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ABSTRACT

This seven-chapter document is designed for individuals who train preservice and inservice teachers and for individuals who train the teacher trainers. Chapter 1 (an introduction by Wynne Harlen) summarizes subsequent chapters. Chapters 2, 3, and 4 provide some general theoretical discussion about workshops. They are, respectively: "Learning and Teaching Primary Science: The Case for a Workshop Approach to Teacher Training" by Wynne Harlen; "The Teacher's role and implications for Training" by Jos Elstgeest; and "Change in Science Education: The Social, Political, and Cultural Context" by Juan Manuel Gutierrez-Vazquez. This latter chapter suggests that the power structure in a country, often reflected in the power structure within the educational system, affects the individual teacher; it also suggests that new teaching materials and methods cannot bring about change alone. Chapters 5, 6, and 7 provide examples of in-service workshops in practice. They are, respectively: "Reflections on a Workshop to 'Ask the Water'" by Jos Elstgeest; "Planning, Running, and Following Through a Workshop in England" by Wynne Harlen, and "Developing a Workshop Approach to In-Service Training in Indonesia," also by Wynne Harlen. Workshop activities, organizations, and implications for science instruction are noted. (JN)

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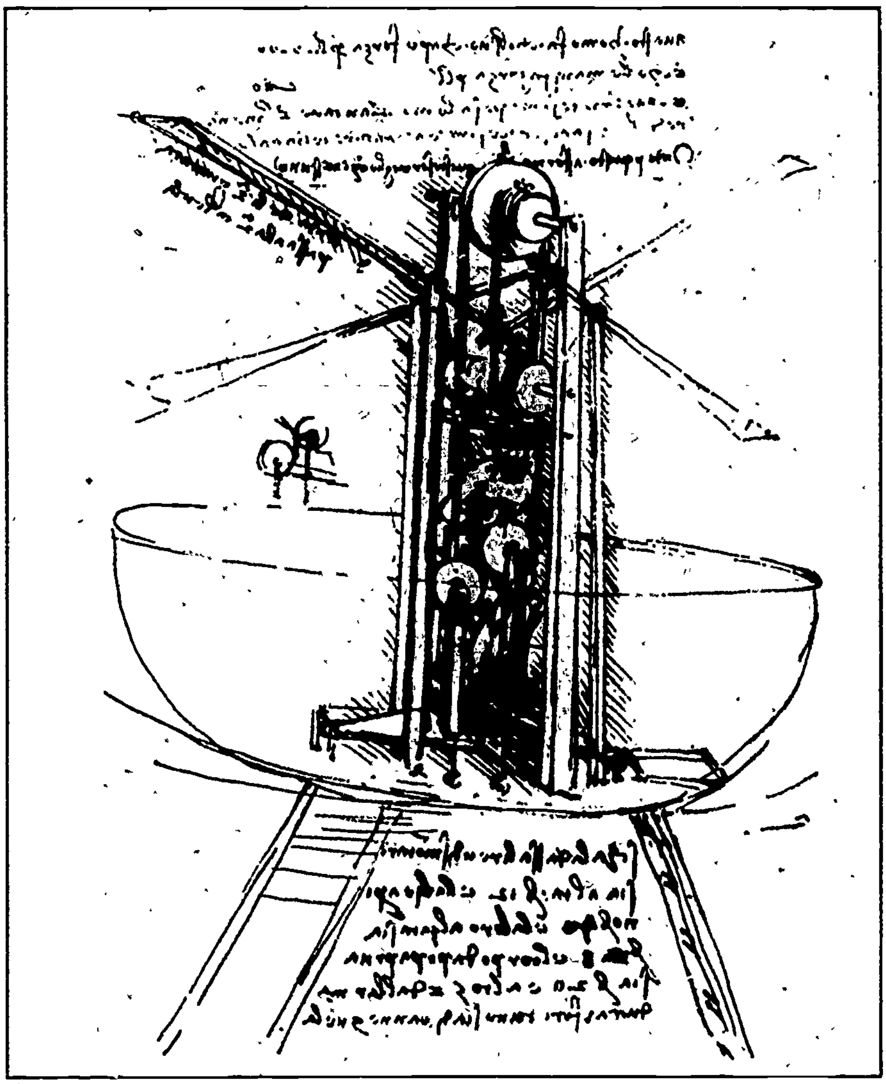
The Training of Primary Science Educators — a Workshop Approach



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SCIENCE AND TECHNOLOGY EDUCATION DOCUMENT SERIES NO. 13

THE TRAINING OF PRIMARY SCIENCE EDUCATORS - A WORKSHOP APPROACH

A document prepared by members of the Subcommittee on Elementary Science of ICSU/CTS.

Edited by Professor Wynne Harlen

This document has been written by three members of the Subcommittee on Elementary Science of the Committee on Science Teaching of the International Council of Scientific Unions (ICSU). The three members are Mr Jos Elstgeest from the Netherlands, Dr Juan-Manuel Gutierrez-Vazquez from Mexico and Professor Wynne Harlen from the United Kingdom. The opinions expressed are those of the authors, and are not necessarily those of Unesco.

Division of Science, Technical
and Environmental Education
Unesco

Paris, December 1984

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CHAPTER 1

INTRODUCTION

Wynne Harlen

The authors of this document have not set out to make a case for science as a basic part of the primary curriculum. This case is taken for granted. Instead their attention is turned to the steps that have to be taken to ensure that science has a real part, not just one on paper, in children's education from the start. In most countries where there is a written statement of the curriculum, science is included at the primary level; where there is no national or local curriculum on paper there is an expectation that science will be included in children's experience, at least from the age of 8 and often sooner. But there can be a world of difference between what is on paper, or what exists in official expectations, and the curriculum in action. What is experienced by children depends little on the official documents, despite the hours of dedicated work which will have been put into their careful wording; neither does it depend to the degree that is generally supposed on the resources available in the school. It depends most of all on the understanding, ideas and confidence of the teachers. These are not qualities that are beyond influence, that teachers either have or do not have; they can be provided by a good training, initially at pre-service stage or later through in-service training or, ideally, through both these channels. It is with the nature and provision of these courses that this document is concerned.

The word 'training' is not a particularly appropriate one in this context, since the chief reason for this document is to describe the rationale for and nature of a workshop approach. A workshop is an experience which enables people - teachers, pupils or anyone else - to learn for themselves rather than to be told about things. Training seems to imply something that some external agent does to those who are trained. Learning science and learning about teaching science are both too complex to be considered in this way; they depend upon understanding that develops from within in response to exploration of real things and situations around. However, as training is the currently accepted word that refers to all kinds of courses for teachers, we will not quibble about its use here.

The intended readers of this document are those who 'train' teachers, at both pre-service and in-service stages and those who train the teacher trainers. The chapters that follow fall into two groups; in the first part, Chapters 2, 3 and 4 provide some general theoretical discussion about workshops and in the second part there are three chapters comprising examples of workshops in practice. Between parts one and two is a short interlude, two small vignettes that warn us of the power we have, as teachers, to distort as much as to develop children's views of science, and one story to remind us of the pleasures of working with children and science. The following brief overview of the chapters gives some ideas of the ground covered in each one.

The basic tenet of Chapter 1 is that decisions about teaching must depend upon a clear idea of what kind of learning is to be brought about. The opening sections give an overview of the nature of this learning, discussing briefly the process skills, attitudes and concepts of science and emphasizing their interdependence. It is argued that to bring about children's learning and development of the kind envisaged, children have to be put into contact with things in the world around them in such a way that they learn through interaction, exploration and investigation. The implications for a teacher of attempting to do this in practice are profound, especially if the teacher has been used to regarding teaching as the transmission of information from teacher to learner. A considerable change in teaching skills and in teachers' attitudes is required and, on the basis of experience, it is suggested that these changes are most likely to be brought about by what is described as a workshop approach to training. The characteristics of this approach are spelled out and the nature of a workshop is described in general terms.

Chapter 3 takes further the discussion of the way of learning that is the aim of primary science education. A somewhat poignant example is used to express the uselessness of learning answers without real experience. At the same time this serves to underline the point that a change of emphasis is required in the aims of teaching, which now have to be conceived in terms of helping children to acquire learning skills and abilities. It is recognized, however, that there is a vicious circle operating to oppose this shift of emphasis. Teachers tend to teach as they were taught, following the 'transmission' view of learning, partly because it brings security and partly because they know no other way. To realize that a different kind of learning is possible and to appreciate their role in it as teachers they must experience it as learners. Only when there is a conviction, and an excitement (well illustrated in this chapter by a charming example) about developing ideas for oneself can the task of the teacher be analysed, practised and improved by critical discussion.

Courses intended to prepare teachers to make changes in the kind or amount or science in their work with children must not treat the classroom as an isolated unit. A class is part of a school and a school part of a community, where cultural mores, social values and political structures mould and constrain what can be done. Chapter 4 deals with the nature and implications of some of these contextual factors. Much of what is discussed there is relevant to any attempt at educational innovation, but its particular significance for science education is emphasized.

One of the problems discussed concerns pupils who drop out from school at an early stage. This is a particular problem in developing countries, where economic necessity makes education a luxury that many cannot afford. In such cases, it is argued, there should be thought given to what is taught in the early years so that these children do not miss the science experience that as is as much their need as it is of all children. In other cases the problem may be that the science that is taught has little relevance to the children's experience and does not add to their understanding of things around. This situation is responsible for the dropping out in developed countries, too, of those pupils who may be present in the classroom in body but absent in mind.

Chapter 4 suggests that the power structure in a country, often reflected in the power structure within the educational system, affects the individual teacher. A view of science may be handed down through teaching materials with which the teacher may not agree or may consider inappropriate for a particular school or group. It is important for teachers to realize that there are alternatives and that the reasons for favouring one rather than another are a matter of policy. Whilst individual teachers may have no alternative but to follow a national syllabus they can be helped to do so in knowledge rather than in ignorance of its implications.

When change is introduced there is bound to be resistance both from those who unthinkingly prefer to keep things as they always were and those who consciously strive to maintain social and cultural distinctions. Science lessons which aim to increase children's curiosity and questioning may offend parents who wish children to be taught to accept what they are told and in some cases to remain ignorant of what are considered adult matters. Teaching methods such as advocated in this publication are quite beyond the personal experience of parents in many cases in all countries; if they feel their children are wasting time and not being 'taught' their support for the school - so necessary for the children's education - will be withdrawn. Workshop discussions should prepare teachers to meet these problems.

For many of these important issues there is no easy solution. Awareness is an essential first step, however, and the purpose of Chapter 4 is to raise the level of awareness so that there are no unrealistic expectations that new teaching materials and methods can alone bring about change.

Chapters 5, 6 and 7 describe events in in-service courses that two of the authors have run in three different countries. Chapter 5 contains an account of a one-day workshop run for the staff of two primary schools, and the follow-up work which took place in the schools. The discussion brings out the importance of dealing with the two sides of practical work - the handling of materials and the handling of children - at the same time. The point is also made that workshop experience is important for everyone concerned with science in primary schools whether or not they are classroom teachers. The chapter ends with an example of how a workshop for a group of advisers was started and adds to this point.

The importance of enlisting the co-operation of head teachers and administrators, if in-service activities are to have a chance of survival, is also one of the themes in Chapters 6 and 7. These two accounts made an interesting pair, read together, for there were striking similarities in the workshops that were run in the two very different situations, of a developing country and a developed one. In both cases the starting-point was a study of the existing situation, leading to the conclusion that the needs of the teachers were for workshop experience. This was not a case of practice being exported from a developed to a developing country; if anything the reverse was the case, for the work described in Chapter 7 preceded that described in Chapter 6 and provided the model for it. The workshops that were run gave teachers several days to work, first on problems and investigations for themselves and then to try out the same activities with children. Evaluation of these trials was an important part of the process of critical reflection which teachers need to undergo when existing practice is challenged by new ideas. The examples also show how important it is to take teachers beyond the initial stages of being willing to try something new to being able to generate experiences for children in new topics to sustain their development of ideas through active problem-solving and investigation.

Despite the differences in details it is the similarities in the case-studies in Chapters 6 and 7 that are significant. It seems that people working in distinctly different contexts have come to the same conclusion as far as teacher training is concerned. Thus this publication on a workshop approach takes on a relevance which is worldwide.

It is the hope of the authors that the various chapters of the document will be useful to teacher trainers. But a small publication cannot cover much of the ground and it was a considered judgement to devote this document to the rationale of a [illegible] to its exemplification. This is not enough to help anyone begin a full implementation of the ideas, though it will give support and further suggestions to those already trying to work in the way advocated. One of the best ways to build on what is presented here is through discussion and to facilitate this use there are points for discussion suggested at the end of Chapters 2, 3 and 4. To go further, to put the ideas into practice requires that workshop materials are gathered together. These will be worksheets, equipment, discussion papers, examples of children's work, slides and, if possible, video-tapes of classes in action. Such things cannot be included in this volume; but we have made a start and we hope that others will find it a worthwhile one.

CHAPTER 2

LEARNING AND TEACHING PRIMARY SCIENCE: THE CASE FOR A WORKSHOP APPROACH TO TEACHER TRAINING

Wynne Harlen

Introduction

As mentioned in the introduction, we are not concerned in this document with making the case for including science in the primary curriculum. That case has been well stated as, for example, in New Trends in Primary School Science Teaching, Volume 1 [1], and is widely accepted in principle. We do, however, have to be concerned with the nature of the science that is included since this affects the role of the teacher and the use of resources in children's learning and consequently the type of training that teachers require. For instance, if science is seen as a body of knowledge, then teachers will be prepared in a different manner than if science is seen as a process of learning in which children's own ideas are gradually built up and constantly modified. In the former case teachers need to have mastered the body of knowledge; in the latter the knowledge they need is about the role of process skills in developing ideas and how children learn.

What kind of learning?

Science activities should contribute to children's learning by helping the development of ways of finding out and dealing with evidence, building up understanding of the world around and attitudes which promote the use of process skills and the development of ideas. Learning in science is a product of the interaction of process skills, attitudes and ideas or concepts. Although it is useful for the purposes of discussion to consider these separately, it is neither entirely feasible nor desirable to try to separate them in teaching and learning. The reasons for this are important to the understanding of the kind of learning we are hoping to bring about. We will come to them after a brief word about the meaning of the terms process skill, attitude and concept.

The term process skill combines the notion of a skill and a process. A skill is generally thought of as an ability that can be developed through practice. So a process skill is an ability in carrying out mental operations and physical actions that can be developed by experience. Science process skills are particularly concerned with the gathering, interpretation and communication of information in generating and testing ideas. Various lists of science process skills have been proposed; none is definitive, but difference between them generally reside in the way the individual items are expressed rather than at a more fundamental level. Thus the following list differs in this respect from those to be found in Chapter 3, page 27, and in Chapter 7, page 74, because each was devised to serve particular purposes in particular contexts. However, each in its own way includes:

- observation (including classifying and ordering observations);
- interpretation of information (finding and using patterns, inferring, predicting);
- raising questions (including defining testable questions);

hypothesizing (including applying concepts and explaining phenomena);

devising investigations (defining operationally, identifying variables, fair testing);

communicating (discussing, reporting, recording, using graphs, tables, charts).

An attitude is usually defined as a state of being prepared or predisposed to react in a certain way to particular objects, persons or situations. Attitudes towards science describe people's reactions to science as a subject or an activity. Attitudes of science, or scientific attitudes, are predispositions towards the activities that are involved in science - gathering and using evidence, creating ideas and treating the natural and man-made environment in certain ways. Someone may know about the testing of hypotheses or the need to consider all the available evidence, but may not be motivated or willing to take the actions that they are capable of taking to work scientifically. Thus attitudes can limit or facilitate the use of skills and the application of ideas. As with process skills, no single agreed list of scientific attitudes exists but the ones generally included are related to curiosity, openmindedness, respect for evidence, critical reflection, recognition of the tentativeness of ideas and sensitive care for living things and the natural environment.

Ideas and concepts describe relationships and generalizations about objectives and events around. Ideas and concepts are formed by children as a result of a variety of influences from the home, the street, the media, the school. At any one time existing ideas are used to help understand new experiences, both in and out of school, and those experiences may bring about a change in ideas. Most learning psychologists agree that concept development involves mental activity on the part of children; ideas cannot be injected, ready-made, into their heads; learners build them up for themselves. The ideas that children should be helped to build through their primary science activities are those that are basic to understanding their immediate environment - for example about sight and light, hearing and sound, movement and forces, air and breathing, hot and cold, water, soil, the sky, seasons and weather, plant and animal characteristics, materials, simple electrical circuits.

Now let us turn to the way these three components of learning science - process skills, attitudes and concepts - interact.

A purely inductive view of science sees knowledge as being generated by the processes of observation, investigation, inference and the search for patterns and relationships in information. It is assumed that the processes of arriving at and using evidence are independent of the subject-matter being investigated. But in reality, this is not the case. Children do not come to a problem or a situation they are investigating with open minds. They already have ideas about it and these ideas influence the process of their interaction with it. What children see, hear or even feel, when they observe, is not everything that can be observed, but a selection from it. Their observation is focused by their expectations, or lack of expectations. A delightful example of this is to be found in the story of 'The Umbilical Devil' which forms an interlude between the chapters of the first and second part of this document (page 32). This phenomenon is not restricted to young children, of course; it is evident in all human behaviour and in the work of scientists. (Many 'discoveries' have been made years after they could have been reported, but in the intervening time were ignored or not regarded as significant.) Similarly, the process of investigation is influenced by ideas about possible effects, assumptions about variables that may influence these effects and the knowledge of relevant ways of detecting or measuring them. Thus what emerges from an inquiry is affected by ideas existing at the start of it as well as by the way it is carried out.

An alternative view of science is that it proceeds from the application of general principles to the explanation of particular events (a process of deduction). But there are serious objections to basing primary science teaching on this view. When children are presented with general principles the only way in which they can respond is to learn them by rote. As mentioned before, ideas have to be built up by children in their own minds. These are the ideas they use in making sense of the world around them, not ones that they can only recite and do not understand. Moreover, children already have ideas about the things around them. They do not wait to be told what to think about the flight of birds, the movement of the sun, the disappearance of sugar in water - they work out some notions for themselves, using the processes of observation and inquiry. They may well have to change their first ideas - and their second and third ones - about something as they find out more, but they will not be confused if they see the reason for changing their minds. It is a different matter, however, if someone else tells them that their idea is wrong and that they have to use some other idea that makes no sense in their way of looking at their experience.

What this means in practice is that teaching involves helping children to develop ideas, not imposing ideas on them. But development depends on the children testing out their ideas against experience by observing, interpreting, hypothesising, raising questions, communicating - in short using all the process skills of science. When children work in this way they learn not only about the things around them but also that they <u>can</u> learn by doing things, by observing closely, by working out relationships, by reflecting on what they find. This can give them power in coming to terms with understanding the world around them, coupled with a growing responsibility for their own learning; it can help them grow into autonomous, thinking, people who will eventually take some responsibility for shaping their society as well as for technological and scientific advances.

<u>What kind of teaching?</u>

The short answer to this question is 'teaching that puts children into fruitful contact with the things in their surroundings from which they can learn'. But those few words have said, at the same time, everything and nothing. There is so much involved in making this provision that it cannot be captured in a simple formula. For a teacher not accustomed to providing for this kind of learning or for a trainee who has never experienced anything other than 'transmission' teaching, it may mean any or all of these changes:

recognizing that the source of children's learning can be something other than the teacher;

bringing 'things' into the classroom - anything from ants to toys, from empty shampoo bottles to empty birds' eggs;

reorganizing the classroom so that children can handle and investigate the things and can broaden their ideas about them by discussing with each other;

putting up with the mess and noise that necessarily accompany active investigation;

developing respect for children's ideas and a sensitivity to the right time for introducing other ideas for children to consider and try out.

These are no small changes. They concern central, crucial features of the teacher's role, self-image and sources of satisfaction in their work.

Why should a teacher change from one who transmits information clearly and apparently efficiently (measured by how much is transferred to children's exercise books or is recalled in tests of memory) into one who asks questions, not to check up that children know the right answers, but to prompt inquiry, who expects children to be the generators rather than the acceptors of ideas? Why, indeed. We should have good answers to these questions if we wish teachers to put their professional confidence at risk in making a profound change in both the products and the processes of their teaching.

What experiences do teachers need?

[illegible] the best ways to convince teachers that it is worth while making the e[illegible]fo[illegible]ke on the role required to help children learn <u>from</u> the things around them is [illegible] provide experienc[illegible] of workshop activities. In making this claim the authors freely admit several facts about it. First, that we have no 'hard' evidence, no results of controlled research to show that workshop trained teachers are 'better' than teachers trained in other ways. We base the claim on our experience over many years of training teachers in initial and in-service courses. Second, we do not regard our notion of training through workshop experience as the only answer to all the problems of teacher training; other kinds of learning (for example about the subject-matter of science) are appropriate for teachers and we do not wish to devalue their contribution by pointing out the value of workshop experience. Third, the claimed virtues of a workshop approach and the kinds of classroom teaching and learning it fosters are based on value judgements about what is considered worthwhile and appropriate education for today's children.

If we begin by describing a <u>workshop approach</u> and how it differs from other forms of training then we are in a better position to explain its importance. This description must be in fairly general terms since no two workshops are alike; they have to be designed to fit the needs of the participants but they share these characteristics:

the participants are active, both mentally and physically. They are involved in <u>experiencing</u> the kind of learning that is being advocated for children, in <u>reflecting</u>, in <u>analysing</u>, in <u>creating</u>;

the messages that are conveyed are not transmitted by direct telling but through active involvement;

through handling materials for themselves the confidence is gained that is necessary to providing similar experiences for children;

understanding is achieved by each participant from within rather than from outside; it comes through reflecting on direct experiences and on new ideas which may be presented for discussion;

the product is not knowledge of a set of specific activities for children to do but an appreciation of new kinds of learning and some of the many ways of bringing this about in children.

Some examples of how these characteristics appear in actual events form the contents of Chapters 5-7. These describe very different situations and ways in which teachers were given the opportunities just listed. They put some flesh on the skeleton.

These examples also provide, in their descriptions of the reactions of teachers and others to workshop activities, some good reasons for running training courses this way. But, to this evidence from experience, some theoretical arguments can be added. They stem from the background of the teachers' own learning and the way anyone - child, adult or teacher - learns. If a person has not experienced learning by interaction and inquiry for him or herself the notion is too abstract to understand by just being told about it. For some adults who have come through a formal education the very word 'learn' means to be told or to find something in a book. It only takes a little reflection for them to realize that learners are, in fact, active in making sense of what they are told or read, but they may never have reflected on the process. So the idea that children's own mental and physical activity is important in their learning does not fit their concept of learning. For those who accept it as a theoretical possibility - even an attractive one - it may remain an abstract notion, not relating to their experience either as learners or teachers.

Not surprisingly, then, teachers who may apparently be intellectually convinced that children should be learning from inquiry and interaction have no feeling for what this means in practice, and so have no basis for providing such activities for children. Like a blind man who has been told that colour is important, they are in no position to apply this knowledge. Being told about something is not a substitute for experience of it. On the other hand teachers who have experienced the interest and excitement of finding out about things through their own activity know just what it is that they are trying to do for the children. They know that such work is exciting, absorbing (yes, also frustrating and irritating at times, but always compelling) and leaves a lasting impression. The knowledge generated this way is their own and no one understands it better than they do; they do not depend on others explaining it to them.

What is a workshop?

Experience by teachers of the learning that can be achieved by activity is the core of the workshop, but it is not the only component. If it were then there would be a danger of mistaking physical activity for learning and concern with supply of equipment and materials for the teachers' role in learning. It is essential that teachers' experience also leads them to appreciate the value of discussing ideas with others, exchanging views and settling arguments by testing out alternatives. This extends their own experience as learners and helps them to appreciate that children need time to talk to each other as well as interact with materials.

But teachers also have to stand aside and reflect on their learning and look at what is involved in making provision for it. It is appropriate, therefore, to give some lead in how the learning experiences can be analysed. This should include some discussion of how particular science process skills, ideas and attitudes develop and how specific learning activities assist this development. It is not enough for teachers to know that children enjoy activities, but they should also know what can be achieved through them.

Reflection is a central role in a workshop. After enjoying specific activities and realizing what children can gain from them, teachers have to be able to see particular activities as means to providing certain kinds of learning rather than ends in themselves. The understanding of the nature of intended learning opportunities provides a mental framework for planning and selecting activities for their own pupils. This framework enables them to see that there are many different ways of providing opportunities for learning, and that, working within it, they can take advantage of the local environment and the interests of the children. With no reflection and analysis, the ideas teachers take away from the workshop may be restricted to those specific investigations which they carried out themselves. And when these activities have been used with the children, the teachers will lack the ideas and confidence to devise and try something new.

Part of the analysis is to examine the teacher's role in the learning. At first, it may seem that the teacher does not have a role, but this is only because it is an unfamiliar one and may not be recognized. Aspects of the role required in helping children to do their own learning are indicated in Chapter 3. A few points only are mentioned here to illustrate how a workshop might help teachers to realize the part they have to take. Questioning skills are an essential part of the relationship between teachers and pupils. Changing to asking more open questions and fewer closed ones, putting questions in a person-centred form ('What do you think about ...?') rather than a subject-centred form ('What is it? Why does it do that?') are effective suggestions. Equally important is to provide help in handling the questions the children raise.

A further aspect of their role is to help children to communicate with each other, and ways of organizing the class to encourage this can be suggested, for example by setting a group task that really demands cooperation. Then there is the issue of what kind of record children might make of their work - how to encourage them to keep notes that help their investigation without giving the impression that science is all about writing things down neatly. These areas must be discussed, for teachers will probably have to change their established ways of dealing with them, and will have to work out for themselves the best ways for them of making these changes. At some point in a workshop there should be time to sit down and begin to reflect on these things. A few notes or a discussion paper can help. Often the reaction to ideas in a discussion paper are low key when first introduced. A lengthy discussion is not often productive before teachers have tried to adopt a new role. When they do, then they are likely to need help and to be glad of some written suggestions to turn to.

It is sometimes possible for a workshop to include trials of activities with children in schools (as in the example in Chapter 7). More often, though, the application of the experience of the workshop has to take place outside it, as described in Chapter 5, but in such cases follow-up meetings are essential. Work with children should be seen as an important part of the training, for teachers cannot appreciate the demands of their new role until they have tried to step into it. Just as they must experience learning about things around before they understand what it means, so the ideas about helping this learning must be turned into reality and not just abstract ideas they they know <u>about</u>.

During the initial period of putting into practice the ideas gained in a workshop, teachers need continued support. Ideally this should take the form of counselling from the advisers or trainers providing the workshop who may visit the school and hold meetings of teachers. If this is not possible, a group of teachers involved in the same enterprise may provide mutual support and meet together to review their classroom experience and apply ideas from the workshop in seeking solutions to problems. By whatever means, it is important for teachers to have some way of replenishing the motivation and confidence gained in the workshop. Otherwise it may seep away in the struggle to make changes in a context that seems to oppose any change. In reality, the degree of change may often be less than hoped for and intended. But, if some impact remains, this provides a start for further efforts. Changes brought about by increments are more likely to be stable than ones that are sudden and create discontinuity.

The context of change

Even modest expectations of change may not be met, however, if the only efforts are those of individual teachers. A change in the aims of science teaching, such as can come through training by a workshop approach, cannot be made in isolation. It can be supported within the school if several teachers are working together in the same direction, and if similar changes are made in other subjects of the curriculum. But outside the school, the values and attitudes of parents, other members of the community, school inspectors, examination and assessment bodies, etc., have to taken into account. Such matters are outside the scope of this chapter. An example of how these operate is to be found in the account given in Chapter 7 and the wider social, political and cultural context is discussed in Chapter 4.

Points for discussion

1. Readers might reflect on their experiences of courses, as trainees or trainers, for evidence relating to the claims made about the value of active, practical, workshop experiences for teachers.

2. Each person in the group should write down their own understanding of the process of learning something, and then compare notes with others.

3. The energy required to prepare and the time required to run a workshop are considerably greater than what are needed to provide a programme of lectures and discussion groups. Can the greater effort be justified in relation to science teaching? What about other areas of the curriculum?

CHAPTER 3

THE TEACHER'S ROLE AND IMPLICATIONS FOR TRAINING

Jos Elstgeest

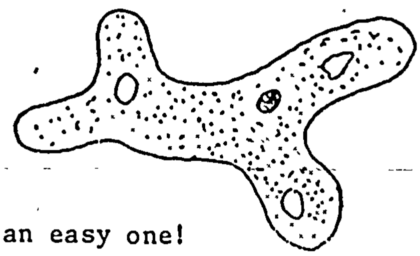
Prelude

At one time, when I was giving teachers training in the finer points of science education, I discovered, almost by chance, a few amoebae in an acquarium which I used to keep. I managed to culture these, and they rapidly multiplied into a solid, populous colony which survived for nine months. As it happened, the amoebae at the time featured high in the syllabus of the Cambridge Overseas School Certificate, which all my students were supposed to have 'covered' and 'passed'. I had a group of students who professed to be particularly interested in biological science, and who had signed up for a special course in science education. They wished to pursue their biological interests to a greater extent and in deeper depth. It was for these special students that I had set up a number of microscopes with preparations of these living amoebae, together with a few prepared slides of dead and stained amoebae.

I told them that I had found an interesting living creature worth our attention, but that I would not tell them what it was, for one should not introduce people to old acquaintances. They focused their microscopes. Some squeezed two eyes tightly shut, others focused on the dust of the coverslips, an indication of the frequency with which secondary students studying for 'Cambridge Overseas' handle microscopes. However, a few old hands managed to bring the amoebae into view, and soon everybody could watch the protozoon at leisure.

Allowing them some time to watch, I carefully asked them who this little fellow might be. The majority thought it was a hydra, some ventured 'a tape-worm', and one boldly stated that it was a 'tripod'. Not one, not a single one, offered the idea that it might be an amoebae!

Then I drew this on the blackboard:



Immediately their eyes lit up. That was an easy one!

Everybody recognized this as an amoebae. Some even identified the protoplasm, the nucleus and the 'vacuums'. I told them that this was nothing but chalk rubbed on a blackboard, and that the amoebae were sitting under their microscopes. Unfortunately, my clumsy drawing was elevated to the realm of reality, while the things under their microscopes remained an act of faith.

This anecdote may serve as well as a lengthy discourse to illustrate the inadequacy with which many well-disposed and able students enter their training as science educators. The rapid expansion of universal (primary) education on the one hand, and the explosion of scientific knowlegde on the other, have given the slower evolving educational systems little chance to keep pace with these developments.

Learning and then teaching by rote

Educational aims and objectives established by national systems of education tend to be static, or, at least, protected from gradual change from below. National systems of education are often centrally controlled, and this brings in a political dimension which cannot be ignored. Either the system, together with its aims and objectives, is perpetuated out of political prudence, or a sudden change is centrally forced upon the unaware. The latter eventuality usually turns out to be a farce, and its 'implementation' becomes a ritual. The covers of the books may change, but the content does not, and the people who carry out 'the change' remain politically prudent and do as they always did! (Chapter 4 will elaborate more on this aspect.)

For these reasons, very little real change has taken place towards learning through understanding. The majority of students entering teacher-training have come through a rote-biased system, and need to shake it off. But this is easier said than done, for it has affected them profoundly. To pass on what you have been told seems the most obvious thing to do, and the simplest way to do this is by rote. The circle is complete - and vicious! It has to be broken by introducing, at some point, learning by involvement, not by rote. The place where this vicious circle should be broken is the teacher-training institution.

A different way of learning

The tendency in those more modern programmes of science education which have had a profound influence on curriculum development for primary schools, has been to educate children through doing science, in contrast to talking to them about the achievements of science. The part of (primary) education which can be called 'science education' aims at educating children towards a logical approach to identifying and solving problems. In addition to building and expanding basic concepts and acquiring necessary skills and abilities, the children must gain sufficient confidence in themselves to put this approach into practice. By engaging children in exploration with a variety of materials taken from their environment, we encourage them to solve problems that _they_ can handle.

Ideally, then, children are placed in a problem situation, surrounded by suitable and appropriate materials, and they are not given answers. They may be shown the way towards a satisfactory solution; they will be encouraged to explore. The answers they seek are hidden in the things which they are allowed to handle, to manipulate, to experience. If they are given anything, it will be the right question at the right time. The searching for and the finding of a solution are activities they have to do themselves. They have to puzzle themselves, to experiment themselves, to reason themselves, to make mistakes themselves, and to find the way out of those mistakes themselves by reconsidering the evidence which led to their faulty conclusions.

The value of these experiences lies in continuous trying, and so achieving one's own result together with one's own confidence. The result, or 'answer' is, by itself, of little importance, for no matter how many answers the children do uncover, they will always encounter a new problem. The good lesson to be gained from this is the realization that we are always surrounded by problems, but that we can face them with confidence, since we have learned to do something about them, by ourselves. This special way of thinking in which we try to educate our children - the logic of cause and effect - stimulates the inquiring mind and goes together with training for basic skills and techniques that will give the children the ability to satisfy their curiosity.

By successfully solving many simple, but challenging problems, the children will be able to transform their problem-solving abilities into the confidence of understanding. This implies quite a change in the approach towards the teaching of science. It is a change from teaching about science to educating through science. It is a change from teaching content to teaching children.

Different objectives for learners and teachers

Clearly, a different approach will have different objectives, and in the approach to science education described above the emphasis has shifted towards assisting the children to acquire, to develop and to use certain skills and abilities - process skills and learning abilities.

These can be briefly summarized as follows:

the ability to handle materials;

the ability to ask relevant questions;

the ability to observe accurately;

the ability to measure correctly;

the ability to manipulate numbers and to compute;

the ability to collect, organize and evaluate evidence;

the ability to recognize and indicate relationships;

the ability to discover and use patterns;

the ability to predict sensibly and intelligently;

the ability to design relevant experiments;

the ability to make and use abstractions;

the ability to communicate effectively and understandably;

the ability to use and increase one's own resourcefulness and creativity.

To these skills and abilities may be added such essential qualities as functional literacy, perserverance, sociability and teamwork, willingness to respect the viewpoint of others, and a willingness to change your own mind when new evidence calls for it. Training in, and a degree of mastering of, these basic skills and abilities provide the children with a powerful tool with which to continue their intellectual development within their environment and within their community.

The reason why I dwell so elaborately upon these basic goals and principles is that they apply equally, if not more so, to the teachers who are to carry out the work. Before finishing ~~their training~~, teachers must go through a complete change of attitude towards science, towards what science education is about, and often towards children and what they ought to learn. They must learn through their own experience the richness of doing science. They must learn how the process of science is related to becoming self-confident and self-reliant in thinking and problem-solving. They must learn to trust themselves.

This has profound implications for teachers' initial training and continued education.

Good teacher training is not served by a spectrum of theoretical 'talkabouts', nor by providing the trainees with a bag of teaching tricks, often called 'methods', which they can learn by rote and forget by the time they will need them. The purpose of a teacher-training course, be it pre-service or in-service, should be to provide the teachers with basic experiences concerning their environment. This will stimulate and reinforce an inquiring mind.

Teachers often teach the way they were taught because this gives them a sense of security. Security is important, for nobody can base his practice on doubt. For this reason, teachers tend to prefer learning materials that reflect 'the way it always used to be' and assume that this must be good. Publishers pander to this conservatism, for the sales value of textbooks, workcards and other printed matter is directly related to the amount of confidence they bring by virtue of their traditional rote character. For such teachers, the training they have had has failed to break the vicious circle.

However, a more open-ended, problem-posing approach to the teaching of science would require the teachers to possess proficiency in the basic skills and abilities enumerated above. This proficiency is never acquired by rote, but only by active involvement. Therefore, suitable fields of study should be found which are open-ended enough to provide for the varied - and adult - interests of the students, but which are related to the environment in which they work. This 'environment' is nothing more than their own surroundings, and they will work in it in the same way as they will have to work with and within the (school) surroundings of the children. Our 'environment' starts within our own shirt or skirt, and it stretches out around us in ever-widening circles - even to the extent of the whole universe.

Breaking the vicious circle

From the very beginning of the training programme, the teachers should be induced to study science in the way they are expected to teach it in the schools. A teacher-training course, accordingly, will comprise many activities, and will have the character of a continuous workshop with a multiple purpose: science and education; things and children; encounter and interaction.

Studies, founded on the many possibilities for investigation offered by the world around us, help the students to realize that science is not merely an enumeration of facts described by others, nor an account of inventions and discoveries, but rather a process of investigation which can lead to a deeper understanding of the world in which they live. Immersion in the study of the environment is a first requirement if teachers are to learn to look at the things around them with different eyes and with questioning eyes; for everything evokes questions, invites investigation, challenges beliefs and calls for creativity and resourcefulness.

A new, fresh look at ordinary things may help one to discover possibilities and potentialities for learning as well as for teaching. Imagination turns a bush of bamboo into a source of balances, cages, containers, vessels, battery holders, water ducts, musical instruments, telescopes, pumps, catapults, spatulae, blow pipes, lens holders, abacus rings, skewers or even artful sculptures. Besides, bamboo itself is a fascinating, fast-growing giant grass with a hollow structure of surprising strength; it has a typical way of propagation; it is the home of many animals. It even is a condition of life for the giant panda! It is a bush full of opportunities for scientific and mathematical activity.

Most ordinary crawling insects, such as dungbeetles or ladybirds, or their larvae, such as antlions or mealworms, become absorbing living creatures with their own enthralling codes of behaviour built in to them, and which, if intelligently handled, will reveal many secrets. The phrase: 'Ask the antlion' or 'Ask the mealworm' may draw a smile, but it is an earnest invitation to scientific work. By placing the creature in an environment which you can control, it will always respond in its own particular manner, thus providing an honest answer to an honest question. This is most revealing to children and teachers alike.

Seeds, instead of being held to be exemplars of the eternal diagrammatic dicotyledon bean or monocotyledon maize, become a multitude of enchanting packages of life, each with its own individual set of enigmas which are disclosed in varied uniformity by the powerful urge of germinating seeds to survive and to become something.

The spinning top, or the spinning calabash or bowl suspended from three simple strings twisted and released, places the forces which govern the universe into the hands of children.

However this may be, it must be acknowledge that in the training field of science education the acquisition of a new attitude is a slow and arduous process, sometimes painful, often rough, but always interesting to follow and rewarding in the end. Many find it difficult to appreciate an unfamiliar approach to science on the first day they are confronted with it, and they put up some resistance. But it is essential to introduce teachers to a number of activities based on the ordinary local environment in order to get them involved in some of the basic experiences of problem-solving activities of the type we envisage for the children they are going to teach. Very often they have never done such a thing before. The introduction often has some shock effect, and people are apt to resent this. It is painful to be confronted with your own limitations, especially when this limitation was hitherto hidden behind some convenient façade, such as the authority of a textbook. Perseverance is called for, and a careful selection of relevant and challenging activities, so that old ways are unlearned and new skills are acquired, together with a new sense of security and confidence.

Being taught by ants

The same students who were flabbergasted by the supposedly familiar amoebae at the beginning of their training, later performed a study of weaver ants which is worth recalling here. They had found weaver ants in the mango trees around their college. The ants, called Oecophylla because they like houses of their own, live in nests made of green leaves which they sew together with the help of their own babies. The larvae secrete a sticky spinning material, and the adults, grabbing them in their jaws, shuttle them to and fro, while uncles and ants hold the leaves together with all their might. The result is a well-fashioned, strong bag of leaves which provides room for a large family of ants. Whether they were homes of family units was one of the problems, of course.

These ants are well advanced and sting viciously when disturbed. The students became fascinated by the ants, and they continued their study for a long time, in the trees as well as in the laboratory. A few nests had been taken into the laboratory and suspended from strings stretched from one end of the room to the other. The ants proved remarkably adaptable to indoor life and provided the students with many surprises, the use of the spinning"babies not being the least.

The problems, and subsequent investigations, were quite diverse. To the problem: 'how do they build their houses', the ants gave a variety of answers. In the trees, they built and repaired their nests in the way described above. But, in the laboratory, they showed their craft by weaving a net right across the mouth of a suspended beaker, and settling snugly underneath. A small group of ants had taken to a test tube which had casually been left some distance from their headquarters. In this test tube the ants built a web-like floor half-way down, as well as a roof at the top.

The ants showed that they were real nomads, for they frequently abandoned their nests and rebuilt them somewhere else. The students noticed that this happened in the trees too. As soon as the sewn-together leaves dry up, the ants build afresh using green leaves. Did the ants prefer the kind of air conditioning provided by the living green walls, and was want of this the reason why they moved so frequently in the laboratory? It was fun to follow foraging ants (were they really foraging?), but it did not solve many problems. They seemed to be rather friendly towards neighbours, who were thoroughly inspected and frisked at every encounter. Yet they were very aggressive towards any other creature crossing their path, including teacher trainees. The community of ants seemed to have a sort of clean or tribal structure, for ants brought in from further away were mercilessly attacked and massacred.

The problem of food preference remained unsolved, as the ants devoured with relish practically anything offered to them. However, since they predominantly lived in fruit trees, the students provided the ants with sugary solutions. Glucose seemed to attract them most. Solutions were dyed with food colouring of different hues, and placed at various distances from the nests. This gave rise to colourful parades along the strings from which the nests were suspended, as the Oecophylla's belly is quite transparent. This experiment began also to answer some questions about the social set-up of a colony of Oecophylla in captivity, but it raised more questions concerning the ants living in the wild, who refused to drink from the coloured potion.

Reproduction was a real puzzle. The search for a queen was unsuccessful, yet there seemed to be a daily supply of fresh eggs. There was also a busy traffic in larvae and pupae, and the population in the laboratory was growing. Normally we assumed that ants have queens who take care of reproduction. Were we, perhaps, observing an Oecophylla republic?

Of problems there were plenty, and many remained unsolved. Turning to the literature on Oecophylla was of no use here, as there was not any. Yet the students learned much, although the challenges never ended. How do they spot their food? By sense or by sight, or by both? How sensitive are their eyes? (Very!) How do they communicate? Of what importance are their feelers? They move, and seem to use them incessantly. When and how do they decide to make a new nest? How do they divide and organize labour? Of the two clearly distinguishable types of ants living together, the smaller and the larger ones, which is the 'male' and which is the 'female'? Do they have any sex at all? For what possible reasons were the smaller ones periodically killed and discarded in huge numbers? They literally littered the floor of the laboratory. What are those free-wandering ants which carry nothing at all, so busy with all the time?

Many of these (and other) problems were not, or only partly, solved, but the work was a boost to the students' morale. Without serious study, these questions could not have been asked, as they came forth from close observation and deep involvement. To not have a ready answer was no longer a source of embarrassment or frustration. Becoming more systematic in their research efforts gave the satisfaction of having found a way towards finding answers. Given time and opportunity they would be able to induce the ants to give up more of their secrets. This is confidence.

Later, when these students were on teaching practice in schools, there were a few classes of children very busy with weaver ants. These children were not told about the weaver ants. They learned to ask the weaver ants questions like those their teacher had asked in the college - and in a similar way: by placing the ants in such a situation that they had to provide some kind of answer. They could not always interpret the answer they received, but that is a different matter. The teacher, having been so much involved with these creatures, could not but introduce his children to Oecophylla and then step aside and let them explore and investigate - helping where help was needed, and informing them only where information carried them forward. Unsolved problems remained unsolved, for the ants did not give up all their secrets. However, the children did not blame their teacher for this, and neither had the teacher reason to feel frustrated, nor ashamed for appearing ignorant. If the answer which the ants gave were not clear, it might be that the right question was not asked in an appropriate way; so, let us try again.

Let this somewhat detailed account convey its own message. In my own experience of teacher education, I have not yet found a better way to prepare teachers to initiate and guide an honest interaction between children and a part of their environment.

Implications for training

In teacher training, one never ends with a discussion of the scientific significance of the materials under study or the activities undertaken. One always goes on to consider the relevance of these to children. What, of what has been done, would appeal to children? What could they do? What would they gain from it? What possibilities are there to challenge the children? In other words, one gauges the educational value to children of the scientific activities evoked by the materials under study (the subject-matter in the environment). This is often done in the discussions which arise from the activities undertaken in the training course. But there must always be a basis of actual experience with children in order to be able to assess the educational value to children of a student's activity. A teacher, after all, is a professional in child development.

During pre-service training, this experience is provided by working with children whenever appropriate and possible - sometimes in small groups, sometimes in classes. Small-scale teaching situations, where a student teacher works with a few children only, and is observed by a few others, give the students an opportunity to watch closely the interaction between children and the materials they are working with and with the teacher who is guiding them. Large-scale situations, where student teachers manage a normal class of children in an existing school, immerses them in the complexity of real school life. Both experiences are needed, even in in-service courses where, of course, the teachers' own experience counts first, but where situations should be created to work with children if so desired. To my mind there is no better way of training teachers than by actually involving them in exploring and trying out (new) ideas, experimenting with (new) materials and considering the pedagogical possibilities of these materials and activities, and evaluating this in interaction with real children.

The task of the teacher has changed. No longer does the teacher do all the talking, nor do the children do all the listening. The things - taken from the immediate surroundings or brought into it - themselves begin to play a very significant role. In fact, the things (ants, magnets, flowers, water) do the teaching, the children do the talking in an inquiring way, and the teacher listens, looks, interprets and provides.

In other words, the task of the teacher is to select from the children's environment relevant subject-matter, or to attempt to provide this from without, thus enriching the children's environment with appropriate materials. With these materials at hand, the children can practice basic scientific skills and abilities. Doing this, they have an opportunity to acquire, and to build further on to basic scientific concepts.

On this assumption, the task of those who train teachers may be summarized as follows:

to provide the teachers with basic experiences of their own environment so as to encourage an inquiring mind and an inventive attitude. Through their own experience, the teachers should discover the rich potential of doing science (as opposed to the infertile ritual of rote learning);

to make teachers aware of the value of education in scientific activity as a progressive way of learning, as a way of learning to think and to solve problems, and as a way to gain self-confidence and self-reliance;

to make the teachers proficient and competent in the procedures through which we want our children to be educated: actual scientific activity;

to make the teachers aware of the special nature of children, of their relation to their environment and of the way they learn, so that they will find it easier to recognize problem-solving situations suitable for children;

to generate in the teachers a degree of resourcefulness, creativity and understanding in handling materials and children.

To build a teacher-training programme which fulfils all these worthy aims is not easy. Much will depend on the overall quality of the teachers, on the flexibility of the responsible authorities, on the prevailing school system, on the immediate environment, and on the commitment of tutors in charge of science education. However, it is good to have teachers who have learned to challenge their children with problems that appeal to them, and who give children confidence by allowing them to find their own way out of these problems. These teachers become children's companions on the long road of learning taking them by the hand when they cannot cope by themselves, but skilfully encouraging them to cope all the same. These teachers have learned to use the environment as a source of knowledge, and their children learn to benefit from it.

Points for discussion

1. Is the vicious circle described in this chapter inevitable? Is it possible to teach children to learn in a way that teachers have not themselves experienced?

2. Contrast the role of the teacher during a lesson where children are using scientific skills in problem-solving and investigating something from their environment with the teacher's role during a 'transmission' lesson, where children are simply told the facts about the same object or phenomenon.

3. What would be the main differences in the way the teacher would prepare lessons of these two kinds?

CHAPTER 4

CHANGE IN SCIENCE EDUCATION: THE SOCIAL, POLITICAL AND CULTURAL CONTEXT

Juan Manuel Gutiérrez-Vázquez

Introduction

Many readers will no doubt have been present at the closing session of a workshop given to improve the teaching of primary science. The participating teachers show themselves to be enthusiastic about all they have learnt and are impatient to apply their new-found knowledge and abilities. We have probably also all been surprised, on visiting these same teachers months or years later, to find them using the same methods that they had employed before their participation in the workshop: the new knowledge and abilities have had no real impact. Although we cannot ignore the fact that this failure has much to do with the organization and methodology of the workshop, we must also take into account that our usual exclusive concern with educational content and teaching methodology leaves aside the consideration of social, political and cultural factors which influence, and are influenced by, educational innovations.

In this chapter we are going to consider some examples of such social, political and cultural factors which influence and even determine the destiny of new approaches in science education. Some of these factors in their turn are affected by the implementation of the new approaches in such a way that the eventual development of the innovations is compromised or altered in a manner far from that desired. These considerations are relevant for the planning of pre-service and in-service teacher training activities, for knowledge and better handling of these factors will permit the teacher to adopt a more realistic position in the performance of his task. If social and cultural influence seem at first not to be relevant to science education it takes but a little reflection to realize their significance and that this realization can give a teacher a better chance of success in the implementation of all he has learnt during a workshop designed to aid and improve his job as an educator.

Science education and social structure

In many parts of the world a considerable number of school-age children never set foot inside a school. Many of these children are of peasant farming families living in geographically dispersed, isolated settlements, who survive by very basic subsistence agriculture. Others are children or urban families living in conditions of chronic unemployment in the 'lost cities' and shanty towns of big cities. Of the children that attend school in such areas, a high percentage leave before third grade (frequently more than 35 per cent of those who enter first grade). In this way the children of the countryside and urban areas are systematically impoverished by prolonged underemployment.

These factors play a part in the problem of what to teach, how to teach it and when to teach it, in the school as well as during teacher training before service and in-service. In spite of this, many countries continue to design curricula and syllabi without considering the problem of school drop-outs. In some countries, for example, during the first grades of primary school, children study the physical and human geography of the region in which they live, in the middle grades the country to which they belong, and in the top grades continental and world geography. In such a system, a child who abandons school between the first and the fourth grades never studies the geography of the world, of his continent or even of his own country.

In the case of the science curricula, the problem is even more dramatic. Frequently there is no science at all in the first grades, with the consequence that a drop-out does not have any contact with science in his brief experience of school. By contrast, in other countries 'spiral' curricula have been designed and implemented, so the most important 'lines' of scientific ideas (matter and energy, living beings and their environment, our planet, heavenly bodies and outer space) are introduced in the first grade so that the drop-out can study, while in school, a relatively wide and comprehensive spectrum of what science is and represents. Furthermore, in some other countries curriculum development groups, taking into account the drop-out rate, have introduced early important topics such as nutrition, construction materials, natural resources, environmental conservation.

We should not, however, continue to assume that the causes of school drop-out are all due to factors outside the educational system. Without negating the importance of socio-economic factors, which the school itself cannot hope to correct, it is clear that within the school itself there is much which encourages children to drop out: the irrelevance of the curriculum to their everyday lives, the alien terminology used, and the methods and values (both implicit and explicit) used in evaluation.

Many will have visited impoverished, small, rural schools where the children are embarrassed by the expected norms of hygiene which may be outside the possibilities of a peasant family, where they are required to learn (i.e. memorize) the structure of the ear (ear-drum, malleus, incus, stapes, utricle, saccule, cochlea, endolymph ...) or that of the eye (iris, pupil, cornea, ciliary body, fovea, aqueous humour, vitreous humour, sclerotic, choroid, retina ...). Similarly there are large, urban schools overcrowded with children from very poor inner city areas, where the middle-class language of the teacher is difficult for the pupils to understand and the topic of the day is to consider the differences in structure and function between phloem, xylem, cambium, suber and phellogen in vascular plants. When a child finds himself for the second or third time in the same grade, he must ask himself legitimately what he is doing there and if there is not a more suitable place to learn the abilities and skills which he needs to survive his hard, everyday life.

When education is regarded as a social process, we have to recognize that in the school society has produced and reproduced a rather conventional and relatively inflexible educational institution. Whether schools are located in the industrial, developed zones of big cities or in rural areas, in many countries, the schools are more or less the same. The same curriculum, the same syllabi, the same textbooks, the teachers prepared in the same way and using the same or similar teaching methods; even the buildings are recognizable from afar without fear of being mistaken. The in-service and pre-service training of teachers, no matter how important the innovation which is to be implemented, must take into account this uniformity and stability of the scholastic process. The training of teachers must conform with the system; the products of curriculum development teams, be they new strategies or new materials, are used generally within the same system. It is not possible to implement a flexible curriculum in a rigid educational system. When there is a syllabus that the teacher is obliged to cover, it is not possible to suggest many and diverse topics, with the idea that the teacher can choose from them according to the interests of the children and the community in which the school is situated. In the school's eagerness to implement the syllabus, some teachers have reached the point of asking pupils to learn (i.e. to memorize) the relatively-complex information contained in the teachers' manual.

Curriculum development and educational policy

The social mechanisms mentioned above provide one reason why the curriculum development is not of equal benefit to all children attending school. Other reasons can be found in the educational policies which many countries have to adopt. When educational resources are insufficient, that which is allocated to basic education is often apt to favour urban populations rather than rural. Educational investment, too, is often greater in the more developed, industrial areas of a poor country than in its zones of subsistence agriculture. Again, a poor country is forced to make a proportionately greater investment in secondary and higher education than in basic education. Consequently, the more experienced teachers with better salaries go to the cities while the less experienced (perhaps with smaller salaries) to the countryside.

The teaching of science, the results of these policies is likely to be reflected in more and better resources, more highly motivated classes and more modern, advanced and flexible methods of teaching for those who live in city areas; in contrast to a near absence of resources and more rigid, traditional types of classes for children in rural areas. Sometimes a rural teacher may be imaginative enough to make creative use of his natural surroundings with the pupils. But, sadly, it is more common to find that the teacher, who graduated in the city, will teach as he or she was taught and explain the structure of the flower with the help of badly drawn diagrams on the blackboard - quite oblivious of the fact that the school is surrounded by hundreds of real flowers! Education is not going to compensate for a nation's lack of resources, but a system should prepare its teachers to improve the teaching of science by making the best of the available or possible opportunities that circumstances offer.

An idealistic view of science itself can sometimes hamper the value of science education. Science is often presented in school in a very conservative manner. It is accepted (without discussion) as a body of knowledge, well established (and sometimes even well structured), where the only requirement is to learn it and reproduce it for the examination. Nothing is mentioned about the problems the pioneers encountered during the search for the validation of new knowledge. Nothing is said about the contradictions, disagreements, criticisms and controversies. Nothing of the conflicts which occur inside scientific activity itself. Science, thus taught, is seen to be faultless. Clearly, teachers of science cannot teach conscientiously and purposefully in the classroom without raising doubts, generating discourse, posing alternative possibilities and creating a willingness to struggle with the facts, as the pioneers themselves had to do.

All these issues affect science educators, and have to be taken into account when planning and carrying out pre-service and in-service teacher training. What is included in courses should not be the same for teachers working in rural schools or destined to do so as for those who are going to work in urban areas, for this may maintain and reinforce existing inequalities instead of correcting them. Training courses should also help the teacher to know and to handle consciously the role that governmental policy plays in the development of syllabi and educational materials and in the educational process and development of the educational system, so that he is able to adopt an informed position, as is his right in a democracy, and can recognize the responsibility he has towards his pupils. Courses should also make provision for helping teachers to understand the reasons for innovations in curriculum if the innovations are to have any chance of permanent implementation.

Educational innovation and cultural variations

Educational institutions and systems are prone to require uniformity in the way they apply methods, procedures, curricula and educational materials. The same norms, models or criteria are applied, despite the sometimes enormous cultural differences between two regions of the country. For example of such differences, it is not necessary to look for zones with dramatic biographical dissimilarities: cultural differences is always marked between the city and the countryside, the mountains and the coast, the plain and the jungle, hot and cold climates, an area dominated by Indian populations and one in which Mestizo people avail. And, of course, there are cultural differences within a single city. Just as a teacher cannot overlook social and economic differences, so it is not possible for him to disregard cultural differences. Every region, area, ethnic or social group has its own culture, which has to be learnt and understood.

A science class conducted in an extrovert, discursive, open manner and based on discussion can be a roaring success in one place and a dismal failure in another. A lesson on computers, prepared for Tokyo children, would have little meaning for rural pupils in Bolivia. A sex education class will be approached in a very different way in urban Sweden than in the Somalian plateau. Although the topic may be the same, the study of plants and animals ought to be differently designed for a countryside pupil than for a child of the inner city. The implications of all this cannot be overlooked in the training of teachers.

Parents also have an idea of what is or what should be involved in the education of their children, of which educational procedures are appropriate and which are not, what the content of their courses should include, of the relationship that should be established between teacher and pupil and of what they definitely do not want their child to do in school. Whilst not suggesting that the school and teacher should faithfully follow all the parents' ideas on education, they cannot be ignored altogether. To do so may mean that on top of the problems within the school provoked by the implementation of an educational innovation, we find too late that problems outside the school only serve to aggravate it. There are many examples of this problem. In science education they can arise from topics relating to the origin and evolution of the universe and the solar system, the origin of the species in general and of man in particular, the functioning of the human body, biological inheritance and sex education, health care including nutrition, the use of natural resources, environmental deterioration and the relationship of science to society. In educational procedures and the pupil-teacher relationship, many communities continue to prefer authoritarian and rigid teachers who will not tolerate any informality in their pupils; they wish to see pupils fill page after page with meaningless phrases, but in good handwriting, whilst the children sit quietly in their places. These parents consider it a waste of time for children to do experiments, to go on trips to the countryside and organize discussions; they say the modern teacher passes the time playing and chatting with the children and does not teach them anything.

The culture of the place may affect work in science in diverse ways. There are cultures, for example, in which the spoken and written word has acquired a mythic status, and is treated with reverence. It does not matter if reality stubbornly shows a contradiction between words and actions: the value placed on rhetoric is high, and it generates an excessive confidence in the belief that documents and lectures can change reality. So, educational officers present addresses, write papers and give press interviews; bureaucrats produce circulars; authors write books and teachers' manuals; professors give talks and conferences; and everybody feels happy and satisfied because 'now we've got it'. The reality, however, is that class practice, and science education with it, continues more or less the same. 'Change' is given much lip-service, but is little acted upon.

A final comment about the implications of culture in science education must concern the traditional role that society still assigns to women in so many places. According to this stereotype, science and mathematics are male territories; if a women really wants to study science, she can do biology, perhaps chemistry, but physics is too much for her. Not a few elementary school teachers address their science lessons mainly to boys, or at least they deform their audiences through the low expectations they show towards girls as science learners. These attitudes are not infrequently reinforced by parents themselves. Thanks to the organized pressure exerted by groups of progressive women, the situation is changing to the benefit of women, of science education and of science itself.

Finale

Significant and lasting advances in science education must be based upon the knowledge and understanding of the daily educational process as a phenomenon in which many social, economic, political and cultural factors join and participate. In preparing teachers, the mastery of scientific concepts and principles and of the basic abilities and skills that we want to teach is not enough. Neither is the mastery of a particular teaching methodology. The educational reality has to be studied, understood and later modified through a multi- and interdisciplinary approach. To achieve this we need the help of teachers, physicists, chemists, biologists, geologists and astronomers, as well as the participation of psychologists, sociologists and anthropologists.

Points for discussion

1. In what respects are pupils' learning opportunities made more unequal by giving them all the same curriculum and teaching? To what extent does justice require that all the children are treated as equal or that the inequalities of their backgrounds are taken into account in school?

2. What examples can readers give from their experience of the clash of values between parents and schools where innovations have been attempted in the curriculum? What suggestions can be collected for reducing the conflict?

3. Examine some currently used science classroom materials with a view to detecting bias relating to sex roles. What action, if any, ought to be taken to avoid communicating a male-dominated image of science?

Suggested readings

Alumnos de Barbiana, 1975. Carta a una Profesora, Ediciones de Cultura Popular, Mexico.

Apple, M.W., 1979. Ideology and Curriculum, Routledge and Kegan Paul, London.

Eggleston, J., 1977. The Sociology of the School Curriculum, Routledge and Kegan Paul, London.

Fuentes Molinar, O., 1979. Educación Pública y Sociedad, en: González Casanova, P., y E. Florescano, 1979. México Hoy, Siglo XXI Editores, Mexico.

Jackson, P.W., 1968. Life in Classrooms, Holt, Rinehart and Winston, New York.

INTERLUDE

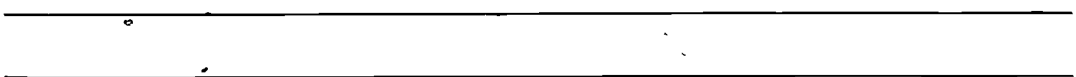
TWO VIGNETTES

Jos Elstgeest

I took over a lesson at the request of a practising student teacher. It was a class five in a primary school. To take over a lesson all of a sudden in a strange school does not enhance a free and open atmosphere. The unprepared teacher is a stranger and has to think things out while he goes along. The children react to a stranger with mixed feelings and misgivings or apprehension. Anyway, I always learn from the experience, and gladly accept every opportunity to work with children.

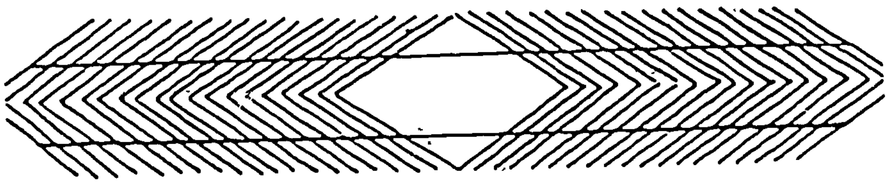
Since I was given barely two minutes notice, I scarcely had time to prepare many things. So, I decided to play about with optical illusions which usually lead to interesting questions. A number of nice problems can be solved with the help only of paper, pencil and ruler.

I used a ruler to draw two straight lines on the blackboard:



My first question was: 'Are these two lines straight?' This was a very poor question, I admit. There was, of course, no response. I could hear them thinking, 'What do you want, stranger? Of course those two lines are straight. We saw you draw them. So, obviously there is some trick behind this question. You are not going to catch me!'

Next I drew lines across the two long ones:



'What has happened to the lines?'

... Silence.

'Do you notice any difference in the lines now?'

... No reply.

'Would you say that the lines are straight, or are they bent?'

... Once more dead silence. Most uncomfortable.

'Oh, come on, who can tell me what his eyes see?'

The silence became oppressive. Even Knowall Johnny, who sits in every class, must have been flabbergasted. This teacher asks questions before he has provided a good answer. It is against the rules!

Finally, two timid fingers were raised at half mast. One answered 'Straight' while the other tried 'Bent'. Obviously the two sacrificed themselves to sound me out which of the two answers I wanted. Non-committally I raised my eyebrows and told them to take their notebooks.

'Draw two lines with your ruler. Then add the little cross-lines.'

The absence of my answer confused them slightly, but they were also reassured: there was a definite instruction to be followed. While they were obeying the command they must have noticed the dramatic change in the appearance of these two straight lines. It is too obvious to be missed. But not a word was spoken, no 'oh' or 'ah' ejaculated, not the slightest surprise expressed. They finished their task and looked up at me for more fodder.

'Now look at your lines,' I dared, 'and tell me what they look like'. And I kept prodding a little to no avail until once more two timorous children raised their hand. A boy ventured: 'Straight'. A girl mumbled: 'Bent'.

Clinging to this thin straw of response I requested the boy to explain why he had answered 'Straight'.

... ?? ...

What was his reason for saying 'Straight'.

... ?? ...

What made him so sure to reply 'Straight'?

... ?? ...

It was torture for both the boy and me, but I kept insisting. His compassionate neighbour finally collected all his reserves and asked: 'May I try, sir?'. Well, yes, of course. He stood up and chanted: 'I checked with my ruler, sir, and the lines were straight!' Nervously he sat down and resignedly awaited the verdict.

I was so pleased with what I thought was a first flickering of common sense that I exclaimed: 'That is good! You did check with your ruler, eh? Well done!' But then I turned to the little girl who had answered that the lines were bent. I asked her why she had stated that the lines were bent. The poor thing literally cringed in her seat and muttered: 'They are straight, sir'.

'Oh, really', I replied smiling, 'but didn't I hear you say that the lines in your drawing were bent? Do you have any reason why you consider them bent?' And to alleviate her fear I added: 'I think they do look bent'. This helped. If she had known the word 'schizophrenic', she would have labelled it on me, no doubt, but I had shown her a way out of her predicament, and she gratefully accepted. In a sweet little voice she answered: 'I checked with the ruler, sir, and the lines were bent'.

In another school, I was attending a language lesson when my attention was drawn to a classroom across the courtyard. A loud hissing sound filled the whole schoolyard. It sounded dangerously like a science lesson being conducted. And, indeed, it was a science class. The lesson was about steam turbines. In the book there was a recipe, which prescribed the use of a tin with a friction lid into which a tiny hole should be made. Half filled with water the tin was to be placed on a fire so as to make the water boil. Steam would escape from the hole in the lid and easily drive a turbine made of small blades cut from a tin and stuck in a cork. This gadget should be suspended on an axle of pins in the jet of steam which would be powerful enough to make the 'turbine' turn.

The teacher was pumping a primus stove with a fury that could only make the thing explode in his sweaty face. The stove hissed ominously loud, the water boiled vigorously, but the turbine hung limp and listless. The hole in the lid was about two centimetres in diameter ...

The children were calm and well behaved. They watched their teacher without apparent emotion. They were told to watch, so they watched. The teacher's running commentary upon what was happening was, naturally, rather incoherent, confused, and almost apologetic, for nothing actually happened to fit the intended commentary.

Worried, I finally hinted at the danger of an imminent explosion, and the teacher begrudgingly gave up. The children flocked obediently back to their places and proceeded to copy the 'experiment' into their copybooks, while the teacher wrote on the blackboard what should have happened.

Not a single child laughed, commented, or even expressed surprise or doubt at the workability of the steam turbine, and less at the ability of their teacher. The working of the steam-cork-and-tin-turbine was transferred from the prescription to the copybooks, revised a following lesson, and possibly revived at the exam to the satisfaction of those adults who had 'syllabusized' this useful toy. The answers were given, the questions remained unasked. Whatever happened to the science seemed to be nobody's business!

A STORY - THE UMBILICAL DEVIL

Jos Elstgeest

Young children often reveal a remarkable sharpness in discovering scientific evidence to support their theories. It may not always fit within the pattern of our own systematic training, but it fits within theirs, and, for the moment, that is the more important. Nevertheless, they are understandably never over-impressed with the force of scientific evidence, however convincing it may be.

In Kigurunyembe's class four it happened that teacher Prema sent her children out to search for creatures with two, four, six, or more legs. Something interesting was bound to turn up, and sure enough, one child returned with an indignant praying mantis. It caused a little commotion, for angry mantids are impressive.

The attention of the class centred more acutely around the insect, when one little girl announced that it was called Shetani, which is Swahili for Satan. When the teacher inquired why it was given such an unflattering name, the little girl revealed the unlikely fact that it eats your navel, and replaces it with its own. A truly devlish habit, most of the class conceded with little shudders. Only a few thought this outrageous, and would not believe it. Instead of arguing the point, the teacher suggested that it might be fun to test the truth of the little girl's statement. Who of the opponents would volunteer?

No one was enthusiastic about the idea, but Paskali, a round-bellied little fellow, famed for other daring feats, was prodded from behind. He finally gave in, and came to the front of the classroom lifting his shirt high. Squirming a little on contact with six hooky legs, he bravely let the mantis walk all across his tummy. The creature completely ignored his navel, although it walked past it more than once. Surely its big round eyes were bound to detect the navel! Nothing happened, and the class applauded heroic Paskali with great relief and genuine admiration.

Subsequent investigation with magnifying glasses revealed interesting details of the praying mantis's anatomy, but no matter how the children searched and searched they could not find the mantis's own navel. This, thought teacher Prema, would once and for all refute the myth of the Navel Destroyer.

But it so happened that, a few days later, the same story popped up in class five! 'Well, let us see whether it is true or not', proposed teacher Prema again. 'Who would like to give it a try?'

There was not a single volunteer in class five, as even the most outspoken disbeliever valued the safety of his navel more than a possible 'you-never-know'. Prema scoffed at them, saying that a class four boy had more guts than any one of them, but caution won over pride, and Paskali was sent for to demonstrate his courage and scientific conviction once more.

The mantis caught by class five happened to be about two sizes larger than the previous one, but now Paskli could no longer withdraw. Full of apprehension he lifted his shirt and allowed the teacher to place the mantis once more on his tummy. Eyeing it closely, Paskali followed the insect tickling across his belly, and again it totally ignored his navel. With triumph already playing around his lips, he saw the mantis turn, its long feelers swaying to and fro. The class held its breath. The big triangle-head of the mantis looked first this way, then that way, and finally decided to traverse once more. This time its course ran directly across Paskali's navel.

And then it happened. The insect stopped, close to Paskali's little button. The long feelers swung nervously forward ... With one powerful stroke of his hand Paskali sent the mantis flying, and streaked out of the door, leaving behind a hilarious class five convinced of the slinky ways and umbilical tastes of the devilish praying mantis.

CHAPTER 5

REFLECTIONS UPON A WORKSHOP TO 'ASK THE WATER'

Jos Elstgeest

Introduction

Two schools indicated, quite independently of one another, that they wanted to 'do' a project 'about water'. They would appreciate some advice and guidance. The two schools were situated in the same town, and their request was sent to the same office (the teachers' advisory centre, where I work), so it seemed a good idea to bundle the two requests and to invite the two teams to co-operate and to share resources. The suggestion was gladly accepted by both school teams.

The teachers' starting-point

In both cases, the staff had already brainstormed about the subject, and they were collecting materials which they thought might be useful. It struck me that 'water', the plain stuff itself, from the tap, from the pond, from the ditch or from the font, did not occur on either of their lists of materials. Instead there was an old tap that would no longer work, there was a pamphlet from the local water supply, an anti-pollution poster from a national anti-pollution action group. They had thought of ice and steam and of soap and detergents. The collected ideas and topics were listed as follows:

What is water?

Where does it come from?

The water cycle.

How do we get our water?

How do the waterworks work?

How does the tap work?

Water management and water pollution.

Waterways.

Floods and disaster.

Water animals.

The three states of water.

Water, soap and washing.

This enumeration of possible topics was accompanied by remarks and indications concerning possible 'experiments', books and booklets and ways of conserving information. Working with water, using water as a teaching or learning aid, was never mentioned.

Listening to these plans being discussed with me as an adviser, I put these questions to them: All right, but do the children ask about these things? Would they be interested in all this? Would they like and enjoy learning about these topics? How would you know? In what ways could, or would, they occupy themselves with these problems? What, in other words, were the children going to do by themselves? What activities did they envisage for their children?

'Oh, they can look up things in the library.'

'Oh, they could talk about it in a class discussion.'

'Well, they could fill in waterways on a map.'

'They could visit the local waterworks.'

'They can experiment!'

These remarks, though born out of forethought, did not bring us nearer to the answers to my questions. What, then, will they look up in the library? What is there to be talked about in a class discussion? (Unless there would be some common experience, but what experiences are you thinking of?) Which experiments would be performed? Filtration? Evaporation? Communicating vessels? What for? Which problems would lead to experimentation or library research? And who raises these problems? Who formulates the questions? Who asks and wants to know? The children? The teacher?

These questions, of course, are annoying. They are nasty and embarrassing. They are almost unkind. But I remember how I learned 'about water' myself. I can still see those vessels communicate! I even pocketed 'H_2O' as a completely meaningless formula. I wanted to safeguard the children from a repetition of this sort of thing. It keeps amazing me (or is it amusing me?) how tenacious our teaching tendency is to tread on the familiar ground of 'what we already know' so that we can confidently be ready with our answers. But the questions, the real problems which perplex us, which compel us to go in search of a solution, these we are inclined to sweep under the table, out of sight. However, it happens to be just these questions which are the very beginning of science, because when we ask we want to know, and we go in search of an answer.

The children's starting-point

'Ask the water' has always been my motto. Wring the information you seek out of the thing itself. By doing just that I have learned so much myself, about water, and about many other things. Knowing how you should ask, and what you can ask, is the basis of effective and pleasant learning. But ... how do children ask? What do children ask? What do they really want to know? How do they phrase their questions? How do they raise them? And, how do we help them to ask good questions or, rather, to ask them well? Which kind of problems could be solved by (working with or experimenting with) water?

Apart from the fact that curious, inquisitive, nosey children who explore and investigate, are full of questions, but never take the time to formulate them properly because they are too busy tackling them, it is none the less good for teachers to be ready with a score of possible questions and queries. This helps when setting children off to work, to investigate. It also helps to distill unformulated query out of what the children are busy with, so you can turn it into formulated questions. It helps to stimulate the children to carry on in the direction indicated by their interests. The question brought into sharp focus by the teacher also helps to give direction to their investigations.

Being ready with the right question at the right time, however, does require some experience, and the best way to learn it is to let yourself be led by a sequence of questions and problems arising from working with materials. And a good opportunity to do this is a workshop. One of the teams with which I worked had experienced this before, so they readily agreed to reserve a Wednesday afternoon, which is normally free, for a workshop on working with water. The other school was invited to take part. Nobody had much idea of what to expect, but they all wanted to be well prepared to start their 'project'. This would be a time of intense activity around the same subject - 'water' throughout the school. Therefore they were all in need of good ideas, especially after the nasty questions I had asked them.

In the workshop

Willingness to take part in a workshop is one thing. Profiting from it is another. In the circumstances, it was clear that some initial guidance was required.

The discussion beforehand had shown that these teachers were in need of some fresh input and some perspective on children working with water. In other words they had to become acquainted with water as a learning, or a teaching aid. They were therefore handed some papers, handwritten and photocopied, which contained a number of ideas, suggestions and a minimum of information. These somewhat 'hastily' prepared papers lacked the official look, and were less compelling, less authoritative than a printed book. The simple presentation underlined that they were merely an invitation from one teacher to another to try out a few things. There was plenty of scope for everybody's own initiative, and there were even some pages left blank for jotting down one's own bright ideas.

It is not entirely for nothing that I dwell on the informal nature of these working papers. The handwritten version is, of course, not essential; informality is. Our schools and teachers' colleges are flooded with handbooks, guides, methods, predigested projects and other 'how-to-do-its'. What these have in common is the authority with which they speak: they appear to be foolproof recipes, and usually lack the invitation to start doing anything. A workshop paper should be a do-paper, a kick-off. It should be impossible to read it sitting back. It must be an invitation to do something of your own choice; an impulse to occupy oneself creatively and intelligently in the workshop. In this case the purpose was to undergo physically what it means 'to ask the water', to search and investigate and solve honest problems - simple as well as more complicated ones - which you pose yourself.

Lists of very common materials and equipment were given, together with direct suggestions, often given in the form of operational questions in such a way that you could not escape from working with water in order to obtain an answer.

Pages 39, 40 and 41 present some examples of the working papers in the form they were given to the teachers. The message on these papers, and some others, in plainer form, is as follows:

Floating and sinking

What happens if ... you place - no matter what - in water?

This is always a good beginning. What floats? What sinks?

Look carefully!

How does a piece of wood float?

Or a cork?

Or a tin lid?

Or a styrofoam ball?

Or a ...?

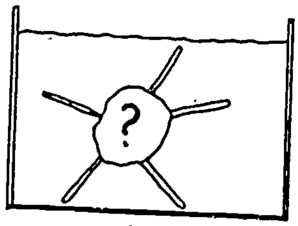
Where does it float in the container when it is full?

Where when it is only half full?

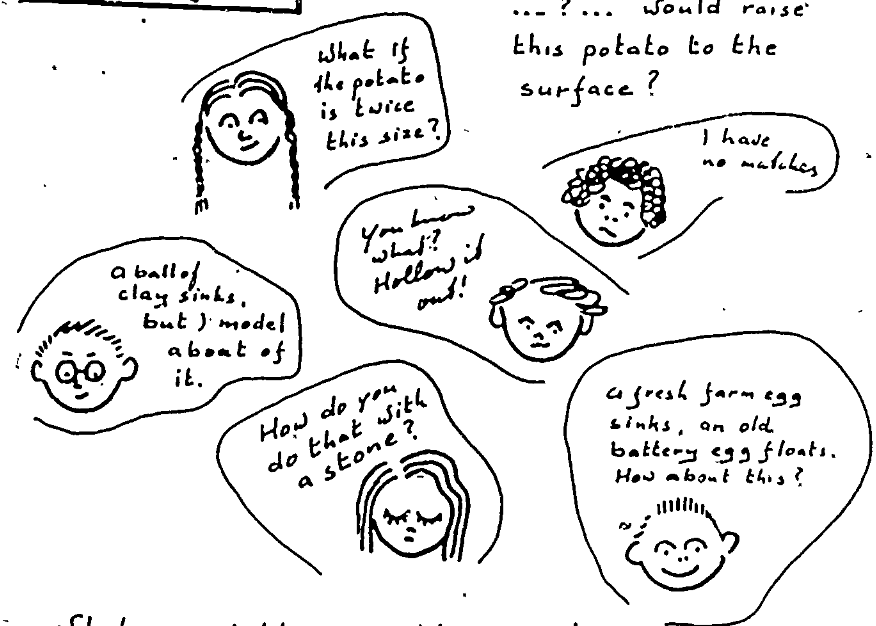
Could you make something which floats sink?

Could you make something which sinks float?

Could you make something which sinks float?

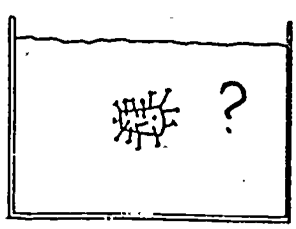


This is a potato
with matchsticks stuck in..
How many matchsticks,
toothpicks,
...?... would raise
this potato to the
surface?



Whatever children might suggest
is worth following up.

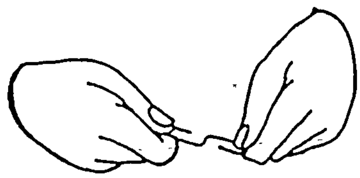
Can you make something
which floats sink?



This is a cork with pins stuck into it.
How many pins make it sink?
Can you make it float halfway down?
And... half this cork?
or a cork twice its size? What size?

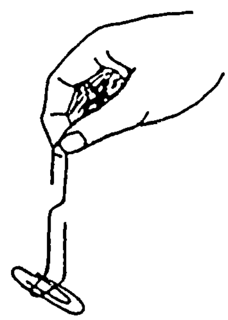
Can you make a pin.
a paperclip.
a needle.
a razorblade.
a ---(?)--- float ?

<u>Try</u> this: Use a simple instrument which you make by bending a paperclip open.



With pliers make a little foot,

and with patience and a little practice lower the object gently into the water.



When it does float, take good notice of <u>How</u> it "floats", and <u>where</u>.

Compare this with a floating cork or wood, or anything else.

What differences can you spot?

(Look also from underneath !)

Could you make a pin

a needle

a paperclip

a razorblade float?

(How do these things float? And where? Draw this.)

How many pins or small nails would you have to stick in a cork so as to make it sink? (Could you make it remain suspended half way down?)

Would you need twice as many pins or nails for a cork which is twice as big? What would you mean by 'a cork twice as big'?

Things which float can carry things ... How many?

But they often capsize ... How can you prevent this?

Try 'boats' made of different materials.

Of different size.

Of different shape.

How does a floating tin behave in water?

What if it has a hole, or two holes, or more, or many holes?

Drops

How can you make drops?

How do they form themselves? (Watch a dripping tap. Let some water drip off your finger.)

How big is a drop?

Can you make drops bigger? Smaller? (Let some steam collect on a piece of glass or plastic.)

Can you change their shape?

Make drops (small ones and big ones, as big as possible)

of water	on wood	and compare them carefully.
of soapy water	on plastic	
of spirit	on glass	Draw them.
of oil	on metal	
of ...?	on cloth	
	on skin	
	on ...?	

By the way, how many drops can you add to a full cup before it overflows?

Let drops of different liquids run off

Slopes of different angles.

Made of different materials.

Or let them run down the curved sides of tins, pots, bottles. Watch them carefully: How fast do they run down? Do they all run equally fast? What does the 'speed' depend on? What is the path of a single drop? Which drops do not run? How can you make them run? Which liquid makes the fastest drops? ... Fill in some questions of your own.

What happens to drops dropped from 10, 50, 100, 200 cm high on to paper?

Glass? Use drops of different liquids.

Floor? Adding some colouring to the liquid makes the spatters more visible and/or permanent.

Water?

These are just brief extracts of what the working papers contained. Further investigations were suggested around such topics as waterdrop lenses, 'internal movement' of water made visible by dissolving coloured crystals, capillarity and absorption by various substances, chromatography, surface tension, freezing and boiling, evaporation and how to measure the rate of evaporation and make other quantitative and qualitative comparisons. Very much, of course, remained unmentioned: water power, solutions, water cycle, pollution and purification and many more aspects. One should not overload the programme in the first place. Secondly, the choice of topics should lie as close as possible to the experience, interests and possibilities of the children.

Except from some measuring instruments like graduated cylinders and a balance, all the equipment and materials for the workshop were obtained from home, garden and kitchen, and from the school where we worked. The introductory talk was kept very brief, consisting only of the advice to pay attention to the empty pages interspersed among the written ones, and to see that different groups would select different topics.

Considering the limited time available, it seemed better to exhaust the possibilities of each topic in different groups, and to exchange experiences, ideas and pious hopes afterwards with those who done different things. The advice about the empty pages was meant to encourage teachers to come forward with their own ideas. They remained, however, mostly empty.

Time was already short enough to absorb the shower of ideas, and really to pursue in depth the possibilities of the topic of their choice. So no one had an opportunity to add anything. The variety of activities to which the participants applied themselves was very impressive. Unfortunately there was little opportunity to exchange ideas and share experiences. At first sight this seemed unsatisfactory, but do not be mistaken. The filling of the empty pages, as well as the sharing of ideas and the exchanging of views could and did take place when the individual school teams sat down together again in their own environment to plan the activities and work in their own schools for their own children.

People worked with great enthusiasm. Not all topics were tackled, not all problems solved, but quite a few were. There was much conversation, which was good, and many a 'why', 'how' or 'yes, but' bounced to and fro, and to which, sometimes, a satisfactory solution was found. However, a number of sticky questions remained. No matter, there were also cries of 'oh!' and 'ah!' and 'oh, yes!'. On the whole, this workshop was appreciated as a liberating and informative gathering, an eye-opener. Participants gained courage to engage their children in problems concerning real water, and letting them have a go at working with real water. They were prepared to leave the adult-oriented problems of water pollution and policy in the background, and to gauge the children's real interests first.

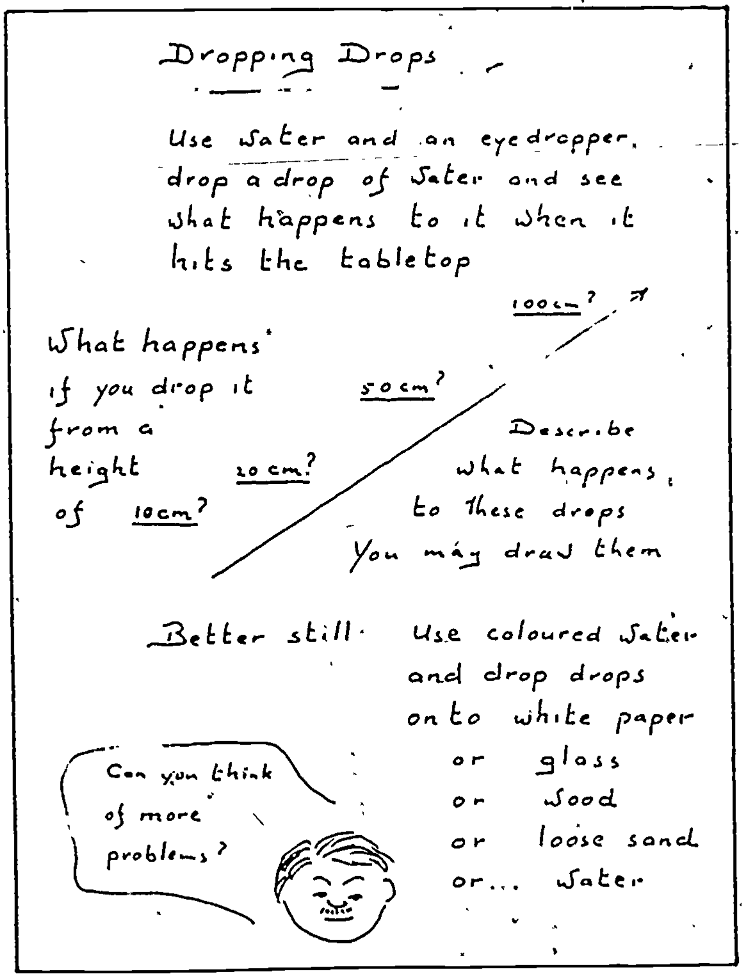
In the classroom

After the workshop, the teams went their own way, and this story continues in the one school where I had the privilege to join in some of the activities with the children. In the preparation and execution of the project (which had now assumed a more scientific character) the experience, the dedication, the personality and the amount of self-confidence of each of the teachers naturally played an important part. Yet the interest of the children was given deliberate priority, and was taken into consideration first, even after the initial activity in the first class deteriorated into a muddy mess. Poor Miss, thoroughly shaken, kept the reins tight after that, but her lessons did not turn into lectures about the increasing salination of landslide groundwater in the delta regions of the Netherlands. Her children kept 'asking the water' - but very politely.

The children, as well as their teachers, were very enthusiastic. The school purchased some glass equipment and measuring apparatus, but the children brought in all sorts of things that could be useful. Tins and pots, salt and sugar, oil and soap, pipes and tubes, saucers and pans, coffee filters and aluminium foil; name it, they supplied it. Everything was made available for everybody in the school's common space, a sort of assembly hall, where things not in use were stored in three big cardboard boxes. The four top classes shared this room, for there was plenty of space to keep half finished experiments on the side; all could share the available equipment, and the greatest advantage was that each teacher kept his classroom clean and dry, while the children were compelled to clean up any mess they made before another group entered to carry on their own work. It was a good lesson in social science, too.

The teachers had prepared workcards, and not just the 'ordinary' ones. Commercial workcards, which find their way into schools (often without being called for) tend to describe experiments - together with their supposed, but inevitable, outcomes - without posing the question why this 'experiment' should be performed in the first place.

However, the home-made workcards were exactly what they were called: cards which make children work. They posed the question(s), but left the setting up of experiments to the children themselves. They gave suggestions, where these would help, but not prescriptions, and certainly no outcomes or answers. These workcards hardly made sense, unless one took the trouble of doing the work which they suggested. Admittedly, they were mainly based on the experience gained in, and the paper handed out during, the workshop. After all, this paper was meant to help the teachers along: the workshop extended into the classroom. These workcards were made to help the children work in groups. A good thing about these cards was that the children were asked first to write down what things they would need. Only after showing this to their teacher, were they allowed to look for what they needed, and to start. This, so the teachers told me, was done to force the children to read the card well. It prevented much mucking about. The sample of the workcards below shows another encouraging aspect, that they consisted mainly of questions, do-questions, whilst the last questions invariably was: ' ... and what else could you ask yourself?'.



In this way, the tasks incorporated a great measure of freedom for the working children, but remained under control: the specific questions posed on each card initiated a certain line of investigation. The teacher could so easily and quickly check what the children were working on. My impression was that this worked very satisfactorily. One activity of a future workshop with teachers might well be the construction of these or similar workcards. Somewhere in the shared room, there stood a box with free 'assignments' which the children were allowed to take home and try out for themselves out of school time. Fights occurred around this box!

The few times I was privileged to take part and work with the children, they worked very hard indeed. Children often interpreted the tasks written on the cards in their own way, so their work assumed a spontaneous character. Some enterprising little fellow, when dealing with the miracle of syphoning, was not content until he managed to syphon water through a quadruplet of vessels in such a way that the fourth one filled up as the first one emptied, while the second and third vessel remained full. After many disappointments - and three-quarters of an hour working at it - he was able to show the others what marvel he had wrought.

'Floating and sinking' was a topic they never exhausted, with new challenges offering themselves continuously. The 'drop race' was repeated many times with the loud support of bystanders as if it were an end-sprint in the 'tour de France'. The children worked so conscientiously that there was no room for 'Sir, I have finished' or 'We don't have to learn this'. Measuring and counting was often repeated, and the problem of 'How do we get such differences' was often referred to their own possible inaccuracies.

Reflection

When we evaluated the work in a team discussion, the teachers expressed satisfaction, even though there had been some difficulties in the lower classes. However, the teachers had been rather disappointed in the way in which the children had kept records and had reported on their work. They would have liked to see neat summaries, descriptions and definitions to fall back on when the time for testing arrived ... However, had not the children been very busy? Besides, keeping a record of findings, noting down the conclusions of experiments, tabulating the data of regular observations, and other such scientific ways of recording and communicating, is something which the children have to learn. This is a skill to be developed and practised, so you cannot expect all that much after a first project of this kind. That the workshop-in-preparation had greatly influenced their approach, and work with the children was acknowledged by all the teachers.

The purpose of giving this detailed account of one example of a workshop approach in action is that it argues for itself. It deals directly with teachers who work with children who work with water in a scientific way. The story moves on a level which is small enough to be entered into by any educator anywhere in the world.

Children are being confronted with (something out of) their environment, something real, something they can observe and handle, manipulate and experiment with, measure and use to solve problems with, their own problems. This is not messing about. This is not laissez-faire. This is purposeful activity during which children use their skills and abilities, all their science, to obtain the information [illegible]ant. To work so, the children need expert guidance, well selected materials, to be given the right question at the right time, encouragement in matters sensible and discouragement in matters trivial. The expert guidance can only come from the teacher, and it is with the expertise of the teacher that we are concerned here.

No teacher can acquire this kind of expertise by being talked to about it. Expertise follows experience. The task of the teacher trainer, or the teachers' adviser, is to provide this experience, to enhance it and to draw on it. The teacher's expertise, however, has two faces, two aspects, which can be distinguished, but, for all purposes, not separated.

First, there is the expertise in handling materials or, rather, in using the environment, and the common things therein, as a source of information and wisdom. It is an adeptness at seeing and appreciating the challenge, the invitation, the possibilities of the materials on hand and, thus, knowing what good science can be 'done' with them. It is a proficiency in questioning and problem-posing. A teacher interacts with the (things out of the) environment.

Second, there is the expertise in handling children, in knowing what they can do, what they are capable of, what can or cannot be expected from them, what they need, what next step (in their development, or their attainment) they are able to make and how they can be induced to take this step. A teacher interacts with children who interact with their environment. The workshop which is directly concerned with work in the classroom enhances this double-sided expertise, and, in as far as the workshop activities run over into the practice of the classroom, the experience has this double effect.

However, teachers are not always in a position to translate the activities of a workshop directly into classroom practice. Pre-service and in-service courses incorporate workshops which are meant to have an effect on the participants such that they will carry with them a score (and a store) of useful working ideas, practical skills, new insights, creative capabilities and confident attitudes which they can and will apply whenever they need them in their own, very specific, circumstances. Also there are those teachers who do not directly teach children, but who are very much concerned with them: the teacher trainers and the teacher advisers among whom I venture to count inspectors. These people have a strong professional influence on serving teachers. For their own refreshment, or for their own training (education is a lifelong occupation, and certainly for those who take a leading part in it) these educational foremen can and should be confronted with ways and means of approaching teachers other than through lectures or advisory discussions and circular letters. They should be familiar with the workshop approach and be able to organize one. If they are not able to run a workshop themselves, they should at least be able to find the right person to do so, and be able to appreciate or evaluate the merits and effects of a workshop approach.

Getting to know a workshop approach is to undergo a workshop, is to take part in filling a working day, to exchange views, to share inspiration, to contribute to the flow of ideas which are generated by the work and to take part in the planning and performance, the development and modification of the tasks at hand. A good workshop is something dynamic, a living process; undergoing it means making it, contributing to it. A good workshop is a process of creation.

In order to become adept in organizing and running workshops, one should be able to recognize a good area of study, appreciate its richness of challenge and possibility, and one should be able to strike this source of activity in such a way that people are induced to start work. Initially some will have to overcome their shyness, or their urge to show off their near omniscience, but eventually people will have to tackle suggested problems related to the particular field of interest and raise their own. At that moment, the workshop will make good progress.

Making a start in a workshop

This final section mainly consists of an example of a workshop paper which has been used several times to initiate people in the work of running workshops. It is good to take into account that this is not more than a starter. The measure of deviation from the text of this paper is a measure of the success of the ensuing workshop, for the sooner the participants take their own initiative, the deeper they are involved, and the richer the outcome will be.

On one occasion, a group of 26 school advisers came together for a three-day conference in a beautifully forested area. The third day was assigned to me to organize and run a workshop on science education. I could not resist making full use of the environment. However, I would not be able to arrive there before 10 o'clock in the morning - much too late to start a good day's work. So, the following paper was sent up beforehand, and the people were encouraged to start nice and early.

One characteristic - I would call it a virtue - of this workpaper is that it encourages people first to view the panorama, to take the general landscape. This overview provides the background against which (and the framework within which) later observed details stand out in relief, or can be related in ways which would otherwise remain obscure. Next, the observer will gradually 'zoom in' to a smaller area, notice many details, use all his means of getting in touch with the living and non-living things that belong there.

Up to this point the observation is rather indiscriminate until, finally, within this mini-world some detail is considered worthy of being scrutinized in greater depth. Approached in this way the chosen object of study does not stand in isolation, but has its full significance in relation to its immediate environment, of which the studious observer has now become part.

Having a good look in the woods

1. What could be of good use:

   writing and sketching implements;

   paper (of course);

   bags or boxes (plastic) to collect and carry things;

   things to dig with, to cut with, to scratch with, to strike, stick, shove and prick with;

   instruments for measuring and closely observing: such as measuring tapes, calipers, handlenses, binoculars;

   and whatever else you consider useful.

2. Look for, and find, a place which catches your interest, which you like, which appeals to you, and have a good look around there first. Try to describe this place as well as you possibly can, or sketch it, or both. Put down your first impression. Characterize this place of your choice.

It may be a small place: a clearing in the wood; a pond; a copse; a hedge; a track.

It may be a bigger place: a lane; a side of a ditch; a bed of a brook; an area dominated by tall trees; the edge of the wood; a field.

It may be a whole area: a thicket; the underwood; the whole wood; a lake; a heath; a hill.

(... and half a page was left blank for sketching and describing the general characteristics of the chosen area.)

3. Now start investigating. You will have to become smaller now, work on a smaller scale, notice details and heed small things. Here you may sit down on your haunches, climb a tree, crawl on all fours. Do not forget to probe and dig.

   What strikes you in the first place?

   What grows there? Trees? Shrubs? Herbs? Grasses? Reeds? Algae? Mosses? Liverworts? Lichens? Ferns? Moulds? Fungi? Mushrooms? Toadstools?

   What moves about? What walks, crawls, creeps, wriggles, slithers, squirms, worms, glides, hovers, hums, zooms, drones, flutters, flies or swims about there?

   Where, exactly, does what grow or move about? Pay attention to the immediate surroundings of the details you notice. Where, and on what, does the fungus thrive?

   Where scurries that cockroach? Whither slithers the worm? Under what hides the centipede? What is green with algae, on which side?

   Whose home, or domicile, is this? Look carefully for and at nests and holes and furrows and hollows and lairs and webs and whatever you find that has been spun, glued, stuck, sewn, joined together, or that has otherwise been built or constructed.

   Where has anything or anybody (what? who?) been living, spinning, building, digging, scratching, walking, eating, nibbling, dropping, fighting?

   What other tracks or remains can you find around there?

   Try and discover relations, or construe relationships between things and occurrences, for instance bird droppings on the ground and a nest up the tree: mould and rot: food remains and eaten; sounds and the soundmaker; track and walker.

   Look up, look down, in front of you, behind you, and underneath: dig and probe, and sniff and feel with finger and toe.

   And listen ... and listen again. What do you hear that you thought you did not hear?

4. Now try and bring order into your observations. Choose a speciality, concentrate on a detail which you find particularly interesting and give it all your further attention. Decide for yourself what to choose, and how to go about it. If you want to crawl through a rabbit's burrow, fine. Perhaps you would like to make a small collection of things, or prepare a small exhibition or display? If so, do so. Or you might want to study everything in, on, around, under and up a tree. By all means, do. There are many opportunities.

5. In case you would like to collect things and take them with you for further study, consider first: can you do it without causing pain or damage? What you cannot take with you, you can always sketch, describe or photograph.

6. No doubt you will encounter problems, riddles, puzzling things. This will be splendid! DO NOT AVOID ANY PROBLEM. Try and formulate clearly any problem that occurs to you.

7. Finally return with your notes, your findings, your data, your problems and your collections. Take care of living materials which you insist on taking along. Make a note of the exact location of your studied area so that you, or others, can find it again.

So ran the text of the paper that sent the teachers to work in the woods. They worked in small groups and applied themselves wi': courage and zest. Of course, nobody worked through all the points laid out in this paper. The experience of each group was different. It would carry us too far to try and make an account of all that happened. It would serve no purpose, either, to do so. Take this paper and go to the nearest wood (and three trees together already form a wood), and make your own report.

For it is not the amount of materials brought in afterwards, nor the display thereof, nor the appreciating sounds that were voiced during the lively discussion afterwards, which are of importance. It is what the participating teachers (of teachers) take home in their hearts and in their minds which counts: their contentment with their own work, their newly found confidence (in spite of being surrounded by many problems) and the enthusiasm with which they repair to their own stations to carry on the good work.

CHAPTER 6

PLANNING, RUNNING AND FOLLOWING THROUGH A WORKSHOP IN ENGLAND

Wynne Harlen

1. Introduction

In the past 20 years, many classrooms in England have been transformed in their appearance. The desks are no longer formally arranged, the children are often involved in using materials and equipment themselves and appear generally active. But if we observe more closely what is going on in science we find that, in many cases, the activity which keeps the children so busy is mainly physical. It does not extend to mental activity. The children may be engaged at a superficial level, following instructions on workcards rather than working things out for themselves, making mistakes and learning from them.

As in many countries, primary teachers in England are not well-prepared by their own education and training to understand the nature of the science process skills nor the importance of helping children develop these skills at the same time as developing science concepts and attitudes. Many teachers 'lack a working knowledge of elementary science' [2] just as they do in many less well developed countries of the world. Indeed, it is useful to read this chapter in conjunction with the following one, which describes the development of a workshop approach to in-service training in Indonesia. Apart from the fact that the Indonesian classroom looks different in certain respects from an English classroom - the desks are in rows, the classroom is somewhat bare, the teacher spends most of the time telling, the children passively receiving - the state of primary science education is in a similar poor state in both countries and for much the same reasons.

This chapter and the one that follows show how a workshop approach to improving practice, arrived at and implemented in different ways, has begun to show promising results in these somewhat dissimilar contexts. In both cases an attempt was made to tackle the problem scientifically, by making observations or using available evidence about current practice, suggesting possible changes, testing out these suggestions in practice, studying and evaluating their effect and modifying ideas in response to findings. In both cases, too, consideration of the kind of learning aimed for in children and the consequent changes required in teaching content and style led to the adoption of a workshop approach to teaching training.

In England, there is no central control of the curriculum, and teachers have the freedom and responsibility to make their own decisions about what is taught and how. It would seem easy to make changes in schools in this situation, but, despite 20 years of curriculum development in this area, the situation is that most primary teachers lack confidence, skills and motivation necessary to provide learning opportunities of the kind with which we are concerned.

To investigate this problem, evidence was gathered about the situation in schools and the events leading up to the present position. Ideas from research, theory and opinions were critically examined, and used in creating proposals for in-service experiences. These proposals were treated as hypotheses to be tested. The main hypothesis was that a particular teaching approach would provide learning experiences from which children would develop the process skills and basic concepts of science. The test of the hypothesis was in the hands of the teachers who took part in the in-service workshop, where the approach was communicated, and in the follow-up work in their schools when it was put into practice.

2. The background

The period up to 1960 could be described as the age of nature study and of whole class instruction in all but a tiny minority of primary schools in England. In the early 1960s, the call to introduce science in the primary school - part of the general movement to re-examine science education, resulting in the early Nuffield science projects - could be answered only after first answering the question 'What is primary science?'. The two main answers to this question - in terms of emphasis on process or emphasis on content - were represented in the first two curriculum projects. The Oxford project [3] focused on the broad concepts of science as a means of selecting and structuring activities; the Nuffield Junior Science Project [4] focused on the way of learning rather than on what was learned.

During the 1960s, there were widespread changes in primary practice, away from subject-centred experience towards child-centred experience. This movement culminated in, and gained vigour from, a major national report on primary education [5] which put its weight behind a resounding message that 'At the heart of the educational process lies the child'. In this climate, the process-content argument was easily won by the advocates of process-based aims achieved through 'discovery'. The consequence was that the types of activity advocated started from problems, perhaps encountered in some integrated topic work, perhaps raised by children or 'caused to arise' by teachers. And then 'Where these problems can be tackled experimentally: where children suggest, improvise when possible, and engaged in experiment, gaining actual manipulative experience of the materials involved; where they use their powers of observation to notice relevant detail, spot relationships and make elementary deductions - this is the stuff of simple science ...' [5].

For teachers, the messages meant that they were somehow to provide experiences that followed rather than lead children's interests. Such a method of teaching demands exceptional skills of classroom organization and management and, for most teachers, a catastrophic change in role. Teachers' guides, consistent with this philosophy, made no statement about the content of activities beyond that they should concern the children's environment. Neither did they give any clear direction to teachers about the development of the skills (mental and manipulative) and attitudes which the activities were to foster. Had this been attempted it might well have been realized that the development of process skills and attitudes is not independent of the development of ideas and therefore of the content of activities (see Chapter 2, page 6). This realization did not come until later; in the 1960s any move towards identifying key ideas or areas of experience was rejected as likely to detract from the emphasis upon process skills.

For the children, the consequences of the single-minded emphasis on process (whilst ignoring the building of ideas) were fourfold: an unbalanced diet of content (for content there has to be, whether or not it is planned and selected); repetition (for some their 'environment' seemed to offer the same activities, for instance, with falling leaves year after year); a high level of physical activity with little allowance for stopping to think; no continuity in activities. In the light of present thinking, it is not difficult to see why the children's ideas about their world and their process skills rarely went beyond those of the 'everyday', the ones which superficially 'work', but bear no closer inspection. As far as children's ideas were concerned, it was assumed that these were formed inductively, by 'discovery' from observations and investigations; any ideas they already had were ignored.

This catalogue of criticism of the process-only approach is not an argument against the importance of process skills. Indeed there is no evidence to deny that children's growing understanding depends upon the exercise of these mental processes. On the contrary, all the evidence points to the lack of real understanding when teaching is attempted without learners being involved in generation, testing and application of ideas. The point is that process skills are necessary, but not sufficient for the growth of understanding of the world around.

It became apparent, too, after a decade of encouraging teachers to promote process skill development, that many of them probably did not have a firm grasp of what constitutes a 'scientific approach'. They were satisfied if children were observing and were active, 'doing and seeing what happens' - a good start, but one needing a follow-up into more controlled investigation. Thus the situation found by the survey, carried out by H.M. Inspectors [2] between 1975 and 1977, was one reflected in comments such as 'in very few classes were opportunities taken to teach children how to make careful observations or to plan and carry out investigations of a scientific nature', 'the progress of science teaching in primary schools has been disappointing, the ideas and materials produced by curriculum development projects have had little impact in the majority of schools'.

The findings of the national surveys of pupils' performance in science at age 11, carried out by the Assessment of Performance Unit (APU), have reinforced the picture of children's process skills residing at a general and somewhat superficial level. The following are some examples of the results reported from the first three surveys carried out in 1980, 1981 and 1982 [6,7,8]:

(i) In tests of observation, the children scored more highly in observing coarse and more obvious features than in observing in greater and final detail. When asked to find similarities and differences between objects, they offered more differences than similarities. Scores were generally high in classifying objects according to observable features, but much lower in explaining in a logical manner why an object fitted into one group rather than another.

(ii) When given data in which there were patterns to be found, performance was much higher in using the patterns to make a prediction than in explaining how the answer was arrived at. The children had difficulty with questions requiring them to consider which of several conclusions was really supported by given evidence. In applying concepts to interpret information, there was again a much higher level of performance in giving an answer to a problem and making a prediction than in giving explanations or reasons for the answers.

(iii) In carrying out investigations, pupils showed considerable interest and ability to tackle the problems in a relevant way. However, when particular aspects of what they did were examined, it appeared that many features which characterize a 'scientific approach' were largely absent. Variables were often not controlled, measurement was much less frequently used than global observation, and very few pupils repeated observations or measurements to check their findings.

3. Ideas influencing the development of a new approach

During the period covered by the events just briefly sketched, ideas and research findings about learning were being developed which offered a possible way out of the situation facing primary science in the early 1980s. The chief of these were:

evidence of the interaction of mental processes and concepts in learning leading to a greater understanding of the role of processes in the development of ideas and the role of ideas in the use of process skills;

evidence of the significance in learning of children's own ideas;

ideas about the role of language in learning and the importance of informal and formal discussion in the classroom;

evidence of children's achievement and of opportunities to achieve scientific thinking and reasoning skills.

Each of these had an influence on the design of the in-service programme described in the next section. Justice can hardly be done to the work behind these ideas in the brief outline here, but references are given to original sources.

Process skill and concept interaction

The emphasis upon children learning from active exploration and 'discovery' in the Nuffield Junior Science Project [4] and Science 5/13 [9] was a thoroughly commendable attempt to break away from whole class teaching, where children were simply told about things, and not given the opportunity to think things out for themselves. But behind this emphasis was a view of the scientific process as one in which observation and inquiry led to the creation of ideas - a process of induction (Chapter 2, page 6). Evidence from examining closely what happens when children (and adults, too) make observations and attempt to interpret them, shows that the process is not a purely inductive one. Existing ideas focus attention selectively on some features more than others and influence the processes of gathering and using information. So the business of solving problems and making sense of the world around is, too, influenced by the way ideas affect process skills. It follows that developing process skills alone is not enough. At the same time we know that the development of ideas depends upon process skills. Attempting to give children ideas by telling them what to think results in no more than rote memorization, and the ideas children are taught in this way do not affect their own ideas, the ones they use in explaining things to themselves. These are ideas they form through their own ways of gathering and dealing with information. But, if the processes they use, of observing and hypothesizing for example, are non-scientific and superficial, then ideas may be accepted which could not really stand up to testing.

The significance of children's own ideas in learning

That children to develop ideas about things around them and that these are not always the same as the ideas of adults is amply demonstrated in the work of Osborne and others [10]. The concern of many of these researchers in this field is that these ideas persist well into the secondary school - and, indeed, beyond, for some pupils. Meanwhile, in their science lessons, it is likely to have been assumed that the words 'living', 'animal', 'force' and so on have been understood as conveying their scientific meaning. Through classroom observation and pupil interviews it has been found that this is not the case. It seems plausible that children's ideas might well develop earlier into more scientific ones through investigations of events and objects around that engage them in using process skills to test their own and alternative ideas.

The role of language and the importance of discussion

Some of the most influential work in this area has been that of Douglas Barnes [11]. He has argued from his study and analysis of children's speech that, in all areas of the curriculum, talking is essential to learning. When children interact with each other and talk about their work in groups the individuals contribute to an understanding which is a considerable advance on their own separate ideas. One child takes up and elaborates, or challenges the idea of another and they led back to the evidence, or to gather further evidence to check conflicting ideas and see which stands up best to testing. The manner in which an idea is tested might also be challenged and subsequently improved to make it more fair. These challenges, to ideas and to ways of gathering and processing evidence, are only possible if the thinking is made open and public through the use of language.

The kind of interaction just described takes place best in small groups when there is a shared task and where joint agreement has to be reached. It may not happen if children have parallel individual tasks or even roles assigned by someone else in a joint task. Barnes also points out that, from his evidence, the exchanges of most value for developing ideas and skills take place when children discuss on their own without the presence of an adult authority. The very nature of the speech in group discussions when the teacher is not present invites all those involved to throw in ideas, which may be only half-formed, hesitantly expressed, but serve to spark off further thinking. When the teacher is present, the speech is more formal, less ideas are put forward because they expect the teacher to know what is the 'right' one.

Communication can also help children to reflect upon the way they have used the ideas and information available to them. 'Much learning may go on while children manipulate science apparatus, or during a visit, or while they are struggling to persuade someone else to do what they want. But learning of this kind may never progress beyond manual skills, accompanied by slippery intuitions, unless the learners themselves have an opportunity to go back over such experience and represent it to themselves' [11, p. 91]. The suggestions emerges that group work should be followed by discussion of the implications of what the children did and found, and which may only have been half understood at the time.

Evidence of existing learning and learning opportunities

Some of the general findings of the APU's national surveys of performance in science of pupils at the end of the primary school have already been mentioned. The full reports [6,7,8] show that while children are generally able to tackle practical problems in a relevant manner, the process skills they use reside at a superficial level and are not being developed in depth. Possibly this level of performance is adequate for the type of science element incorporated in much topic work, but it is not enough to sustain the interplay of process skills and ideas which has been discussed above. There is no reason why the deeper probing and testing of ideas should not be pursued within topic work, but the evidence points to the fact that this does not happen to any great extent in present practice.

Some of the evidence which supports this statement comes from the H.M.I. survey of primary schools [2]. Some comes from the questionnaire sent to schools taking part in the APU surveys [8]. To this has recently been added evidence from an extensive and intensive research into primary classroom practice carried out by Galton and Simon [12]. From detailed classroom observations, they found that children rarely had an opportunity for the use and development of higher level process skills. Group work generally meant children sitting in groups, but working independently. They had little discussion with their peers of the kind which Barnes suggests leads to the joint development and testing of ideas. Neither did discussion with the teacher provide stimulus to thinking, for each child's contact with the teacher was brief, and usually concerned with organizational matters. Significantly, it was found that teachers who used whole class discussion were more likely to expose their children to ideas, and challenge them with open questions and problems to solve.

4. Constructing the in-service programme

The work which has been briefly mentioned in the last section suggests certain guidelines for the classroom experiences which an in-service programme should aim to promote. In summary these are that children would be:

investigating problems and events which involve basic science concepts, using process skills to test and modify their own ideas about the solutions and situations;

· creating hypotheses and exchanging ideas with others and devising with others ways of testing all the hypotheses in a manner agreed as fair;

reflecting critically on how a problem has been approached, on the solution obtained and on alternatives which could have been tried.

To devise an in-service programme which would convey this message, several other facts had to be considered and some value judgements made. The most important of the circumstances to be considered was the teachers' background knowledge and state of confidence in their ability to handle the types of activity suggested. As the H.M.I. survey had reported:

'The most severe obstacle to the improvement of science in the primary school is that many existing teachers lack a working knowledge of elementary science appropriate to children of this age. This results in some teachers being so short of confidence in their own abilities that they make no attempt to include science in the curriculum. In other cases, teachers make this attempt, but the work which results is superficial since the teachers themselves may be unsure about where a particular investigation or topic in science could lead' [2, para. 5.83].

Whilst appreciating the inhibiting effect of a lack of scientific knowledge, it was decided, on the basis of experience as well as expedience, that confidence was more likely to be built up by the development of teaching skills for handling children's ideas and promoting their use of process skills than through attempting to fill the gaps in scientific knowledge. Mastery of science content could not be ignored, but no crash course would supply all the knowledge that a secondary science teacher, for example, has. Neither was it thought necessary for a primary teacher to have this amount of background knowledge, given that the emphasis was upon revealing and testing our children's ideas.

The teacher's own background knowledge was also taken into account in considering the format and nature of the in-service activity. It goes without saying that merely describing or giving information about a teaching approach, with however persuasive a rationale, was not considered to be an effective strategy. Telling teachers what they might do - using teaching methods in practice quite contrary to the ones being advocated in theory - would be likely to be a waste of time. Giving participating teachers experience of the proposed teaching approach could be more effective. Experience at two levels was considered to be essential within the context of the in-service programme; at the level of the learner, using his or her own ideas and trying them out, using process skills, and, at the level of the teacher, testing out the approach with his or her own class. Experience at both these levels would help teachers to assess the kind of background knowledge that had turned out to be important. It was expected that much of this knowledge would be more readily available to teachers than they had initially assumed.

A third consideration concerned the degree of prescription to be adopted in the programme in relation to the teaching approach. There were arguments both for and against. In favour of some prescription, were points made in the last section which appeared to argue forcibly for the kinds of classroom activity being proposed. To allow a 'take it or leave it' approach, or to allow teachers to pick some parts, but not others, would destroy the consistency of the teaching approach and the intended learning. Against prescription, were regard for the individuality of children, classrooms and teachers. In reality, no teaching approach can be entirely prescribed by guidelines; teachers always have important decisions to make about classroom events, in response to what happens from moment to moment. But too much prescription strangles initiative, and eventually reduces confidence; too little may not give the support that is needed to make a start.

The solution to this dilemma which was adopted in planning the in-service programme was to ask the participating teachers to adopt, on an experimental basis, the overall teaching approach suggested. As part of the course, teachers would try this out with their own classes and evaluate these trials. The feedback from the evaluation would be used as a basis for discussion and reflection. To enable this to happen in a manner which gave the initiative for adoption, change or rejection to the teachers, the evaluation would be carried out by teachers in collaborating groups.

Finally, the time factor had to be considered. For some teachers, the degree of change required in the teaching would be greater than for others, but for all to achieve enough understanding and experience of the approach, and to be able to assess its worth, a considerable time was required. Experience shows that 50 hours is a reasonable minimum, and sufficient only to create the motivation and confidence for teachers to embark on the planning of their own programme of work, not to carry out this planning and preparation. Fifty hours in a concentrated course was neither practicable nor desirable given that part of the in-service programme was trying out and evaluating the suggested approach. So the pattern of an initial residential workshop, giving 18 hours work, followed by eight weekly two to two-and-a-half hour sessions in schools (20 hours) and three five-hour conferences/workshops (15 hours) was adopted as the best compromise between what was possible and the optimum conditions to achieve the programme's aims.

In summary, the main conclusions on the in-service programme were that it should provide:

opportunity for teachers to experience the intended teaching approach from the point of view of learners;

input on the nature of the process skills to be used by children in the approach;

discussion of the importance of children using and testing out their own ideas;

opportunity for teachers to try out the approach in their own classrooms;

feedback to the teachers about the children's and their own behaviour when testing out the approach;

further discussion and input found to be required as a result of the trial work in schools.

These conclusions were arrived at in the course of a long series of meetings of a planning committee. The members of the committee also devised the workshop activities which formed the core of the initial residential workshop and the basis for the classroom trials. They also advised on the selection of discussion papers and the preparation of a video-tape showing some elements of the approach in action. Some, but not all, of those involved in planning acted as tutors during the initial workshop and in the course of work in schools.

An outline of the programme is given below and its operation in action is described in the next section.

Initial workshop (residential)

Day 1

10.45 a.m.-11 a.m.	Opening session (plenary)
11 a.m.-12.30 p.m.	Workshop on Topic 1
1.45 p.m.-2.15 p.m.	Plenary discussion on teachers' questioning in the classroom, based on the paper 'The right question at the right time'
2.15 p.m.-3.15 p.m.	Workshop on Topic 1 continued
3.15 p.m.-3.45 p.m.	Group discussions
4.30 p.m.-5 p.m.	Plenary discussion on the process skill of observation, based on the paper 'Helping children to observe'
5 p.m.-5.45 p.m.	Plenary session on the proposed teaching approach, illustrated by video-taped extracts

5.45 p.m.-6.30 p.m.	Viewing of edited video showing children engaged on Topic 1
7.45 p.m.-9.30 p.m.	Talk by visiting speaker on the implications of findings from classroom observation research in the primary school

Day 2

9 a.m.-11.30 a.m. 11 a.m.-11.45 a.m.	Workshop on Topics 2 and 3 (different groups in parallel)
11.45 a.m.-12.30 p.m.	Plenary discussion on investigation planning skills, based on the paper 'Helping children to plan investigations'
1.45 p.m.-3.15 p.m.	Workshop on Topics 2 and 3 (groups interchanged from morning session)
3.15 p.m.-3.45 p.m.	Group discussions (questions formulated for following session)
4.30 p.m.-5.45 p.m.	Plenary discussion: further input on the teaching approach and response to matters raised in group discussions
5.45 p.m.-6.30 p.m.	Participants free
7.45 p.m.-9.30 p.m.	Talk on the national surveys in science (APU) at age 11 and some implications of the results

Day 3 (Saturday, half day)

9 a.m.-10.30 a.m.	Plenary discussion of the organization and evaluation of school-based trials
10.45 a.m.-11.45 a.m.	Group meetings to arrange programme of teaching and visits
11.45-12 noon	Closing session

School-based work (eight weeks)

Organization:	Teachers arranged in groups of four (by geographical location, with administrative boundaries in mind).
Visiting:	Each week each group met in the school of one of the members, rotating so that different schools were visited in turn.
Teaching:	The teacher being visited by the group had to arrange to teach science activities at the agreed time. Teaching when not visited was, of course, at normal times. All teachers were expected to be trying the approach each week whether or not they were visited.

Topic:	Although it was not essential, it was more profitable for all the teachers in a particular group to be working on the same topic. This was agreed. Groups chose two of the three topics introduced in the workshop.
Observation of teaching:	The visiting teachers observed the class and recorded observations using forms and schedules, as explained on the final day of the workshop.
Discussion:	Following each weekly meeting, each group met for at least an hour to discuss their observations with the group tutor. In these discussions they drew on their own experience of teaching the topic as well as on the observed lesson.

Follow-up meetings of all participants

At the end of the school-based work the whole course membership met on three further occasions from 1.30 p.m. to 7 p.m.

5. The initial workshop

Course material development

The preparation, carried out by the course team, included the development of activities on three topics. These were chosen to provide a spread of opportunity across a range of process skills. Although it can be said that almost any activity can be carried out so that process skills are used, it is also true that certain topics lend themselves to some process skill development more than others. The topics, activities and main process skills were:

'Floating blocks' - children given four blocks of wood of equal size and shape, but different types; observe similarities and differences in the way the blocks float in water, and in other respects; look for patterns in the differences; use the patterns to make predictions; test the accuracy of the predictions in a fair manner; draw conclusions from their observations; proposed hypothesis to explain findings, and to devise ways of testing them.

'Snails' - children observe giant African land snails and other snails; discuss observations and raise questions from the group; discuss questions, select one and design an investigation to find answers to it.

'Cool cans' - starts from presenting children with phenomenon of condensation on a shiny can with ice inside; children make observations and from these propose hypotheses to explain the phenomenon; plan an investigation and carry it out, draw conclusions from it, reconsider their ideas and possibly suggest and test further hypotheses.

For each of these topics a simple worksheet was prepared - its purpose being to bring the children into contact with the phenomena or events as quickly as possible. A set of teacher's notes was also prepared for each one. For 'Floating blocks' these were written in two versions. One gave full details, indicating the intended class organization (group work or whole class discussion) at each stage, the teacher's role and the likely time for each activity. The other was a shorthand version using terms such as 'collect' and 'discuss' to indicate a cluster of teaching actions which were explained in the full details. For the other two topics, only 'shorthand' teachers' notes were provided.

A second major element in the preparation was the production of a video-tape of a lesson on 'Floating blocks', using some elements of the approach. Since the teacher who undertook this was a head teacher, not the class's normal teacher, and there was only a brief opportunity to explain the intention, he worked from the teacher's notes, but was unable to implement as many aspects of the intended role as was hoped. Nevertheless, the children's work in groups showed many features of group interaction and the whole class discussions were useful examples for discussion, although not illustrating all the elements of good practice. From 2½ hours of continuously taped activity, an edited version of 30-minutes length was produced for use in the course programme.

Two further elements of preparation were the selection of discussion papers and the devising of evaluation instruments to give feedback during the trials.

The participants

Teachers and LEA advisory staff	27
Full-time course team members	5
Part-time course team member	1
Visiting lecturer	1
Visiting advisers	2

The groups in which the teachers were to work in the workshop were arranged with the trial work in schools in mind. Five groups were formed (four of five and one of four), based on the location of their schools. Each group was to be the responsibility of a local authority adviser during the trial period, and this adviser met with the group at times during the workshop, but, during activities, the groups were of teachers only, the advisers being formed into a group of their own.

The first day's activities

The introduction was deliberately kept short, lasting no more than 15 minutes. Theory at this point in a workshop finds no obstruction to passing through the heads of those present and serves only to delay activities from which something can be learned. Once teachers have had experience, not only at their own level, but with their own pupils, and have begun to reflect on it, then theory can aid this reflection.

So the teachers and advisers were immediately put into groups and set to work on 'Floating blocks', just as if they had been a class of children. There was an astonishing interest in the simple phenomenon of how the blocks floated. Many of their observations of differences and sameness among the blocks were similar to those made by children. Like the children, too, many observations were the result of small investigations (for example, whether the weight required on one end to make the block float upright varied from one to another). After about an hour, their observations were collected and discussed with a course tutor acting as 'teacher'. The practical work continued in a later session, but first the process of reflecting on the activities, as teachers as well as learners, was begun.

A discussion paper on teachers' questioning had been one of the three circulated before the course, and it was chosen for discussion first because it offered the clearest practical suggestions. Some of its messages were about getting away from the 'right' answer, recognizing a sequence of questions, with 'how' and 'why' towards the end of the sequence, employing questions as organizers of children's thinking, leading to a questioning approach becoming internalized by the children.

During discussion of the paper, the points which teachers said they particularly appreciated were: that teacher intervention in activities is not always appropiate, the teacher has to listen and encourage the children to listen to each other, the aim is to help children to value each others' ideas, but always return to the real objects to check them.

At the end of the second practical session on 'Floating blocks' the teacher's role in this particular topic was discussed, and the notes produced to summarize it, both the long-hand and the short-hand versions, were introduced.

The second discussion paper, on the nature and encouragement of skills of observation was then considered. The points raised by participants reflected some misunderstanding of perhaps the most widely known science process skill. Since 'observation' is also a general goal of work across the curriculum, the problem was to define its particular meaning in the context of science. What are 'relevant' observations? Should 'observation' be directed towards a particular pattern? What distinguishes quantitative from qualitative observations? Is the role of the primary school to help children make observations and the secondary school to help them use them? These were typical of the questions asked. Many were answered by the participants themselves, and many led to more general issues, such as the extent to which children should be allowed to 'go down blind alleys'. The discussion confirmed that there was initially no shared meaning of the term 'observation' and that this may take some time to develop.

There followed a discussion of certain features of the teaching approach which was illustrated by the edited video-tape of a class engaged on the topic 'Floating blocks'. The tape showed the teacher setting the children to work in groups, using the worksheets; the extracts focused mainly on the children working in groups and on parts of a whole class discussion. There was a great deal that could have been learned about the children's reactions to the activities, their interactions in groups and the effect on their activity of the teacher's intervention. However, many of the teachers were resistant to taking the taped material seriously because they immediately judged the children and teacher as 'middle class' and consequently in a different world from their own inner city, working class children. This culture clash in the medium mostly destroyed the message.

The first day's programme ended with an evening talk by a visiting speaker on his work over ten years of observation in primary classrooms. He spoke not so much about his results as the methods that teachers can use to improve their practice. Some of his messages were: treat the classroom as a curriculum laboratory; question your ideas and assumptions about it; start by questioning what you are doing and define your problems; if you do not at first like a new approach that is offered, suspend judgement and try it; teachers' views and children's views of what happens in a classroom may not coincide. Clearly these were apposite messages for those teachers who were disposed to reject the approach the workshop was introducing.

The second day's activities

The morning was spent in activity on the two topics: 'Snails' and 'Cool cans', participants being equally divided between the two sessions running in parallel.

The 'Snails' topic was enjoyed, and it was felt to be a good idea to have the large African Land Snail as well as small local snails. Teachers like the open-ended approach, of asking children to define problems, but they were a little disappointed that only the 'science' aspects of the topic had been included. They would have liked some idea of how integration with other activities would be managed. The teachers showed in their own work on the topic a tendency to jump from a question in their mind to actions which could not be described as scientific investigations. When questioned about this, their reply was that they were 'playing' and would come to more serious investigation later. The idea of a 'play period' appeared to have value for all the topics, and it was reinforced by the teachers' later experience in teaching their own classes.

'Cool cans' also proved a useful and enjoyable exercise, illustrating a different part of the approach, that of relating cause and effect. The initial observations were thorough and detailed, but teachers found difficulty in separating observations of the effects from speculations about 'causes' (i.e. mechanisms). This may have been a problem resulting from asking adults to speculate about an observation to which they felt they knew the 'right' answer. They were not content to investigate the variables, the different conditions associated with the condensation on the cans, but in no time were inventing all sorts of possible mechanisms. It was felt that perhaps more time should have been spent on clarifying the difference between 'causes' as variables and 'causes' as mechanisms and on the likely problems created in the classroom by ignoring it. Devising tests, hinges on this distinction, and the clarification of the principle involved in manipulating variables to test explanations.

After a discussion of the third paper 'Helping children to plan investigations', the workshop continued with the groups interchanged. Then half an hour was set aside for the groups of teachers to meet for discussion with their local adviser, but without a course team member present. Groups wrote down questions and comments which were considered by the course team during a tea break. A lively open forum ensued in which participants were active in responding to each others' questions and points of view.

The third half-day's activities

The first session was devoted to explaining the overall plan for the eight weeks of trial work in schools and to introducing the methods of evaluating these trials.

The five groups in which the teachers were to work during the trials had been anticipated in forming the groups for the workshop activities. This proved to have been most valuable in helping to overcome any resistance to having observers in the classroom; there was already created a sense of co-operation in trying out and developing, rather than accepting or rejecting, the approach presented.

Each group of four (in one case, five) teachers decided which two of the three topics they would use during the trial period. The groups were to meet once each week in the school of one of their members, where they were to observe the lesson (usually for one hour) and then meet afterwards to discuss it. Meanwhile, all the teachers were trying the work, so that each week they saw a different phase of the topic in a different school as well as trying it with their own classes. At the weekly meeting they could, therefore, not only discuss the lesson they had observed, but share their own experience and problems with each other.

The evaluation was introduced as a means of focusing attention on the particular aspects of teaching and learning in the classrooms which related to the approach. It did not attempt to provide comprehensive information about classroom events. Each observer in the classroom had a specified task and these were rotated among the group members. The evaluation forms were introduced with the help of notes which described how they were to be used. For each form, a section of the video-tape was used in order to practise its use and to agree some of the boundary definitions necessary for consistent use. Rather too little time was available for explaining and practising the evaluation. It could have been made into a useful exercise in identifying examples of children's behaviour relating to process skills and hence in clarifying their operational meaning. This was an opportunity missed through lack of time, but the hurried training was perhaps just sufficient for the purpose of enabling teachers to use the forms in the classroom trials. It was emphasized that the results were to inform the immediate discussion after a lesson, not to form a basis for any broad conclusions going beyond a particular lesson.

In the second part of the morning, groups met with their local advisers to arrange their programmes of work. The full support of the adviser was crucial to the success of this part of the programme. They facilitated the drawing up and implementation of a series of weekly visits to schools for observation and meetings. In all cases the meeting was also attended either by the adviser or a course team member (occasionally both).

6. The trial work in schools

Every group carried out the programme of work and visits which had been drawn up, with the necessary adjustments to allow for the unexpected events such as one teacher suffering a broken shoulder and another being temporarily drafted to another school. Only one teacher dropped out voluntarily, having signalled his intention to do so from the start of the initial conference.

An overview of the trial work, as reported by each group at the first follow-up meeting at the end of the eight week period, is given in the next section. During the trials, the messages received from all the groups were that the work was being enjoyed by all involved. The teachers were particularly valuing the chance to visit other schools and classes, and to discuss openly substantive issues of teaching. The advisers valued the structure of the in-service activity. It enabled them to help teachers at the level where help was most needed and most applicable - in relation to particular classes and specific instances. The course team members were excited to see that the activities were proving interesting and stimulating to the children in the hands of many different teachers. Moreover the teachers showed, in discussion, that they were thinking critically about what they were doing and beginning to see through the surface activities to the intellectual activity of the children.

Descriptions of one of the 40 meetings must serve to exemplify the atmosphere of the trial work. It was held in a school where the teacher was beginning the topic 'Floating blocks' with his class of 30 9- and 10-year old children. There were, on this occasion, five observers in the room, though a casual visitor might not have noticed them. Three were seated near to three different groups of children, silently completing the observation schedules for a group and not moving throughout the lesson. One observed the whole class, again unobtrusively from a fixed point. The fifth had to follow the teacher closely enough to hear what he said, but this was not difficult, given that the noise level in the class was quite low, and the teacher moved slowly from group to group, visiting each one about twice in the lesson, for a period of four or five minutes each time.

The resulting records of the first 40 minutes, spent on group work showed a high proportion of children actively working on the task. When the nature of this work was examined, however, it was found to be almost entirely concerned with making observations and recording. Despite the agreement that one pupil should record observations made by all members of the group and discussed among them, in many cases all the children in the group were making their own record - a drawing of the way the blocks were floating. At one point in the lesson the teacher called the attention of the children to the expectation that one record, discussed and agreed in the group, would be made. The children nodded and went back to their individual recording. Several spent 30 minutes on the drawing and only two or three minutes discussing observations. The association of 'work' with 'writing', or putting something on paper, is deeply ingrained!

Other evidence showed that this class was not used to working in groups (perhaps used to sitting in groups to work individually, but not used to cooperative group work) and much of the teacher's talk was concerned with encouraging certain procedures for working. The effect upon a group of the teacher's approach was to raise the level and demand of activity for a while, after which it slumped again to a routine level. It was noted by group observers that the children would respond to the teacher, when he visited, as if they had done what was intended on the work sheet. The observers, however, had seen very little group activity to justify this.

The brief, whole class discussion was mainly a reporting session. For the most part, the children's remarks were addressed to the teacher; only occasionally did a pupil respond to what another pupil had said. Some of the children's observations were not accepted by the teacher, and opportunities were missed for returning to the equipment to check controversial observations. Indeed, children were discouraged from doing this. When children heard another group report some observation which they had not made, they immediately wanted to see for themselves. Fearing that the reporting back would be interrupted, the teacher did not allow the children to touch the equipment. Hence the value to the children of exchanging findings was diminished by the structure imposed on the discussion. The handling of whole class discussions was an aspect of the approach with which most teachers needed more help.

In the discussion following the lesson, the three observers who had focused on groups found some differences as well as some similar patterns in the children's behaviours. In some groups, the children had gone beyond making observations and had suggested explanations. (One group had seen, through the transparent sides of the water trough in which the blocks were floating, that there were bubbles on the undersides of the blocks and had proposed these as explanations of the different levels of floating.) They had also noticed the different images they could see through the corners of the trough and the 'bending' of objects half in the water.

As a solution to the children's concern to write or to draw, rather than discuss, it was thought that there could well have been a period at the start of the topic for 'free play', with no suggestions as to activity, observations, discussion or recording. Perhaps, if they were free from the burden of having a task to complete, the children would spontaneously talk about their observations to each other, and continue to make observations free from any pressure they might feel to get the work done (cf. the teachers' own behaviours in the initial workshops, page 63).

A second main point arose from the teacher's verbal exchanges with groups, which had often been designed to lead the children to use process skills - 'look again and check that what you said is right', 'if your explanation works, what else would you expect to find?', 'can you think of another explanation', and so on. The teachers wondered whether it would help to make explicit to the children the processes they were being encouraged to use. It was even suggested that a list of what to do to tackle a problem scientifically could be put up in the classroom. But what would such a list contain? The first idea reflected a purely inductive approach, and the notion foundered when it was realized that this would be too simplistic. Other effective ways of tackling problems, not easily pinned down on a flow diagram, are more often used by children. There was also the danger that teaching children about processes might end up in knowledge of skills rather than the ability to apply the skills to understand the world around.

Many other points raised came under the general heading of the recognition of the benefit of being able to watch children closely while working. The teachers realized that what they saw happening in the groups (such as the children responding to the teacher according to his expectations rather than giving a true reflection of what they had done) would probably also be happening in their own classes. They saw from another angle the effects of different kinds of teacher interventions. As observers, they could more easily assess the pros and cons of working in different ways.

7. The first follow-up meeting

This was a five-hour working session, from 1.30 p.m. to 7 p.m. with break for tea and sandwiches mid-way. Seventeen teachers and six advisers attended; two teachers were unable to come, and one adviser could stay only for one hour. The first two hours were spent in gathering reports from groups, sifting out the main issues and discussing them.

The reports show that, even though many had not arrived at any personal solutions, most of the teachers had achieved a sharper realization of the issues. Indeed, the reporting from each group and the ensuing discussion helped in the understanding of the problems (and in so doing exemplified the value for teachers as well as for children of working on a common problem and exchanging views about it). Clearly teachers were not agreed on several matters. Some reported that children were not observing carefully enough, some that children did nothing more than observe (was this a difference in the teacher's conception of 'observing'?). Some found that having all the class working in groups at one time was too demanding, whilst others managed comfortably (possibly a difference in perception of how much value there was in leaving children to work out their own ideas?). Most had found the evaluation schedules easy to use and helpful; others had wanted to participate in the lessons rather than observe.

Many of the issues which seemed to be of most concern to teachers were organizational: the use of worksheets, the notion of a group reporter, having all the groups working at the same time, managing the whole class discussions. The second level of concern related to the children's reactions: their enthusiasm, their supposed lack of previous experience, their ability and willingness to work in the way suggested. A third set of issues related to the children's activity and learning: whether they spent too much or too little time observing, whether they developed other skill and concepts, how they learned new words. Finally, there was the structure of the activities themselves: the idea of a free play period at the start, the need to encourage observation at something more than a superficial level. Interestingly, no one questioned the appropriateness of the activities nor whether they provided sufficient opportunity for process skill and concept development.

During the discussion of these issues, team members reminded the teachers of the rationale of the approach. The approach and the suggested way of implementing it were devised to achieve specific aims: of enabling children to work out and test out ideas for themselves; to have access to alternative ideas; to review critically their ways of working and the findings they achieved; during all these activities, to think as well as to do and to communicate with others. All the features of the approach were open to modification, but any changes should be consistent with the pursuit of the same aims.

Though not all were convinced, there were several whose views about a shared class topic were swayed by the arguments in favour (which have been outlined earlier, pages 56-58). Despite the difficulties, they were persuaded that class discussion could be of such help to children's learning that it was worth the effort of trying to make it work. On other matters - such as the use of worksheets - opinions remained divided and probably for good reasons relating to the different experience and habits of children as well as teachers.

Planning further topics for developing process skills and basic concepts

Application of ideas and skills is important in learning of all kinds, no less for teachers than for pupils. Applying the ideas discussed in the course, to date, was the next step planned in the teachers' in-service education. In planning this part of the meeting, the course team had identified a number of topics to suggest. These topics were chosen to meet the criteria of:

interest to children, and relevance to their understanding of the world around;

investigation by children, and giving opportunity for the use of process skills;

involving basic science concepts which children can grasp at their level;

amenable to investigation, using simple, readily available equipment.

Each group of teachers was asked to agree upon one topic (from the list supplied or something similar) and to begin to devise process-based activities through which it could be explored by children. They were to make a start at this meeting (held just before the Christmas holiday) and continue in the next follow-up meeting at the beginning of the following term. A selection of books and science schemes of various kinds was provided.

The teachers worked for about $1\frac{1}{2}$ hours completely unaided, except by the written resources. During this time, the team tutors and the LEA advisers met to discuss the success of the course to date, and to plan future in-service collaboration.

Groups then reported, to a final plenary session, on the activities they were planning. Although some were imaginative, and would clearly be intriguing to children, the proposals were, for the most part, disappointingly subject- rather than child-centred. They emphasized learning outcomes in terms of content, rather than learning processes. Some groups mentioned that children would be involved in observing or making predictions, but some made no reference at all to process skills.

The realization was unavoidable that most of the teachers still had far to go in their understanding of the role of processes in learning, the gradual building of children's ideas, and the recognition of the children's own ideas. Whilst it is one thing to use activities devised by others, it is quite a different thing to be able to construct such activities. It was realized that the teachers had not analysed the activities they had tried out, to identify those features which gave opportunities for children to interpret, to plan, to explain, to test. Thus, they were in no position to identify the structure and the features that had to be planned into new topics.

The course team might not have appreciated how big was the gap still to be crossed had they sat with the groups and helped in the initial planning. It was then possible to plan the kind of help which was clearly needed. Even though this meant that the meeting ended on a lower key than the earlier high point of enthusiasm about the classroom work, important lessons had been learned by all concerned. The course team applied this learning in drawing up the programme for the second follow-up meeting.

8. The second follow-up meeting

At the start, some ideas were put to the meeting about the planning of classroom activities with a process emphasis. Notes were circulated which suggested that planning should start from thinking about the kinds of learning that the science activities were intended to help bring about. The next steps were to consider:

What activities and other experiences give opportunity for this learning?

Which of these kinds of opportunity can be provided in this topic?

how should the activities/experiences be organized?

What is the teacher's role in the activities/experiences?

'Activities and other experiences' was a phrase used to signal the idea that not all learning takes place through physical activity; mental activity plays an important part, as does using secondary sources in some cases. Nevertheless, the consideration of 'activities and other experiences' has to take into account the age and experience of the children. Primary children learn best if they start from concrete experiences, if they can interact with real things, for such experiences give them the opportunity of using and developing process skills. It is also necessary to bear in mind that children already have ideas about things around them, and these ideas influence their thinking and their approach to classroom activities. The role of process skills in developing and changing children's ideas is important, but so are exposure to others' ideas and the opportunity to reflect upon their own and others' ideas. These considerations had led the course team to propose the approach to teaching used last term. It was certainly not the only approach, but alternatives should be rigorously evaluated against the same criteria. For instance:

there should be opportunities for children to think as well as do;

children's ideas should be challenged by others' alternative ideas;

children's ways of thinking should be developed by active teacher intervention;

children should be encouraged to go back over what they have done, reflect on it and consider improvements that could be made in procedures and ideas.

To meet these points, it was necessary to create a balance between teacher intervention and children discussing in groups without the teacher present.

The teachers were then asked to reconsider the activities they had begun to plan in their groups in the light of these points. In subsequent planning, for which $1\frac{1}{2}$ hours was provisionally made available in the meeting, they were asked to think out and make explicit the way in which the activities met the following criteria. The activities were to be developed in practice using materials and equipment brought along or supplied at the workshop. Later in the meeting, each group was to present the activities to another group so that critical comments and further suggestions could be obtained for revision of the activities. In planning their own and in evaluating others' activities they were asked to keep these criteria in mind:

1. the children's activities in the plan should meet all the above criteria;

2. the plan should indicate the scope of the topic - what is included, what is excluded;

3. the plan should specify the process skills and concepts intended to be involved, and how the activities relate to them;

4. the way of introducing the topic to the children should be specified in teachers' notes, which also indicate how one activity is linked with another (e.g. the outline teachers' notes);

5. the content of worksheets (for optional use) should be planned;

6. the teacher's role should be specified and indicated, including the identification of possible key questions;

7. the time, space and equipment needed should be specified.

Group planning

Several groups had met prior to the course meeting and had well-advanced ideas about proposed activities. All, except one group, brought materials and equipment with them - in one case this took the form of a carefully made wooden structure to use as an inclined plane.

Groups took various starting-points in their discussions. The most profitable later emerged as the consideration of the fundamental ideas that children could reach or consolidate from simple observations and investigations. For instance one group had initially listed a range of ideas about dissolving, including the notion of saturation, the effect of temperature, evaporation to 'prove' that the solute was in the solution, etc. In the end they found a great deal that could be done to establish the understanding of what 'dissolving' means. Children could gain ideas about it by simply observing what happens when a sugar lump is put in water and by watching the sugar particles disappear into the water. They could try changing the rate of dissolving, using hot water, and compare the dissolving of a sugar lump with sugar from a crushed lump. They could investigate everyday substances in a similar way, and they would encounter both clear-coloured solutions and cloudy 'solutions'. All of this would add to their understanding of the concept of dissolving in a much more direct way than by dealing with saturation and evaporation.

A more catastrophic change in their plans was found to be necessary by the group that brought along the wooden structure. They wanted children to use the inclined plane to 'discover' that the greater the load on an object on the sloping surface the higher the incline had to be before the object would slide down. The teachers in the group soon 'discovered' that this was a relationship that held neither in theory nor in practice. So this part of their planned activities was abandoned. The teachers involved freely admitted that their failure lay, not so much in their ignorance of physics, but in their starting-point. They had taken as their starting-point a (supposed) physical relationship, and had engineered a situation in which children might 'discover' it; in doing this, they ignored the absence of the application of the supposed relationship in everyday life and therefore the lack of relevance to children's understanding of the world around them. The teachers involved learned a very good lesson from their mistake.

Devising the activities took longer than the timetable for the meeting allowed, and only three groups drew up worksheets and teachers' notes. They were, however, very keen to present their activities to another group, and particularly to find out what other groups had done. This arrangement worked well, and took about 30 minutes. When groups reformed, they spent another half hour on revision, but again did not reach in the time available the state of planning prescribed by the criteria.

Summing up

In the final plenary discussion, teachers accepted a general criticism that their activities had overlooked opportunities for children to use process skills (to watch things happening closely, for instance, and to predict the effect of changing things before doing it) and they agreed to give more attention to such matters in revision. They considered the work of the meeting to have been very valuable, and thus agreed to complete the written form of their plans within a given time limit so that they could be distributed to others. They would be using their own plans with their own classes at first, and then trying one of the topics received from another group.

Many written resources - sets of books for teachers, workcards and handbooks - had been made available for use during the meeting. It was interesting to observe that not a great deal of use was made of these during the meeting. However, the teachers said that they had used the books (mainly Science 5/13) for initial ideas, and for information about materials and substances to try in their tests.

Teachers made the point that although the planning and devising of children's activities were useful as training activities, they would not have time to do such things for themselves as a regular part of their lesson preparation. In discussing the most useful form in which ready-made ideas for children's activities could be supplied, it was suggested that starting-points which focused on simple phenomena (such as friction and dissolving), could meet their need. Some ideas could be developed in detail, others left in the form of skeleton outlines of children's activities.

9. The final follow-up meeting

Report of trials of teachers' own activities

This third five-hour meeting took place only a few weeks after the second one. In the intervening time, the teachers in each group had tried out the activities they had devised themselves, but had not had an opportunity to try the activities produced by other groups. It became clear, through the reports of their work, that the teachers were adopting an experimental approach to their work and had been using aspects of the method of teaching introduced in the workshop. In particular, they had had all the children in the class working in groups on the topic, they had asked groups to report to each other and had held whole class discussions.

Two examples of the more open approach which emerged from the reports concern, in one case, the use of process skills and, in the other, children's own ideas. The first was a class of 7- and 8-year olds who were dissolving sugar in water. The teacher had set them first to observe a cube of sugar dissolving in a cup of water, to make a group record and then to report. One group reported seeing a 'syrup' coming from the sugar when they stirred with a spoon just in the top of the water. All the others wanted to try this, and were told by the children in the group who had observed it how to obtain the effect. This part of the work stretched out far longer than the teacher had expected. When the children went on to find out if hot water made any difference, they noticed a cloud above the surface of the water. To the teacher's surprise, they tried to relate this cloud to the dissolving.

The second example was a group who produced a neat method for measuring the pull needed to move a brick across the floor. They introduced this method to the other children, and, indeed, produced a pre-work sheet which gave directions for making the force measurer. (In discussion at the meeting this group accepted that many other ways of comparing or measuring the forces could have been used and it would have been better to have worked these out with the children.) The children put a cm scale on their measurer, and when they pulled the brick along something was measured, but what? One teacher reported that the children's answers to what they were measuring included 'the strength in your muscles', 'the strength of the elastic band', 'the weight of the brick', 'how much you can pull', 'how far you move it'. He was surprised, and recognized the danger of giving a set of directions that children would follow though having little idea of the meaning of what they were measuring.

The activities produced by a further group should also be mentioned for their conceptual complexity. In these, the first two worksheets led the children into investigating the slope of a plank when a block would slide down it. The next worksheet led them into making measurements, and looking for a relationship between the height of the plank and the distance the block slid along the floor after slipping down. Here, the pattern relates to the potential energy of the block rather than to friction. The confusion of the two complex ideas would make any pattern extremely difficult to explain. Indeed, it did appear from the teachers' accounts that their children had not shown much enthusiasm beyond the 'playing' stage. This may well have been because it was not at all clear why they were making the measurements they were asked to make. By contrast, the third group working on friction had focused well onto this one phenomenon by keeping to a simple way of comparing the force needed to pull a block covered in a sock across different surfaces. Their account showed that they had allowed children to make mistakes, by not controlling variables, for example, and the children had wanted to repeat their trials to improve their 'fairness'. A general awareness grew among the teachers of the time needed to allow children to do things more than once.

Discussion and use of 'indicators' relating to process skills

The next part of the meeting was concerned with selecting and modifying activities with the aim of giving opportunities for the use of process skills. The starting-point was the open-ended set of operational statements about the six process skills which had previously been listed. These were presented as 'indicators' - statements of those behaviours of children that would indicate that the process skills were being used (cf. Chapter 7, page 74). One of several uses of such a list is to analyse written materials to find the extent to which opportunities were provided for using process skills. This can lead on to using the list to identify missing learning opportunities and suggesting modifications. A further use, which could only be briefly alluded to at this meeting, is to use the list for the teachers' own evaluation of classroom activities.

To exemplify the first of these uses of the indicators, the groups were set the task of analysing a series of activities from a published programme. They were also asked to consider the list of indicators itself in the process of doing this, and to suggest amendments. A grid was supplied for summarizing their judgements, and for collecting their estimates of the time that each activity would take. After the group work, the judgements were collected together and discussed. The activities in the 'Cold cans' topic were treated similarly. The results made the point that the 'value' (in terms of process-based activity) for time spent was much greater in the activities with the cold cans. The teachers made few suggestions for modifying the indicators, but they clearly found them very useful, and they later said they would like some indicators of 'attitudes'.

There was no time to use these indicators systematically to 'improve' those activities which were thin in the use of process skills, as was intended. The exercise might well have seemed to have had more point if this had been done. Neither was it possible to begin to examine the problems of assessing the development of process skills in children. These matters were left to further follow-up meetings outside the bounds of the course.

Beyond the course

The course team felt that it was too soon for the work with the teachers to come to an end, although the planned programme had finished. Some teachers no doubt felt that they had given science more than its share of attention for a while, and needed to direct their effort to other areas of the curriculum. However, further meetings were offered to those interested, and this offer was taken up by four groups - two to consider assessment, using a check-list for pupil observation, one to consider concept/process development, and one to help in making more video-tapes of classroom activities. There were also the LEA advisers to continue to give some support. The team maintained contact with the advisers, and immediately began planning with them the next course for other groups of teachers.

CHAPTER 7

DEVELOPING A WORKSHOP APPROACH TO IN-SERVICE TRAINING IN INDONESIA

Wynne Harlen

1. Introduction

In Indonesia, in the late 1960s and early 1970s, the concern was with setting up a system of universal elementary schooling, and it was only towards the end of the 1970s that serious thoughts about quality could take precedence over thought about numbers. The national elementary school syllabus, devised in 1975, gave science a compulsory place in the curriculum, and laid down in detail the content to be covered in the six grades of the elementary school. Textbooks were prepared. These followed the syllabus closely, but were often not available in large enough quantities for all children to have one. Teachers were supported with official guides to teaching topics in the syllabus which outlined the content lesson by lesson.

The demand for about one million teachers, needed to staff the new primary schools, was met by providing teacher-training courses. These replaced, for intending teachers, a senior high school education. These courses have a very small science component, if any. Moreover, the teacher trainers' own science education is generally meagre. It is not suprising then, that primary teachers' scientific knowledge is not very extensive, and their understanding of the contribution of science to children's education is restricted to learning by rote the facts and principles given in the textbooks. This situation was naturally of concern to many people, including the science educators in higher education, who were aware of the great gulf between the skills and the ideas the young generation were able to develop and those which they would need in the rapidly changing world into which they were growing. The pace of change in developing countries has been greater even than in the more developed ones; children of the 1970s were living in homes which provided none of the incidental education that children in the more industrialized countries may derive from the home, the media, from libraries and from daily contact with technology. Yet these children would, in their life time, be expected to operate in a modern society, moulded by advanced technology and networks of communication.

2. Studying the problem

A seminar was held to study how elementary school science might be improved, particularly through promoting teaching methods designed to develop children's process skills and attitudes towards science. The 35 participants includes inspectors, teacher trainers, university lecturers, curriculum developers and elementary school teachers. The seminar was run as a workshop where the problem was studied scientifically by the participants, using the same skills that it was hoped to develop in children. Thus, their own understanding of the meaning of scientific processes was advanced by the way they were working together. It was felt to be essential to work in this way, for many of those taking part had knowledge, if at all, only about such processes as observation, planning investigations, interpreting findings. So they thought that 'teaching process skills to children' meant passing on this information. Only through their own personal involvement in the processes did they come to appreciate their deeper meaning, and the value for children of similar involvement. Furthermore, this helped to steer them away from the single-minded concern with what the teacher would do or tell the children towards a concern with pupil activity.

The study of the present problems of teaching elementary science began in the classroom. The preparation for observing pupil activity began by considering how the use of process skills would be recognized. Taking a simple and restricted list (observation, raising questions, planning investigations, interpreting findings, communication), participants were arranged in heterogeneous groups and asked to identify five or six indicators of the use of these skills. The task was to express each process skill in terms of actions or words that were observable in the way children were carrying out their work.

After one hour, groups were asked to write out their lists on large sheets of lining paper, and pin them up for others to see. As the first few lists appeared, it became clear that the task had been misunderstood. The 'indicators' listed were of teacher behaviour, not of pupil behaviour. Moreover, they were related to telling children about the processes rather than to providing children with experience of them. The task had to be begun all over again. This could not be avoided, for the indicators were required to assist observation in schools the next day. It was no use betraying the very approach we were hoping to convey by simply presenting 'answers' to them; the participants had to think them out for themselves. Everyone worked late that night.

Eventually, through a painful, but crucial process of refining ideas about the meaning of 'process skills', a list of indicators was drawn up. As an example, the indicators which related to 'planning investigations' were:

1. decides what equipment, materials and resources are needed for an investigation;

2. identifies the variables to be controlled when one is changed;

3. decides what to look for, measure and record in an investigation;

4. identifies the various steps to be taken in an investigation.

The indicators for each process skill were used to decide whether there was any sign of pupils being involved in using process skills in the lessons observed. A very simple observation schedule was prepared (enough was known about the kind of science lessons to be expected to realize that a more sophisticated instrument was not needed). The schedule required observers to note, in each five-minute interval in the lesson, any behaviour that indicated the use of any of the process skills.

The next morning participants were split into groups and travelled to different schools to observe lessons. The following two examples were typical. The notes made in each five-minute interval are as follows:

8.10 a.m. A grade 3 class with a young male teacher. The observers sit at the back of the class in spare desks. The class has single desks arranged in rows all facing the front and the blackboard. It takes some time to settle the class and the visitors. The teacher is understandably a little nervous.

8.15 a.m. Teacher tells children to take out exercise books. There are no textbooks. After a brief introduction he begins a question-and-answer routine. The questions require one-word answers which are chanted by the class as a whole. They listen and chant as the series of questions goes on. Already some children are not participating in answering, but the teacher does not notice. He speaks kindly, and tries to put some interest in what he is talking about by smiles and gestures.

8.20 a.m. Teacher consults a book on his table. This is the official lesson guide. He begins to draw on the blackboard a diagram (a cross-section) of the sea and of mountains on the land. He is describing how moist air from the sea goes up the mountains and forms clouds. The children name the parts as he draws them, in response to his questions, again chanting. In five minutes he has described the process of rain formation.

8.25 a.m. He is describing the effect of the rain washing down the side of the mountain, and the importance of trees. He adds trees to his drawing, rubs them out, and describes the erosion which takes place if they are not there. No child has yet done anything except listen and look at the blackboard. There is some fidgeting, but the children are docile (probably aware of the visitors behind them) and do not talk to each other.

8.30 a.m. He continues to discuss water erosion, adding to his diagram to illustrate points, but going at a very quick pace (which, with this subject-matter, would be too fast even for a revision lesson).

8.35 a.m. Another period of question-and-answer, in the same pattern as before. The children's exercise books and pencils are unused.

8.37 a.m. The teacher consults the lesson guide again. He spends three minutes doing this, during which time the children wait.

8.40 a.m. The teacher continues to tell them about the formation of clouds. He rubs off the clouds from his drawing. He marks a point on the mountain-side as Rarahan (the village of the school), so he is trying to apply the ideas to the children's home village and surroundings. He puts the clouds on the diagram again. He asks some questions which the pupils cannot answer, so he answers them himself. Repeating the answer is presumably his attempt to teach what the pupils do not know. Some children from other classes look through the window.

8.45 a.m. More of the same questions from the teacher followed by one-word answers from the class. All questions are addressed to the class as a whole. The teacher stays at the front of the class all the time. One of the children looking through the window calls out. No one reacts. The teachers come to tell us that the lesson is over.

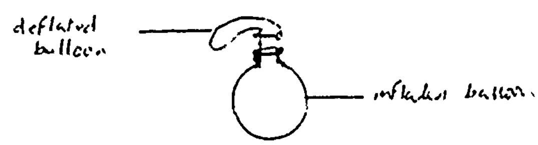
The observers have seen nothing which they can record on their observation schedule of pupils' activities, since these deal only with the process skills which have been noticeably absent throughout. The teacher used one technique throughout and made no use of equipment other than chalk and blackboard.

In another school, a grade 4 class of 43 pupils occupy a large classroom, but some children have to share a double desk between three. These pupils have several exercise books, either in bags or held in a bundle by a rubber band. The lady teacher has one of the pupils' textbooks on her table, which she consults frequently. Some of the pupils also have these books, but not many.

9.45 a.m. The teacher stands at the front of the class asking questions which are answered in unison by one-word replies. Many such questions are asked.

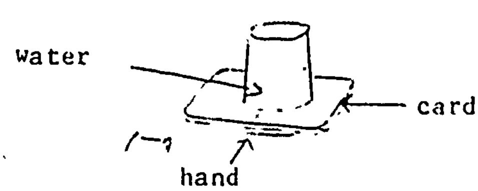
9.50 a.m. Continuation of questioning by the teacher, interrupted only to consult the textbook. At one point a child calls out an unexpected answer, but the teacher takes no notice, waiting only for others to give the correct answer. After each question she repeats the correct answer. Several children are absorbed by other matters or their own thoughts, as judged by their inattention, but they are passively uninterested, not disruptive.

9.55 a.m. The teacher consults the textbook again, asks another question and goes to the blackboard to draw a balloon attached to another balloon, one being inflated, thus:



Her blackboard work is poor, but the change in activity, as she questions whilst drawing, stimulates more interest. Later we see that this same drawing is in the textbook.

10 a.m. It becomes clear that she is describing an experiment and telling them what happened when the air is allowed to go into the other balloon. She changes the drawing to show the result. Then she consults the textbook again. She picks up a glass of water, not full, which she has brought in, and a piece of card. The latter is the cover of a folder, about 30 x 40 cm, and is double. She places the centre of this over the top of the glass and inverts it.



She keeps her hand on the card to hold it up, but apparently is telling the children that the air pressure is keeping it up. She turns it upright quickly.

10.05 a.m. She invites a child to come out to the front and repeat the action. A second child is asked to do it also. Again we find that this is in the textbook, but the teacher has not noticed that the glass has to be full and the hand removed before anything is demonstrated! The teacher then asks two children to bring a paraffin stove from the side of the class into the front. They put it on the floor. The stove is lit and a pan of water placed on it. She tells them what they are going to see when it boils.

10.10 a.m. While the water is being heated, the teacher stands in front of it addressing the class.

10.15 a.m. The water is now boiling, but hardly any of the children are looking at it. Most could not see anyway from their seats. The teacher calls on a pupil from the back of the class to look at the boiling water and to make some statement about it. This child has an opportunity to observe and communicate since he is asked to tell the class something. However his observation is very brief (about 30 seconds) and his statement even more brief, since the teacher rephrases his statement for him. Another child is then called upon and the procedure repeated. This happens for a third and a fourth child all within the space of three minutes. It is noticeable that the other children become interested in what is happening as soon as one of them is involved in doing something.

10.20 a.m. After another look at the textbook the teacher tells the children to take their exercise books and copy what she is writing on the board. Her writing is not clear and her lines of writing are crooked. Little wonder that some of what gets copied (when their books were inspected) is incorrect. What they are effectively doing is copying the textbook into their exercise books, but without diagrams which help it to make sense.

10.25 a.m.-
10.35 a.m. Copying from the board continues. While they write the children say the words to themselves, so there is now a quiet hum, but they are not talking to each other.

In this lesson there was some attempt to give a few children a chance to observe and carry out an action (even though simply following instructions). What disturbed many of the observers was that much of the subject-matter was presented inaccurately.

The involvement of children in the lesson, even to the limited extent seen in this second lesson, was, it seemed, rare, according to the reports of the observers when they came together to share their findings from visiting different schools. On the surface, it seemed that all the hard work in defining 'indicators' had been wasted. The observers had seen hardly anything in the pupils' behaviour which could be related to them. But, by thinking out what they would like to see, they were armed with evidence about what was happening, and the implications of it. They had seen teachers who concentrated upon content, yet had not themselves mastered that content, and so they taught it inaccurately. Teachers had given the children minimal opportunity to find out or think for themselves. When asked for the objectives of the lesson, they mentioned only knowledge of the subject-matter; they did not recognize that anything else was required of them. The seminar participants were somewhat stunned by what they had found, yet, if they had not been given a new framework for observing what was happening, and, instead, had used their old one, they may not have been so dismayed by what they saw.

The challenge to the seminar was to change this situation into one in which children have opportunities to raise questions, to observe discriminately, to plan and carry out investigations and to communicate effectively.

The task was enormous. Moreover it became clear that there was a complex set of interconnected factors which acted to produce the situation which existed. To attempt to change any one factor alone would be unproductive. If teachers would be persuaded that different methods of teaching science should be used in the interests of improving children's learning there would not only be the problem of providing training for them, but one of providing a context in the educational system which could support and not reject the change. The more obvious factors which influence teaching, and which must, therefore, be taken into account in any plans to change teaching were:

the syllabus that defines the content to be covered;

the assessments which are made of the pupils;

the expectations that head teachers, inspectors, parents, have of teachers;

the training the teacher has had;

the resources available, in terms of materials, funds and the environment of the school;

the help that a teacher has from colleagues inside the school and from others outside it.

3. Planning action

Within the context of the seminar which is being described, quite clearly very little could be done about these things except to make plans and representations to those who were in a position to influence the decision-makers. Over subsequent years, however, some actions were taken. Eighteen months later, a seminar was held at which the syllabus content was reviewed, and reorganized under broad concept headings, so reducing the burden of content to be covered. Meanwhile projects were initiated to change teaching methods in other subjects of the primary curriculum, and to set up, in a limited locality, teachers' centres, where teachers could obtain help and give each other mutual support. Further science seminars and workshops were held on the development of the process skills of science, and care was taken to ensure that inspectors, representatives of initial training institutions, curriculum development projects and assessment sections were always among the participants.

Here, we return to the story of the seminar that uncovered the extent of the problem. Its work had only just begun. The educational system could not be changed in the next few days, but at least it was possible to test some hypotheses about the changes that might more readily be made in the classroom.

The schedule of classroom observation had given very little information about what pupils and teachers were doing, as opposed to what they were not doing (using the process skills). Therefore, it was useful to make a separate list of typical activities of the pupils and teachers which had been observed:

Pupils: Listening to the teacher;

(Infrequently) Watching demonstrations and observing;

Answering the teacher's questions, mostly in unison and only occasionally individually;

(Rarely) Doing something individually and interpreting findings;

Copying from the blackboard.

Teachers: Asking 'closed' questions requiring one-word answers;

Answering his own questions, if the pupils did not answer;

Writing on the blackboard;

Remaining always at the front of the class;

Talking and asking questions, with only the rare use of any equipment or aids;

Following the pupil's textbook, or the lesson guide, step by step;

Explaining concepts inaccurately, and giving wrong information;

Covering manv topics and a large amount of content in one lesson;

Repeating a good deal of material previously taught, and only occasionally carrying out a demonstration or giving pupils a chance to join in doing an experiment in front of the class.

These teacher- and pupil-activities were considered in relation to the type of learning that was encouraged and discouraged. When the way in which children acquire ideas of process skills in science was considered, it seemed that there needed to be an almost complete reversal of what was encouraged and discouraged. What was wanted was, for example, for teachers to:

ask 'open' and person-centred questions;

allow time for children to answer (not do so themselves);

follow the children's ideas, not the textbook;

not always be giving information and not always talking, but providing children with experiences that 'do the telling';

use real things wherever possible, rather than the blackboard, so that children would have an opportunity to:

express their own ideas, discuss, ask questions;

do things which help them to try out ideas and develop fresh ones;

understand what they are doing instead of learning by rote;

communicate through discussion, and their own notes, to help in the clarification of ideas.

There was so much to be changed, but it was not necessary to wait to do all of it (which would mean waiting for ever) before making a start. One of the most easily made changes was, in fact, the one that many teachers see as the obstacle to change - the provision of materials and equipment. The classrooms were bare, yet the school surroundings provided plenty of real things for children to use in their learning; it was a matter of recognizing these as learning materials.

4. Testing out ideas about changes

As a start, one of the lessons that had been observed was considered and the question asked: 'how could we change this lesson so that the things the children and teacher were doing were more like the second, rather than the first set listed above?'. The records of what had been done were re-examined, but it soon became obvious that there was a big problem of 'content coverage'. An idea that appeared to have been taught in two minutes became, as we discussed what might be done to involve the children in learning actively, the basis of two hours' investigation. As mentioned, the syllabus burden was eventually reduced, but, at that time, it loomed as a very large obstacle. Even when the teachers and other participants realized the difference between 'being told' and 'understanding' something, they were still uneasy about the slow pace at which 'the ground' would be covered. It took several more workshops before some of these teachers could change their conception of their job from 'covering' to 'uncovering'.

In the meantime, we returned to the improvements that might, realistically, be brought about within the existing constraints, as indicated by the difference between the two lists given above. The workshop continued, with participants working in groups devising and trying out on themselves activities that children could do to learn about the topics that we had seen them told about in the observed lessons. This took two days, one of them a planned 'rest day' in the seminar! At intervals, there were plenary sessions in which each group in turn presented its planned activities, which were criticized by others. Alternative suggestions were made, and plans revised. Repeatedly the participants fell into the same trap in their planning, that of attempting to pack in too much content, with the inevitable consequence that the teacher forced the pace, and children's ideas could not even be expressed, let alone followed up.

Much of the discussion of lesson plans at this stage was, of course, based on assumptions and hunches. No one present had tried to teach in the way being planned. Their plans were hypotheses, about to be put to the test. The next day, the groups once more visited schools. This time, by arrangement, one member of the group taught the class, and the regular teacher, together with others in the group, observed. The same observation schedule as before was used, and observers, made notes about the lessons. In each school, a double lesson period was taken up (as planned), but there was time to use only between a half and two-thirds of the prepared lesson material.

Groups met to review their own lessons, and to summarize the observations that had been made. They were asked to agree upon the incidence of the use of process skills by the children, to list the activities of the children and the teacher, and to prepare a critical report on the lesson. The group reports were later presented to a plenary session and discussed.

Everyone involved was then in a position to review the extent to which the hypothesized changes in teaching had taken place, and been accompanied by intended changes in the activities of the pupils. The main points were summarized as follows:

without too much difficulty, arrangements had been made for all the children in all the classes to handle objects, to use equipment and to carry out some simple investigation; in many cases, however, teacher demonstration had been used where pupils could have experimented for themselves;

there was still too much teacher talk; the teachers saw themselves as sources of information instead of encouragers of pupil-learning from observations and investigations;

the balance of parts of the lesson (the time spent on different kinds of activities) needed more thought; e.g. introductions were too long, whilst not enough time was given for pupils to make contributions;

too much content was packed into the plan for a lesson;

pupils were not encouraged to raise questions.

The following points of criticism were also made about the lessons:

more use should be made of good, clear visual aids (charts, drawings, etc.);

attention should be given to pupils' wrong answers and strategies should be used which enable pupils to reconsider their misconceptions;

pupils should be involved in setting up a demonstration so that they see all the things which are being done, not just the result;

the blackboard should be used appropriately, e.g. for recording different suggestions or observations made by pupils, but not for giving generalizations;

the teacher should be observing what the pupils do in their investigations and give help where needed;

the teacher should arrange the desks and benches so that the children sit in groups; the groups should be spread out as much as possible;

the teacher should be moving around the classroom and not standing at the front;

the conclusions drawn from observations and investigations should be based on the pupils' views, not on what the teacher wanted them to conclude.

5. Implications for in-service experience

It became clear towards the end of this seminar that a great deal had been accomplished in raising the consciousness of the participants to the shortcomings of present practice. There was much less cause for any satisfaction with what had been done in supplying remedies. One important lesson that had been learned - seeming very obvious in retrospect - was that recognizing what is wrong may be a first step in putting it right, but many other steps also have to be taken. It requires an awareness of alternative courses of action to see not only that change is needed, but what change may actually bring the intended improvement.

A second lesson came in the realization that, to the seminar participants, the notions we were discussing - about children using process skills, learning through activity, forming their own ideas and so on - these were highly abstract. To teachers and educators who had never seen children learning in this way nor experienced such learning themselves they were ideas with no concrete form. Somehow, direct experience had to be given, or the notions would remain abstract.

Thirdly, in order to keep our feet on the ground, we had started from what was already going on in the classrooms. We had tinkered with the lessons, shifting them some way in the direction we thought most useful, but we had not been very satisfied with the result. We had begun to question whether worthwhile and lasting improvements would ever be produced by piecemeal changes. The dissatisfaction centred round the lack of consistency between what teachers might be able to do through this approach and the kind of learning that was hoped for.

It seemed important in further in-service activity to ensure that participant teachers and others had the chance to experience for themselves the use of process skills in learning, both at a personal level and in work with children. To provide for this opportunity, it was necessary to produce examples of learning activities exemplifying the use of processes in developing concepts. In doing this, it would be necessary to start from the vision of the kind of learning we looked to bring about, but, in working this into a viable plan, the realities of the classroom, the teachers and the system would have to be kept in mind.

Thus, a further in-service seminar was planned so that participants could:

(a) experience themselves the use of process skills in learning;

(b) clarify their own understanding of certain basic concepts;

(c) learning about a teaching approach which develops process skills as well as concepts in children;

(d) try out this teaching approach with children in trials which are evaluated, so that they obtain feedback and constructive criticism to help improve their use of the approach;

(e) have experience of applying the ideas introduced by designing more activities for children using the same approach;

(f) have help in planning their science programme in schools, and in assessing children's progress.

6. The next course - a workshop

Members of the course planning team, together with an overseas consultant, selected a part of the syllabus that children in grade 4 would be following at the time of the workshop, and prepared beforehand activities that would give children opportunities to observe, to discuss and try to interpret their observations. Some of the decisions to be taken in this preparation were about how to arrange for children to carry out the investigation. The lack of equipment and of teachers' background knowledge in science were constantly kept in mind. The solution adopted was to arrange the activities on a particular topic in groups, each relating to a basic concept. The first topic chosen was 'air', and the concepts relating to it (drawn from the syllabus) were):

1. air fills space and has mass;

2. air exerts pressure;

3. air is needed for burning and rusting;

4. the composition of air is changed by breathing;

5. the pressure of moving air is lower than still air;

6. air is expanded by heat.

The activities were then arranged in 'stations'. (A 'station' is a set of related activities through which children can begin to develop one or sometimes two of the basic concepts. There were several stations for each topic. Usually one station related to one concept, but sometimes there were two stations for one concept or two concepts relating to one station.) For each station, worksheets for the pupils and teachers' guides were produced. The equipment used was very simple. The children were to follow the directions on the worksheets for making observations and try to explain what they observed. The teachers' guides give hints for helping the children. Six stations were prepared for the air topic, each consisting of activities that would require about two hours of lesson time.

After a trial introduction about the importance and nature of process skills, the course began with a workshop in which participants, in groups, worked at the stations using only the worksheets devised for the children. The groups were mixed, containing teachers, a head teacher or inspector, and teacher trainers. They were slow to start on the activities, spending quite a time reading the pupils' worksheets. When, at last, they did start to do something, all the members of the group tried the first item in turn and, after discussion, filled in the space in the worksheet. For some later activities, the equipment was found unsatisfactory (it was not easy to find empty washing-up liquid bottles - which were ideal - and the plastic laboratory flasks supplied instead were not suitable). Most members of the group became very involved in this work, though some showed a reluctance to do the activities themselves, being content to record observations made when others carried out the experiments. (This tendency was also observed, later, in some children who appeared to regard the writing of the answer as the important part of the work.)

During the try-out by the participants, changes to the activities and equipment were suggested. Some issues were also raised: would all children be able to participate? What kinds of answers from the children could be expected, and what would be acceptable? It took time for some of the teachers to grasp the notion of children working in groups; it gradually dawned on them that the children would be handling the equipment, and that they would not be demonstrating - the only type of teaching of which they had any experience.

Groups were later asked to report on their experience, in particular to comment on which of the process skills they considered to be involved in carrying out the activities. This was valuable, not in the decisions reached, but in the further analysis of the meaning of the process skills which it provoked. There was considerable disagreement on certain points, particularly the interpretation of 'communication'. If interpreted in a general way, then communication was involved in every activity, so it was considered preferable to restrict the meaning to the communication of ideas and to exclude the reporting of observations.

Comments were also made about the activities and the worksheets, particularly the wording of the latter. Changes were proposed and implemented, as part of the preparation for trying the activities in schools.

The teacher's role was also discussed, both in general terms in relation to children learning from experience rather than being told, and also in the specifics of these particular activities. It was noted, however, that, at this point, little reference was made to the teachers' notes provided - questions were often asked later which appeared to be answered in the notes - and, instead, the teachers' attention was focused on the children's worksheets. This may have indicated a concern for content rather than the way of working. Later the teachers' notes were read when they had to plan lessons for children.

The trials of the activities in schools took place during the following three days. The purpose was primarily to experience the method of teaching in which children were investigating things for themselves, but at the same time the activities were tested out, and various organizations of the stations were tried.

The organization of the trials provided for three days in three schools. Each group of participants worked in the same school for the three days with one class of grade 4 pupils. During this time, all the pupils in the class would try all six stations, though the arrangements for this varied from school to school, so that different patterns of using the stations would be tried out. What this meant for the pupils was that for three days they had nothing but science lessons! The burden was considered to be worth imposing for the sake of trying out as much as possible in as short a time as possible. The schools were ones in which three of the teachers at the seminar were employed. These teachers were to carry out the teaching with their own classes throughout the trials. The remainder of the group were to make careful observations to gather various kinds of information about the trials.

The roles of the observers in the classroom were described, and the instruments which had been drawn up for their use were explained. The observers' tasks were the following:

Observer 1: To follow one group throughout the trials and closely observe their behaviour and reactions. The form asked the observer to collect four types of information: to use a tape recorder to record samples of the group's discussion with and without the teacher, to record the types of behaviour observed in each three-minute interval on the grid supplied, to give a general description of the activities, noting particularly any difficulties or interesting extensions, and finally to discuss with the pupils and explore their reactions to the activities and the way of working.

Observer 2: To record the teacher's activities. Again a three-minute interval was chosen, and the observer ticked any behaviour observed in that time. A questionnaire was also drawn up to collect the teacher's opinions about the way of working.

Observer 3: To report on some general features of the group work. The form for this observer suggested photographing the classroom at certain intervals, drawing a plan of the classroom to record the teacher's movements and reporting certain judgements about the teacher's general organization and about the behaviour of pupils not in contact with the teacher.

The initial reaction was to question the expectation of recording so much information. It was explained, however, that if the seminar was to conduct its trials in a scientific manner it was necessary to observe, and collect in other ways, as much information as possible, then to interpret it and apply the results to the purpose of the trial. This was, in fact, the first and the last comment made about the burden of the evaluation. Everything that was planned was accomplished, and the observers seemed to find their tasks worthwhile. The observations, photographs and recordings were completed meticulously.

School experience

This is a brief glimpse of a day in one of the trial schools, a rather overcrowded, old building near the centre of Bandung. The ceilings were very high, the 'windows' unglazed, being simply closed by shutters. The head of the school (and its inspector) as well as the teacher of the class were participants in the workshop. By 6.50 a.m. the group of four were already busy re-arranging the furniture into groups. This was no small task in a room which held a class of 67 pupils. The teacher had prepared herself well, having made labels for the stations and the groups to help her to explain the organization to the pupils.

A first experience of group practical work in a Bandung class of 67 pupils

When the pupils came in, they had already been organized into nine groups. All the worksheets and sets of equipment were on the tables for each group. As soon as the teacher had explained to the children how they were to work they began immediately. The noise level was high, as could be expected with 67 children discussing with each other in their groups. The record of the teacher's movement showed that she was highly mobile in the first session. She moved from group to group and often paused to look around to see where help might be needed. She only stayed at two groups for more than three minutes. She was in control throughout, though extremely busy.

The children stayed in their groups and only rarely moved around the classroom, usually to seek help from the teacher if she was not nearby. They did not appear to have difficulty reading the worksheets. There were some problems with the equipment, but these were minor and for the most part overcome by the teacher. One group finished after only 40 minutes, but most stations were not completed until the end of the 90-minute first session.

In the second session, after the children had had a break and moved to another station, they settled quickly to work, knowing immediately what to do with the worksheets. They completed these carefully. The record of the teacher's movement showed that she did not move round as quickly as before. This time she frequently stayed with a group for more than three minutes. She was doing more explaining to each group, but this meant that other groups missed the occasional attention that was sometimes needed to prevent them becoming struck by a problem of reading or of manipulation. In some groups, the noise level was higher than in the first session. However, in general, the children who were not in contact with the teacher remained engaged on the task, and were working seriously even after three hours of this work (which was clearly too long).

There was no doubt that 67 children were too many for the most effective teaching to be carried out. But this probably applies to any form of teaching with such a number. What was done in this trial was to show that 67 children could be actively working, and could have some experience of handling materials and making observations. To do much more, at least at the start of this type of work, would have required more attention from the teacher than she could possibly have given. What we did see, however, was that 67 children did work in groups, did carry out some investigations and did discuss and record their findings.

Evaluating the school experience

After each morning's work in the schools, the workshop participants returned to the seminar room to sum up and discuss what had been observed. The groups working in each school first met together to read through the worksheets and evaluation forms. They were asked to produce a summary, indicating which stations had or had not been completed, which activities in the stations appeared to have been understood, and which had been omitted or appeared to have been misunderstood.

Secondly, the observed behaviours of the pupils were drawn together by indicating the frequency of records made of each one.

Thirdly, each group summarized the teacher's actions and behaviour in terms of the intended behaviour. After the first day, the main discrepancies between observed and intended teacher behaviour were in helping groups of pupils when they encountered difficulties and in helping children to work things out for themselves. In both cases, there was a tendency for the teachers to give the explanations to the children, or at least to ask 'closed' questions which suggested the answers to them. Discussion of these problems each day improved the situation to some degree, but these were still the two aspects of their role which were of most concern right to the end of the trials.

There was a great deal more information to be derived from the schedule of teacher observation, though there was not time for the analysis to be carried out during the workshop.

By the end of the three days of work in schools, it was possible to see that changes were gradually taking place. The teachers reported that they felt more relaxed as time went on, and they improved in their handling of group work. They also gave clearer directions to the pupils about class organization, and, indeed, the smoothness of the organization increased noticeably each day, and there was no problem in moving pupils from station to station.

In the school where all six stations were out each day, the observers had the impression that the pupils might become bored just following round to activities that others had already done. This was a factor taken into account in the recommendation that three or four stations, each duplicated according to the number of groups, were ideal. The pupils remained concerned about getting the answers right, but were also interested in being involved in the processes. It would obviously take a much longer time for pupils' expectations to change in regard to writing the answers. For so long, their concern had been to put down what was regarded as 'right' rather than their own ideas or observations. New responses and expectations would need to be reinforced by teacher reactions and praise over a period of time.

When the trial work was reviewed by the participants, the main points made were:

1. The activities had been very interesting to the children. At one school, the children wanted to do more out of school time. Also, at that school (where work had been slow because of the language problem), more time had been needed. In all cases, there had been no time for discussing the activities with the whole class.

2. The worksheets were thought to be very helpful, but they needed improvement in several respects; in layout, in use of simpler language, in asking one question at a time, in providing clearer and better labelled diagrams. It was thought important for teachers to be involved in developing the worksheets, so that the language used would be at the right level for the children.

3. In two schools, the insistence, as a general school 'rule', upon writing answers in whole sentences had presented problems for the children. This could be met to some extent by starting the sentence and leaving the pupils to complete it, but there was a danger of making the activities too 'closed' if pupils had only to write in words in spaces.

4. The teachers' guides were found very helpful, especially in the ideas for helping children with difficulties and the explanations of the phenomena involved in the activities.

5. Although in theory the combination of teachers' guides and worksheets would make the pupils' textbooks unnecessary, it was not acceptable to dispense with them. It was suggested that selected parts of the textbook could be used for reference.

6. Although teachers and observers had only experienced one pattern of stations (either two, three or six stations at a time) the exchange of views led to a general agreement that six was a little too many and the optimum would be three or four at a time.

7. The experiences in the different schools had varied considerably, as might be expected given the range of backgrounds of the children and the size of classes. It was difficult for each group to appreciate

the experience of the others, and there would have been considerable advantages in rotating observers round the schools, so that they could have seen the responses of different groups of children.

8. There were still aspects of the teacher's role which remained uncertain. In particular, the handling of experiments which 'did not work', or what to do when children got the 'wrong answer', were revealing queries. Clearly much more time should have been given to detailed practical points of this kind.

9. The possible problem of the end-of-primary-school examinations was raised. Would children who had learned through process-based activities be in a good position to answer factually oriented multiple-choice questions? Here was a warning that the nature of this assessment would need to be examined when changes in the curriculum were implemented.

Applying the teaching approach to a new topic

The next stage of the in-service activity was to apply to another topic the same approach used in the air topic. 'Water' was chosen, and the work began by identifying, from the items in the grade IV syllabus, the main concepts relating to water (as had been done for the air topic). It was eventually agreed that the main ideas about water were the following:

1. water flows from higher to lower levels, takes the shape of its container and rests with a horizontal surface;

2. water exerts pressure and objects lose weight when immersed in it;

3. water will dissolve many things;

4. water evaporates when heated, and becomes solid when cooled; there is water vapour in the air at all temperatures;

5. some things sink in water, some float and some are suspended;

6. water seeps through small cracks and holes.

Participants were divided into five groups, and each group was assigned to one of the first five of these sets of ideas. The groups had to devise activities, try them out, and put them into the form of worksheets. Books and equipment were available, and some small items not at hand were purchased.

After giving some help to the groups for the first three hours of this work, the workshop leaders left the further development and writing of worksheets entirely to the participants. Only in this way could it be judged whether the ideas it was hoped to promulgate could be applied.

The groups worked intensely, and after six hours had prepared worksheets, most of which had been typed for distribution to other groups. All the activities had been worked out in practice, and, although the books had been the starting-point, they had not relied on the written word.

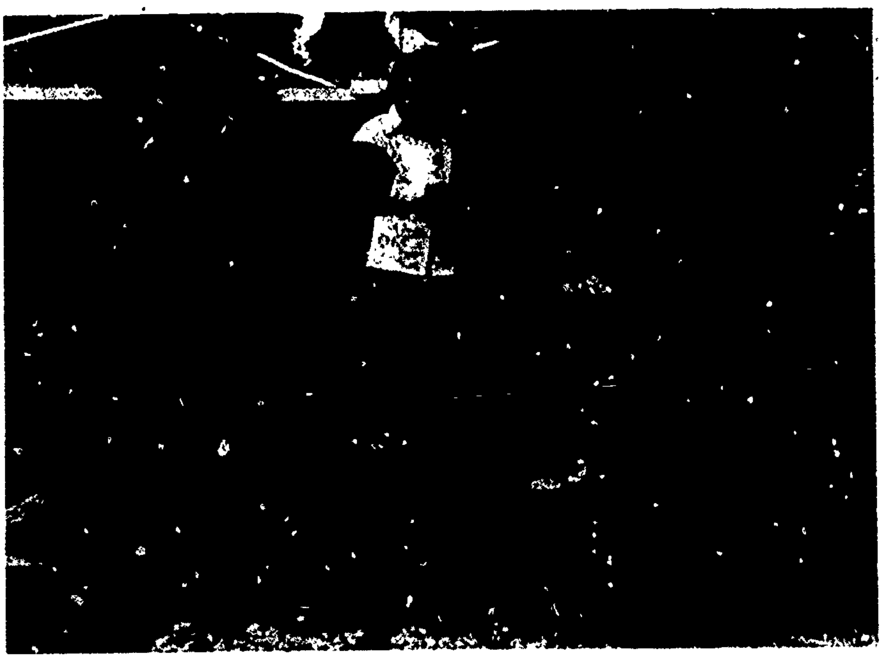
Each group presented to the others the activities for a station on their assigned concept. They demonstrated the activities, and explained their purpose. The other groups questioned closely, and helped in the revision of the activities with suggestions for rewording and for extensions of the activities. The main criticisms of the proposed activities were that they remained at the observational level, and opportunities for involving children in prediction, interpretation and devising investigations had to be pointed out. However, in general, the proposals constituted a very satisfactory and thoughtful attempt to give children first-hand experiences of the concepts in action. In the discussion and revision of the proposals, the teachers among the participants played a major part in making suggestions for amendments. This was in contrast to their reticence to offer comments in earlier discussions.

Postscript

The teachers involved in this workshop used the activities on air and on water in their own classes in the following months. Another workshop was later run along the same lines as the one described here, the input activities being the ones on water and the output being a revised version of the water activities and draft of activities on another topic. Other workshops followed; each was productive in two senses: in the experiences they provided, and in their products for use in classrooms, which were devised by teachers and therefore handlable by teachers.

Soon it was realized that the number of teams running each workshop had to be increased. So, on one occasion, a workshop was run with a parallel development taking place to create a training package which would enable trainers outside the existing team to run workshops of the same kind. This material was produced with the assistance of a small grant from Unesco who make copies available in response to requests.

Teachers (and an inspector) trying out new classroom activities in a spare moment during the workshop



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