

# Teaching Children in the Laboratory

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## PREFACE

Teaching, like being an understanding parent, is an empirical art which is only made possible by listening to the spontaneous and outspoken comments of children. It was such a response that finally made the writing of this book seem urgent and important. It happened at the end of one of those 'discovery' sessions, when a suggested experiment had yielded surprising results which my pupils had then immediately followed up with tests of their own. The topic was electromagnetic induction; given a solenoid, a magnet and a galvanometer, the class had shown that although a stationary magnet did not produce a flow of current, a moving magnet did. They then, on their own initiative, collected data on the various factors that affected the magnitude of the current and it had all seemed to present an almost perfect example of the guided discovery method at work. Yet there was none of that feeling of elation which such an experimental success should have generated. Instead a girl turned to me at the end of the lesson with outright disappointment and reproach, and said, 'I can see all that but I don't understand it one bit! You haven't explained it.' Children's comments can be difficult to interpret. Was it I, rather than experiment, that was expected to 'explain' nature? Why was the experiment so unsatisfying? Isn't it true that seeing is believing? Obviously it was not. The movement of the electrons in the wire remained incomprehensible and indeed unacceptable until I had contrived by word and gesture to suggest how it might *feel* to be an electron in such a situation. Only then did the girl relax and smile; the experimental result was now meaningful and she was ready for more.

This incident, and many like it, gave me the clues I needed to unravel the curious patterns of success and failure which attended practical work. *Imaginative understanding was not a sequel to successful experiment; on the contrary, it was an essential prerequisite.* The point arose again and again in practical lessons and with its help I was able to pre-empt many a halting question and add real impact to a wide variety of experiments. Its implications were important.

In the first place, and most obviously, it offered an explanation for the obstinate difficulties which arose continually in the discovery method of teaching. In spite of its appeal to any sympathetic teacher, its practice was often very disappointing. It also seemed curious that my

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own children, who would beset me with questions about science and listen with fascination to tales of discovery and hypothesis, showed the same frustration and uncertainty when faced with the use of discovery as a method of teaching.

Even a reflection on the history of the great seminal discoveries of science does not lend support to this practice. From the records it becomes quite clear that it was always the initial act of imagination which both prompted the experiment and provided the framework within which it could be understood. In the words of T. S. Kuhn, one of the greatest living historians of science, 'surveying the experimental literature. . . makes one suspect that something like a paradigm is prerequisite to perception itself.' Kuhn uses the word *paradigm* to denote the established view of a particular topic, as laid out in the textbooks of the period. It includes the discoveries, the theory arising from them and the experimental procedures to which it leads. Because it pervades their education it is strongly entrenched in the thinking of scientists and is applied, consciously or unconsciously, in all their research. From there it reaches out to society at large: 'the electron is a particle' and 'cancer is a disease' are widespread and potent paradigms. If some inkling of every new revolutionary paradigm predated and prompted experiment instead of being discovered as a result of it, there can be no grounds for expecting that naïve inquiring experiment within school lessons will demonstrate the appeal and method of scientific research.

Once we accept that prepared imagination holds such a key position in the learning of science and the understanding of experiment, then our methods of teaching are bound to take account of it. The prime motives of almost every lesson will be the understanding of children's imaginative processes and the stimulation of them along scientific lines. This is an *active* philosophy of teaching, probably quite hopelessly at odds with the practice of solitary learning from a worksheet of practical instructions which has become such a feature of the last ten years of educational theory. It takes a really human teacher, not a programmed learning aid, to listen to children's imaginative comments and to recognise their imagery.<sup>1</sup> Only then can the teaching begin.

Although there have been many *learning* theories based upon animal experiments — rats in mazes, pigeons pecking at discs or apes reaching for bananas — established theories for the *teaching* of human children are non-existent. Certainly the contemporary studies of classroom techniques being carried out both in this country and in America which try to evaluate such factors as 'eye-ball action' and 'wait-time' between

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the asking of a question and the receiving of an answer do not begin to fill this gap.

The essence of teaching lies in the familiar interactions between the class and its teacher, too individual, diverse and empathic to be captured easily by any research programme. The trust and confidence it engenders, however, are of paramount importance for the cultivation of the images which will be needed in the school laboratory, all the way from the choosing of apparatus to the elucidation of scientific concepts. To lay down some new technique of teaching, even one based on the discussion of imagery, could do violence to the personal variations which are inherent in teaching. It has therefore seemed better to relate the laboratory activities being described to the practice of teaching by an illustrative anecdotal structure rather than by any formal theory.

For student and new teacher it is to be hoped that this will present a realistic picture, though it would be false and damaging to ignore the many pitfalls that obstruct the path to such a fruitful teaching dialogue. These obstacles are excavated by the kind of pupil behaviour that our societal attitudes have brought about and they can be very hard to face. Colleges of education do sterling work preparing their students, but such novices can do with all the discussion of matching practical work to behaviour problems that they can get; so a chapter on this has also been included.

This book has been written at a time when the whole profession is buzzing with new projects at almost every level. I have made reference to the better-known science syllabuses in the text whenever I have had personal knowledge of their use and impact, but the initiative in the design of syllabuses has already passed out of the hands of the large project committees to small groups or individual schools. The new format is no longer the book but the worksheet, often both written and duplicated within the school itself. These are used not only for the first two or three years, but right up to CSE, where the present total of school-devised science courses numbered more than 30,000 in 1979. Some have reacted with alarm at such proliferation, but it is a sure sign of the vitality and inventiveness of the teaching profession. The art of designing such worksheets has been learnt through trial and error on the job by these same science teachers. For this reason a chapter on the implications of worksheet learning and of the art of programmed learning from which it may be derived is to be found in the first part of the book. Worksheets not only vary in quality, but they can also serve a wide variety of purposes. The whole craft of teaching has been subtly transformed by their use, and discussion is vital.



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Finally I must admit to having ignored, quite shamelessly, the whole question of course content. Readers will find no references here to such important matters as the teaching of health and sex education, environmental science or microelectronics for everyone. I intended no disparagement by concentrating on 'core' items of school science, since children learn and experiment in every practical department of science by application of the same vivid powers of growing imagination. Nor have I written one word about teaching the social implications of science, although I value most highly the sense of compassion and fierce argument for social justice that our pupils can bring to such discussion. New courses devoted to the social context of science<sup>2</sup> for schools are just beginning to emerge, but it might well have needed another whole book to study and describe the child's growing powers of social commitment and evaluation. A full-time teacher, of course, can always plead lack of time, even while knowing how loath she would be to mend such shortage by retreat from the boisterous, busy, but magical world of children in the laboratory.

## Notes

1. Comment from a 12-year-old boy on seeing bromine vapour diffusing into air: 'Look, the colour's coming out of it'. . . Like dye out of a dripping jersey?
2. See, for example, the SISCON-in-Schools Project.

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