will differ in the extent to which they can use and benefit from these learning resources. In particular, able pupils may gain much benefit from the use of a text; less able pupils may gain most from work in class. *All* will gain a great deal from doing science practically. We thus decided to present the course in such a way that a pupil and a teacher can use the learning resources *in the way best suited to each individual*. Activity material of the practical type has been placed on independent worksheets, separate from the text, and the whole course has been written as a coherent set of resource materials which can be used in different ways with pupils with differing needs. This mode of presentation was seen as an important part of differentiation. It has been recognised, for example, that some pupils may not benefit from a text at all, and suggestions have been made in the *Teachers' Guide* about the use of other, parallel, resource material.

This need to produce a course which can be differentiated for pupils with different aptitudes and needs has strongly influenced our presentation of the course material. Hence we were able to write the text for pupils who will benefit most from reading. That is not to say that the text has not been designed to appeal to a wide readership: expert opinion was sought on the readability of all the pupils' texts. However, there comes a point when the needs of the more and the less able pupils are incompatible in a single, written text. When this point has been reached, we have given priority to the more able pupils, believing that these can benefit most from a written text. This allows teachers either to use some alternative text with less able pupils, or (perhaps most appropriate) devote a greater amount of time to oral explanation and discussion.

The writing timetable

We had to write the course to a tight timetable. The DES policy statement referred to earlier had been published in the spring of 1985. Schools were to start work on the fourth year of GCSE courses in the Autumn of 1986. We wanted *Nuffield Coordinated Sciences* to be published as soon after this as possible, and the current interest demonstrated by schools in the project has shown this decision to have been a wise one. The publication date of April 1988 meant that the manuscript had to be in editorial hands some eighteen months earlier—we were in fact asked to deliver the manuscript for September 1986.

The general editors could not be appointed until May 1985, nor released from their teaching duties until September of that year. Thus they had just over a year in which to do all the preliminary thinking, writing (in conjunction with other authors) and revising of the course. In fact, a first draft of the course was written between the end of November 1985 and April 1986. This was then revised, redrafted and handed to the publishing editors on schedule.

With such constraints of time, it was clearly not possible to 'trial' the material in schools on the long-term basis that had been used for some earlier curriculum projects. On the other hand, there were many good reasons for drawing on the best of established skills and practices currently in operation in schools—and these had already been extensively tested. Conscious as we were of how short money is in schools, we were careful to specify very little new equipment.

Consequently, the pattern of testing of material was different from older patterns. First of all the general editors had the advantage of drawing on the skills and experience of a consultative committee, under the chairmanship of Professor Malcolm Frazer, which represented much of the best in science education. This committee read and commented on all the material which was produced, contributing much that was invaluable. The editors managed a wider distribution of draft material amongst practising teachers, some of whom contributed new material to the project. Again, these teachers made detailed comments and suggestions. Inevitably, new ways of doing things were introduced and consultants were specially appointed to check out the experimental consequences of these. Thus all material of an experimental nature (and there is a great deal in the course) is either well tried or specifically tested for the course.

Finally, where essentially new material has been developed, authors arranged their own limited trials—as in the case of the electronics work in physics, which was tried out on a range of pupils and other teachers before publication.

The future

More recently we have been developing a syllabus and assessment package which we hope will be made available on an inter-group basis. By the time this article is published, work should have started on a complementary set of materials designed to support a third year course with the same approach to coordination, significance and process that has formed the basis of the *Nuffield Coordinated Sciences* in years four and five.

References

DES 1985 *Science 5–16: A Statement of Policy* (London: HMSO)

——1986 *Assessment of Performance Unit: Science Reports for Teachers* (London: HMSO)

Problem: fuses

Many high current fuses consist of a central conductor passing down the axis of a ceramic tube, commonly packed with a quartz sand. Can you think of four reasons for packing the tube with sand?
(*Solution on page 238*)