FOCUS ON EDUCATION

Series Editor: Trevor Kerry

Teaching Science

A teaching skills workbook

M.K. Sands B.Sc., Ph.D., M.I.Biol.
Richard Hull M.A., M.Inst.P.
University of Nottingham

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First published 1985
Reprinted 1986

Published by
MACMILLAN EDUCATION LTD
Houndmills, Basingstoke, Hampshire RG21 2XS
and London
Companies and representatives
throughout the world

Printed in Hong Kong

ISBN 0–333–37821–0

CONTENTS

Editor's Preface 5
Introduction 7

PART 1 PREPARING TO TEACH SCIENCE

Topic 1 Why teach science? 8
Topic 2 Class management, control and safety 12
Topic 3 Composing worksheets 20
Topic 4 Marking pupils' work in science 23
Topic 5 Study strategies for science texts 27
Topic 6 Observing science teaching 30
Topic 7 Teaching mixed ability science classes 33

PART 2 TEACHING SCIENCE

Focus 1 Lesson planning 37
Focus 2 Reviewing resources in the science department 40
Focus 3 Teaching mixed ability classes in science 42
Focus 4 Using group work in science lessons 43
Focus 5 Encouraging experimental skills 46
Focus 6 Developing pupils' thinking in science 50
Focus 7 Practising basic questioning skills 52
Focus 8 Preparing, marking and analysing a test 55

PART 3 REFLECTIONS ON EXPERIENCE

Topic A Taking stock 59
Topic B Scientific vocabulary 63
Topic C The science curriculum 67
Topic D Reflections on assessment 71
Topic E The science department 75

Conclusion 79

Further Reading 80

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Focus 7 Practising basic questioning skills 52
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Topic D Reflections on assessment 71
Topic E The science department 75

Conclusion 79

Further Reading 80

ACKNOWLEDGEMENTS The authors and publishers wish to thank the following who have kindly given permission for the use of copyright material:

The Association for Science Education for an extract from *Education through Science*, the 1981 Policy Statement of the Association;

The Controller of Her Majesty's Stationery Office for tables from *Science in Schools*, Assessment of Performance Unit, Report No. 1 1982;

Dr Paul Gardner for an extract from his *Words in Science* report (1972);

The Institute of Physics for a table from *Girls and Physics*.

EDITOR'S PREFACE

The titles in this series are designed to examine basic teaching skills in their respective subject areas. Each title is laid out as a workbook so that the practitioner can utilise his or her own classroom as a basis for progressive professional self-development.

Impetus for the series came out of the DES-financed Teacher Education Project, which ran from 1976 to 1980 in the Universities of Nottingham, Leicester and Exeter. That project explored general teaching skills: class management, questioning, explaining and the handling of mixed ability classes and of exceptional pupils. A direct outcome from the work of the Teacher Education Project was a series of skills workbooks under the general title *Focus*, which was published by Macmillan through the years 1981 and 1982.

It is, perhaps, a measure of the success of the *Focus* series that I was approached by a number of colleagues in the universities involved, with the proposal for a Curriculum series of workbooks which would apply some of the teaching skills highlighted and researched by the project to specific subject areas.

Each title in the current curriculum series is aimed at subject teachers in the appropriate field. Our corporate intention is to make each workbook immediately relevant to the needs of three main groups of users: qualified teachers of the subject in question; teachers qualified in some other discipline who find themselves pressed into service on less familiar ground; and students in training in the subject area concerned. Past experience has led us to believe that each exercise is adaptable for use at various levels of sophistication according to the stage reached by the user and to his or her own needs.

Each workbook has a tripartite format. Part 1 is intended to start the user thinking about issues in the particular curriculum area, and many of the activities designed for this purpose can be carried out away from the classroom itself. In Part 2 a collection of practical exercises encourages teachers to become more self-aware and to scrutinise their own practice. A final section helps the teachers reflect on practice and experience by relating classroom events to research and theory. Within this basic structure individual authors are given some flexibility to interpret their own theme.

The series makes frequent demands on teachers to get together in order to watch one another at work: a process we have labelled 'observational pairing'. Traditionally the classroom has been 'a fine and private place' as Marvell might have put it. We believe that professional self-respect demands that a more open attitude should prevail.

It is especially opportune to be producing the curriculum series of workbooks at a time when economic stringencies are making in-roads into the education service in general and into in-service provision in particular. There is a mounting public pressure for increased accountability by the teaching profession. This series will, we believe, help to make teachers more analytical in their teaching and more articulate in expressing the rationale for their work. It will also fill a void for really practical advice for all those whose jobs involve a responsibility for professional training, as university and college tutors, inspectors, advisers, teachers' centre wardens, headteachers and heads of subject departments.

Dr Trevor Kerry
Doncaster Metropolitan Institute of Higher Education

INTRODUCTION

This workbook is designed to help you teach science. It contains a series of activities which focus on practical teaching skills, and on important issues in science teaching and how these are interpreted in the classroom. BEd or PGCE students on teacher training courses will be able to use the material in the book under the guidance of their tutors. Qualified teachers may welcome the chance to practise specific skills, alone or with their colleagues. A workbook such as this can easily be adapted to form part of an in-service training course, and can be used by a science department as part of a programme of professional development. In some of the exercises it is suggested that an observer should watch and comment on the performance of the skills being practised. Some teachers, particularly those who have not worked in schools which are open-plan, nor in team-teaching situations, may find the idea of being observed a little daunting. However, the amount to be learned by the pooling of ideas between professionals is well worth the apprehension generated by these 'observational pairing' lessons. Teachers have a lot to learn from each other, and the exercises here will yield more if they are talked over with colleagues.

This science teaching workbook is one of a series concerned with the skills of teaching. Much of the material has been subjected in trial form to scrutiny by individual students and teachers, and by tutors and advisers responsible for planning and implementing courses. It is flexible in the options it leaves open for the user to construct his or her own way of working with the material and to adapt the ideas and activities to particular circumstances. It is not intended to be a definitive statement of how science should be taught nor an exhaustive summary of all the skills required in a competent science teacher. Nonetheless, a teacher using the material efficiently will be able to improve many aspects of his or her teaching.

We acknowledge the help of Florence Davies who wrote the material for Part 1, Topic 5 (*Study strategies for science texts*).

Part 1 PREPARING TO TEACH SCIENCE

Topic 1 WHY TEACH SCIENCE?

Answers to the question 'Why teach science?' are often concerned with three approaches to the subject. These are:

> Science has intrinsic value as a body of accumulated knowledge and as a way of finding out about the world.
>
> Learning science is a means for helping individuals to fulfil their own personal potential.
>
> Learning science helps the individual to learn to live in a society and both to contribute to it and to benefit from it.

There is pressure to broaden the basis of science teaching, because it is felt that we have perhaps been too concerned with the first of these approaches, particularly with science as a body of knowledge, at the expense of the other two.

It is often found to be convenient for practical purposes to make a distinction between the *aims or goals* and the *objectives* of science education. Aims or goals are broad statements of principle. For example, the Association for Science Education in its 1981 policy statement lists the following aims:

> The acquisition of a knowledge and understanding of a range of scientific concepts, generalizations, principles and laws through the systematic study and experience of aspects of the body of knowledge called science.
>
> The acquisition of a range of cognitive and psycho-motor skills and processes as a result of direct involvement in scientific activities and procedures in the laboratory and the field.
>
> The utilization of scientific knowledge and processes in the pursuit of further knowledge and deeper understanding, and the development of an ability to function autonomously in an area of science studies to solve practical problems and to communicate that experience to others.
>
> The attainment of a perspective or way of looking at the world together with some understanding of how it complements and contrasts with other perspectives or ways of organizing knowledge and inquiry.
>
> The attainment of a basic understanding of the nature of advanced technological societies, the interaction between science and society, and the contribution science makes to our cultural heritage.
>
> The realization that scientific knowledge and experience is of some value in the process of establishing a sense of personal and social identity.
>
> *Association for Science Education*, 1981, p. 11.

Aims or goals tend to be rather general statements, difficult to translate directly into what to do with 3X on a wet Friday afternoon. Objectives are statements which are sufficiently specific for a science teacher to be able to translate them into action. They are likely to be sharper in meaning if they have:

> a *verb* which specifies an activity
>
> an *object of the verb* which indicates clearly and definitely what the verb applies to.

Compare, for example, the specific objective 'interpreting data presented in tabular or graphical form' with the more vaguely formulated objective 'understanding scientific data'.

Because of the widespread use of aims and objectives in curricula and examinations, it behoves a teacher to understand both, and to see how they can be translated into teaching and learning activities. Activities 1 and 2 below are aimed at helping you to review your own aims and how you put them into practice.

Activity 1: Reviewing the aims of science teaching

The aims listed in Table 1 emphasise some of the general educational purposes of science teaching.

1 Indicate how important you think each aim is by ringing the appropriate number.
2 Select a science topic which you have recently taught or discussed. Think what teaching and learning activities you might use to develop the aims which you considered important in 1. (For example, the study of waste materials would probably not be a conventional science activity to include in a topic on materials, but could help to achieve a number of the aims, in particular (a), (b), (e), (g), (h), (j), (k), (l), (m).)

TABLE 1: THE AIMS OF SCIENCE TEACHING

Aim	Very important		Unimportant		TOPIC: How to develop the aim in this topic
(a) To develop knowledge and awareness of the natural environment	4	3	2	1	
(b) To develop knowledge and awareness of the man-made environment	4	3	2	1	
(c) To develop knowledge and awareness of the applications of science in the home	4	3	2	1	
(d) To develop understanding and awareness of the importance of technology	4	3	2	1	
(e) To develop interest in and knowledge of the local environment (natural, man-made, including local industry)	4	3	2	1	
(f) To encourage and develop actual or potential leisure activities	4	3	2	1	

Aim	Very important			Unimportant	TOPIC: How to develop the aim in this topic
(g) To develop good attitudes to science (e.g. realise potential for good as well as dangers for evil, need for social responsibility of scientists)	4	3	2	1	
(h) To develop scientific attitudes (e.g. inquiring mind, critical attitude, honesty, caution in making claims, being methodical and careful)	4	3	2	1	
(i) To develop practical skills	4	3	2	1	
(j) To help to develop mathematical skills	4	3	2	1	
(k) To develop logical thinking skills	4	3	2	1	
(l) To develop problem-solving skills	4	3	2	1	
(m) To help to develop pupils' skills in English	4	3	2	1	

Activity 2: Reviewing the aims of practical work in the 11-13 age range

In a survey of practical work by Beatty and Woolnough (1982) it was found that most teachers estimated that, with the 11-13 age range, between 40 and 80% of class time was spent on practical work. It is therefore important that the aims of practical work at this level should be clear. The aims which Beatty and Woolnough presented to teachers in a questionnaire are listed in Table 2. In the first column put the aims in what you think is their order of importance. In the second column enter the order in which the teachers themselves put these aims, given upside-down below the table. Then comment on the similarities and differences between the two orders. Compare your own order with that of colleagues. A blank column is included so that you can also record your attitudes at a later date.

TABLE 2: AIMS OF PRACTICAL WORK IN THE 11-13 AGE RANGE

	YOUR ORDER	TEACHERS' ORDER
1 As a creative activity		
2 For finding facts and arriving at new principles		
3 To arouse and maintain interest		
4 To be able to comprehend and carry out instructions		
5 To develop a critical attitude		

		YOUR ORDER	TEACHERS' ORDER
6	To develop an ability to communicate		
7	To develop an ability to cooperate		
8	To develop certain disciplined attitudes		
9	To develop self-reliance		
10	To develop specific manipulative skills		
11	To elucidate theoretical work as an aid to comprehension		
12	To encourage accurate observation and description		
13	To give experience in standard techniques		
14	To help remember facts and principles		
15	To indicate the industrial aspects of science		
16	To make phenomena more real through experience		
17	To practise seeing problems and seeking ways to solve them		
18	To prepare the student for practical examinations		
19	To promote a logical reasoning method of thought		
20	To verify facts and principles already taught		

Comments

Aim	Order	Aim	Order	Aim	Order	Aim	Order
1	16	6	8	11	17	16	4
2	11	7	13	12	1	17	9
3	2	8	7	13	15	18	20
4	5	9	14	14	10	19	3
5	12	10	6	15	19	20	18

For Further Study

Association for Science Education, 'Education Through Science', *School Science Review*, 1981, **63**, 222

Beatty, J.W. and Woolnough, B.E., 'Why do practical work in 11-13 science?' *School Science Review*, 1982, **63**, 225, p. 768

Richardson, M. and Boyle, C., *What is Science?*, Association for Science Education (Study Series No. 15), 1979

Topic 2
CLASS MANAGEMENT, CONTROL AND SAFETY

Management and control probably cause more concern to new teachers than any other aspect of teaching. They will be given the same basic advice by almost everyone:

- Be more firm at the start than you mean to be in the end.
- Ensure that lessons are well-planned and have a clear structure; good control and effective management are then less of a problem.

It is most important to:

- give the pupils work which is *appropriate* to their age and ability
- provide *variety* in lessons (in activity, teaching technique, content)
- develop the art of *pacing* activities to fit the available time.

Activities 3 and 4 develop these points and help you to think through some class management situations.

Activity 3: Assessing your class management and control

Table 3 contains practical advice for science teachers on class management and control. It is organised into things to do at various points before, during, and after the lesson. Find an opportunity to use it as a checklist, both for yourself and for an observer of your lesson. Allow yourself and the observer a few minutes after the lesson to complete a copy of the list. Be honest with yourself, for you are then likely to be able to accept more easily any critical points raised by the observer when he or she discusses the lesson with you.

TABLE 3: A CLASS MANAGEMENT CHECKLIST

DATE:	CLASS:	TIME:
Course of action	*Yes/No*	*Comment*
Before		
1 Prepare lesson thoroughly and give it a clear structure		
2 Book apparatus well in advance with a written list of what is required		
3 Prepare furniture and apparatus in the room before pupils arrive (if possible)		
4 Practise experiments before the lesson		
5 Know how many of each item of apparatus you have at the start		
6 Plan distribution and collection of apparatus		
7 Have extra material available for able and weak pupils		
8 Arrive at the room before the pupils		
Start		
9 Control the pupils' entry into the room		
10 Get silence and attention before you start speaking		
11 Start the lesson 'with a bang', clearly and definitely		
12 Deal with latecomers quickly and efficiently		
During		
13 Know and use pupils' names		
14 Give clear instructions		
15 Organise transitions between activities carefully		
16 Be mobile: walk round, don't 'hide' behind the front bench		
17 Look at the class when speaking and scan the pupils		
18 Get feedback frequently by asking questions		