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ABSTRACT

Recent years have seen a substantial growth in research that probes children's ideas about natural phenomena. This paper places that research in a context which enables comprehension of how it informs and influences the practice of science education. To this end, past, present, and future styles of research are considered to: (1) demonstrate links between alternative conceptions research and earlier investigations of science learning; (2) identify new issues of importance for science education in current research on children's ideas; and (3) indicate directions that research should take. Consideration of past research inevitably involves an elaboration of personal epistemologies. Therefore, the first section of the paper considers the evolution over the last 20 years of the general direction of science education research at Monash University. More specific research on students' alternative conceptions of science are then outlined. This leads to a consideration of present research in terms of the relations between research and practice, and of the implications for further development. The future developments described focus particularly on research on the strategies used by learners, and on the continued growth of interaction between research and practice. The paper concludes with a discussion of emerging styles and purposes in science education research. (JN)

DEVELOPMENTS IN STYLE AND PURPOSE OF RESEARCH ON THE LEARNING OF SCIENCE

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Introduction

The last decade of science education research has seen a dramatic and worldwide growth in the probing of children's ideas about natural phenomena. The purposes held by researchers in this area vary, as suggested by ariety of terminology used to describe children's ideas (childre. science, alternative conceptions, misconceptions, naive conceptions, alternative frameworks, and so on), but still there is a broadly common goal in the research: to understand ways in which students seek to explain the world, and to consider the implications for science learning and teaching.

The purpose of this paper is to place this research in a context that enables comprehension of how it informs and influences the practice of science education. To this end, past, present, and future styles of research are considered in order to demonstrate links between alternative conceptions research and earlier investigations of science learning, to identify issues of importance for science education in the current research on children's ideas, and to indicate directions that research should take.

The consideration of past research inevitably involves an elaboration of personal epistemologies. As a consequence, the first section of the paper considers the evolution over the last 20 years of the general direction of science education research at Monash University. More specific antecedents of research on students' alternative conceptions of science are then outlined. This leads to a consideration of present research in terms of the relations between research and practice, and of the implications for further developments. The paper concludes with a discussion of emerging styles and purposes in science education research.

The Evolution of Science Education Research at Monash

The beginning of science education research at Monash University in the late 1960s and early 1970s was very much influenced by the science-based origins of those involved. Either because of explicit experience of the sorts of empirical investigations in common use in the physical sciences or because of familiarity with them through less direct experience but through extended learning of these sciences, we had an easy and natural affinity with the sorts of experimental designs for educational research that had been so remarkably described by Campbell and Stanley (1963).

Accordingly, a number of the early studies at Monash such as those of White (1974), Linke (1974), Gardner (1974) and West and Fensham (1976)are marked not only by their adherence to a manipulative or experimental type of paradigm but by the contributions they made to extend the modes of analysis for the data of such research. The well developed mathematical skill and confidence of these investigators (a usual concomitant of a science education in Australia) enabled them to quickly master complex statistical procedures. Complex designs and sophisticated mathematical analyses were thus, as it happened, easier ways for these ex-science teachers to enter research into the teaching and learning of science than was a more critical approach to the teaching/learning situation itself. In hindsight, it is now clear that quite primitive and over-simple models of learning were being employed. They ignored most of the context of the learner and of the teaching situation and gave little acknowledgement to the nature of the scientific knowledge being learnt.

Two of these simple (or apparently simple) learning models which had a complementary attractiveness for us were those of Gagne and Ausubel. Gagné's (1968) stress on the hierarchical nature of cognitive learning was naturally attractive to the learning of the sciences which we had so often been told were sequential in the nature of their knowledge relationships and development. White (1974), Thomas (1975) and Beeson (1977) all used these sorts of hierarchies for learning topics in physics and chemistry in their research. Quite early, however, a small cloud of confusion appeared about this simple approach to what was to be learnt when university level teachers of the sciences were asked to spell out hierarchies for various topics. They found this task far from simple and tended to want to define multiple routes and much more complex interactions between concepts and skills than this theory of learning assumed.

Ausubel's concern for the process of learning and in particular for how the existing knowledge of a learner interacts with new knowledge presented for learning seemed to fill a gap between the levels of the hierarchies (West & Fensham, 1974). Nevertheless, his complicated description of these processes was reduced by West and Fensham in the early 1970s to a treatment involving advance organisers, an aspect that could be explored using the experimental-type of paradigm. Despite, again, sophisticated design and analysis, the authors of this study were conscious that they had not really lifted the veil from the learning process that Ausubel's theory intended.

The fascination of what lay beyond was, however, hinted at by several studies. Heffernan (1980) investigated what he called a "hierarchy of understanding". A sharp discrepancy emerged between what the teachers and the learners in his study of three fields of science knowledge saw as its highest level. For the former it was the application of algorithms embodying relationships between concepts in problem solving, whereas for the latter it was the nature of the relationships themselves.

In another study Fensham (1972) found that certain knowledge the students had acquired in physics and chemistry was responsible for quite unhelpful and erroneous assumptions many of them made about quite unrelated (in terms of the public science) topics they subsequently were required to learn.

Apart from a few minor studies that were reflections of Piagetian investigations (A. Phillips, 1972; J. Phillips, 1977) our interactions with learners in this period were via paper and pencil instructions or tests under controlled conditions of administration. These minor studies and the very active debate in the early 1970s in Australia about group or individual tests for Piagetian stages did, however, serve to keep us aware of alternative ways of interacting that were to become our dominant mode by 1980.

In parallel with these sorts of studies, the scientific strength and the extensive teaching experience of the group at Monash had enabled a critical appraisal of the content of science courses at both the school and university level. The active involvement of various members in decisive roles for the curriculum conte of school science such as external examiners, designers of curriculum materials, and pre- and in-service educators of science teachers enabled the group to reflect on these matters and to become increasingly aware of the very powerful social constraints that operate to maintain certain definitions of what science is, how it should be taught, and what is recognised as learning of worth. Some of these reflections did lead to scholarly publications (Fensham, 1976; 1980), but more significant for the group's directions was its growing acceptance of the complexity of what had initially appeared a relatively simple sort of learning.

The Monash group has throughout its life had an ideological commitment to the idea that learning science should be learning of worth not only for an elite group of school learners who may go on to study science at university but also for the great majority of school learners. Its involvement in moves within the school system for this democratisation of science has given it, over the years, a deep sense of the gap that exists between most school science learning and its social relevance to the learners.

By the middle of the 1970s there was a need for a convergence of what had been hitherto several rather separate approaches. A common focus in the questions the separate strands of Monash work were exploring was the learner, but it took us quite a time to recognise this.

Perhaps a reason for this was the fact that progress in the direction of the learner required us to switch from a stance which essentially was a teacher perspective to one that reflected much more of the view that learners, unsocialised by success in science, have of science and science teaching. At this point it also became apparent that the experimental paradigm for research with its inherent feature of "treatment" is itself interventionist in a sense that may be consistent with a teacher perspective but certainly is not consistent with a learner's stance. This shift of focus and its accompanying search for new research methods were gropingly explored in several papers as the 1970s became the 1980s (Fensham, 1979, 1983; Gilbert, Osborne & Fensham, 1982; White, 1982).

In taking the learner seriously we also had to take the science content more seriously. It was no longer good enough to assume the science content is established with a meaning provided by public science. It was the meaning attached by learners to it and its phenomena that we had to explore if we were to have any hope of knowing how and why these sorts of learners relate to the real world of natural phenomena and to what they are taught in science classes.

Our long term interest is still in the teaching/learning processes of education so this focus on the learner in the early 1980s was a necessary but not sufficient long term target for our research. The other target that is now growing steadily important in our research is the way(s) that people learn. Perhaps our present position can be summarised by revising Ausubel's famous dictum "Ascertain what the learner knows already and teach accordingly" to "Ascertain what a topic in science now means to a learner and how he/she learns science and we may be in a position to suggest how to teach science".

Antecedents of Research on Alternative Conceptions

Campbell and Stanley's (1963) great influence on the style of research through the 1960s and 1970s has been acknowledged above. The concern that they expressed for the validity of conclusions led to ingenious and elaborate investigations, with complex statistical analyses of scores obtained on reliable tests by people in various sub-groups. Notwithstanding these sophistications, these investigations were often based on primitive, simple theories or models of learning. For example, there were many studies of discovery learning in the 1960s. Essentially these involved instructional treatments that varied in the amount of guidance given to learners, who after an hour or so of experience with the treatments were given tests, typically for acquisition of subject matter, its transfer to similar problems, and then retention of subject matter after some weeks. Generally no attention was given to the motives of the learners, their reactions to the investigation, or to any conflict between the treatments and what they expected or were accustomed to. In consequence, interpretation of the results of the experiment involved the researchers in conjecture about what had happened inside the learners' heads.

A specific example is a study by White (1976), a three-factor version of Campbell and Stanley's Design 6, Post-test only, control group design (although published in 1976 the study was executed in 1970). In it, people were placed in 32 groups, derived from four types of guidance, four ways they were taught earlier information, and two sequences of instruction. Mean scores of the groups on two tests, of speed of initial learning and retention, were compared by analysis of variance. Although it was ignored at the time, the most interesting part of the experiment to someone in 1986 is the variation between the people within each group.

It was called "error", and regarded as a nuisance that could mask differences between the groups. Yet consideration of this "error" after the study was published turned out to be the most productive part of the experiment, since it led to questions that spurred much of our subsequent research: Why did some people learn faster or better than others who received the same treatment, and why did some remember the subject matter longer? These questions were important in that they encouraged us to consider both the nature of memory for science knowledge and the strategies that people use in learning, issues that have been prominent in subsequent research.

The studies based on Ausubel's theory (such as West & Fensham, 1976) and on learning hierarchies, intensified our interest in both issues. The final study in the substantial series on hierarchies, by Trembath and White (1979), showed that instruction based on a valid hierarchy could enable all people with relevant, simple entering behaviour to learn a complex skill, but it was clear from the speed with which they forgot how to perform it that despite acquiring the skill the learners had no deep understanding of it Consequently this study stimulated concern for understanding: what is involved in it, and how can it be measured? Thus this line of research, too, directed our attention to the arrangement of knowledge in memory and the strategies that people applied in learning.

We were influenced also by early work on the probing of cognitive structure (e.g. Johnson, 1967; Shavelson, 1972). Gunstone (1980,1981) extended this work and used a variety of forms of achievement test to explore the development of understanding in physics. His experiment involved two different forms of teaching programme. Analyses of data (largely multiple regression and path analyses) considered teaching programme groups as units. Although significant differences appeared between the groups on both cognitive structure and some forms of performance, again questions were raised about individuals: Why were there such dramatic differences between individual cognitive structures in students who had received the same instruction? Why were there dramatic performance differences between individuals with apparently very similar cognitive structures? Other issues arose: Why did learning strategy, as measured by a cognitive preference test, show no connection at all with any post-experiment measures? What explanation could there be for the significantly better performance of the groups from one teaching programme on a subsequent common learning task?

Some of our ideas about knowledge were expressed in a theoretical paper (Gagne & White, 1978) that put us in touch with scholars such as Driver, and Champagne and Klopfer, who were already probing students' conceptions of science. The issues that our research had generated made us ready to appreciate the significance of the early work on alternative conceptions.

Research on Knowledge

It is not our inten here to review the field encompassed by studies of cognitive structure and probes of beliefs about scientific principles and phenomena. A number of reviews, written from a wide variety of perspectives, already exists. Some are in book form (e.g. Driver et al., 1985; Osborne & Freyberg, 1985) and others in journals (e.g. Champagne, Gunstone & Klopfer, 1983; Driver & Erickson, 1983; Gilbert & Watts, 1983; McDermott, 1984; West & Pines, 1984).

The purpose of the present paper in considering this research is to identify four issues that have implications for the future directions of research, and for the way that research can influence the practice of science education.

1. Methodological connections to earlier research. As early as 1880, G. Stanley Hall (cited by Colvin, 1911) explored the ideas of children about natural phenomena. Hall's purpose was to establish "an inventory of the contents of the minds of children" (Colvin, 1911, p.84). However, the results show it to be of a considerably different orientation than the current wave of investigations.

More genuine antecedents to present research are to be found in the work of Piaget. This connection is most obvious in the wide use of clinical interviews, and is argued in detail in Pines et al. (1978). Epistemological connections are harder to tease out. One of the prime reasons for this is, of course, that the extent to which research on children's ideas grows out of a Piagetian perspective is very much a function of the individual researcher. For example, one of the earliest of the current wave of investigations (Driver, 1973) began from Piagetian considerations; the work at Monash has very different origins (as outlined above).

Links with Piaget are quite clear in apparently forgotten investigations of children's ideas conducted 50 years ago in the U.S. Of particular interest among these are studies conducted in the 1930's of explanations of natural phenomena of children (Oakes. 1947) and adults (Oakes, 1945). Oakes (1947) reviews a large number of studies, including some with "Piagetian" purposes such as the study of children's reasoning and notions of physical causality. In this review, he shows clearly that the origins of his ideas are firmly in the work of Piaget. Oakes' work is intriguing for a number of reasons: the demonstration of a wide knowledge of European research (including that published in languages other than English); the use of research methods and questions which were unknowingly used again with very similar purposes decades later (e.g. Champagne, Klopfer & Anderson, 1980; Gunstone & White, 1981; Symington & White, 1983): the apparent total failure of his work to influence the practice of science education. It is this final point which is the most significant, particularly given the focus Oakes claimed for his work:

> Other investigators [including Piaget] have been concerned primarily with <u>interpretational</u> classifications of explanations ..., in other words with the effort to interpret the nature of the child's thinking. The interest of the present author is not so much that of the psychologist as that of the elementary science teacher in the explanations themselves.
>
> (Oakes, 1947, p.3)

Despite this, we have found no evidence that this extensive set of investigations had any effect on science education. We are still grappling with explanations for this lack of effect. However it is clear that inferences about reasons for the failure can be drawn from a consideration of the remaining three issues discussed below.

2. <u>Mutually beneficial interaction between research and practice</u>. A significant factor in the evolution of research on children's ideas has been the consistent interplay between research and practice. This has occurred at two broad levels.

Firstly, interaction has involved researchers with school classrooms and teachers. At inservice programs, researchers have presented ideas to teachers for their use and reaction. Reaction by teachers has been very significant here. Because many of the ideas from the research have implications for curriculum and classroom practice, it has been relatively easy to structure inservice so as to have teachers take ideas with which they identify, explore their utility, and return to the inservice group to report on their experience with them. These teacher reactions have contributed to the thinking of the researchers through allowing a better understanding of the robustness of research perspectives in normal classrooms and through the occasional development of research perspectives <u>per se</u>. Both avenues have also been available on a more personal basis to researchers who have undertaken long-term teaching commitments

(Northfield & Gunstone, 1985). Such an experience has had considerable impact.

Secondly, researchers have used the research to reconsider their normal tertiary teaching. This has been a particularly strong influence on the pre-service education of science teachers at Monash University (Northfield & Gunstone, 1983). One general principle used in the construction of this course is described in the next section, while one example of such research-based teaching is considered later in this paper. Again, not only does research inform tertiary teaching, the teaching informs the research.

3. Implications of research for practice. Several authors have argued implications for science curriculum and classrooms to be found in research on children's ideas. These have included both general reviews (e.g. Osborne & Wittrock, 1985), and more specific thrusts such as appropriate purposes for science education (Fensham, 1983), the use of the laboratory in science education (Gunstone & Champagne, in press), and the design of instruction in particular content areas (e.g. Mitchell & Gunstone, 1984). One of the consistent messages in these statements is that learners generate their own meanings and that existing beliefs are a very significant influence on this idiosyncratic meaning. There is an obvious implication in this for pre- and in-service education of teachers. If one seeks to explain these research perspectives to others, it must be recognized that individuals will construct their own meanings from what is said, and will need time and practice to judge the utility of the ideas for them in their professional context. (This perspective is argued in detail in Gunstone & Northfield, 1986.)

4. <u>The broader context of the research</u>. The long neglect of the work of Oakes may be due to absence in his time of the perspectives described in (b) and (c) above. Also the dominance of behaviourism in the 1940s was not consistent with the style of his work. Now it is different. In recent times general theories of learning are consistent with the research on children's ideas about natural phenomena. Links between science learning research and constructivist perspectives, information-processing theory, and cognitive psychology in general, have been important in the development of the science oriented work (e.g. Champagne, Klopfer & Gunstone, 1982; Osborne & Wittrock, 1985).

The research field itself has developed in a way which provides a supportive context. In response to rapid growth and widespread interest, an informal international network has been established and international meetings have become relatively frequent (e.g. Cornell 1983; Marsailles, 1983; Ludwigsburg, 1982, 1984). Substantial visits by researchers to other institutions have been significant. For example, in the last seven years those with important perspectives in this area who have visited Monash for periods of at least one month include Berliner, Champagne, Driver, Erickson, Novak, Osborne, Pines, Shavelson, Shipstone, Shuell and Wittrock. Through all of these vehicles, research perspectives and findings have been disseminated around those working in this area with greater frequency and rapidity than would have happened through journal papers. This has contributed significantly to the development of the field.

Consequent Research

Although the volume of studies of alternative conceptions may have dulled appreciation of their remarkable results, we should remember that the early probes of students' understandings revealed a state that surprised not only researchers but also teachers, who could hardly believe what they saw and heard their students respond in interviews. Another characteristic of the results is their consistency across topics and across educational contexts. For a wide range of topics in diverse sciences, at all educational levels and in many countries, students have been observed to have alternative conceptions, often while being able to state the scientists' conception as well.

These characteristics of surprise and consistency lead to three questions:

- Why weren't alternative conceptions widely known about earlier?
- How do alternative conceptions arise?
- What can be done to change alternative conceptions?

The first question is a topic for philosophers or historians of ideas. Monash researchers have not attended to it, though we are interested in Oakes' case. Perhaps we have a concern that we, too, may have negligible influence on practice unless we discover why Oakes was ignored.

Conjectures about the second question have been made by many of the researchers who have probed alternative conceptions; most appear to subscribe to the view that conceptions come from interpretations of experience and social transmission of ideas. Such a broad statement is not particularly helpful, however, and we need sharper and more direct studies of the formation of conceptions. Where did Brumby's (1984) medical students get their Lamarckian beliefs? What sorts of experience formed them? Why did the students interpret those experiences in a Lamarckian fashion? How important are students' own interpretations relative to the effect of social transmission? Questions like these cannot be tackled with the methods of Campbell and Stanley (1963). The lumping together of people into a group and treating them as identical except for "error" variance cannot reveal reasons for differences in what they do. Rather, the Campbell and Stanley procedures reveal the effects of things the experimenter does. Although those can be important effects, they are not what matters with these questions. Therefore we have had to turn to a different style of research, the case study.

Our case studies have only begun to uncover the procedures of learning. In the first one, Baird and White (1982a) identified two contrasting styles of learning, one of which appears more likely to lead to good understanding. It is characterised by reflection on the meaning of information and a drive to relate it to subjects outside the topic itself. For instance, in learning technical terms and rules in genetics, the person displaying this style related the genetics information to literature, history and personal experiences. In contrast, the other style is limited to dealing with the information within its own boundaries, and to doing little or nothing more with it than the directions of the teacher require. It might be called a content-restricted or task-specific style.

The case study described in the preceding paragraph may be superseded by a more extensive longitudinal study, involving a series of interviews and observations of children's in- and out-of-class experiences. Although difficult and time-consuming, such a study could do much to reveal how alternative conceptions arise.

Our second case study (Baird & White, 1982b) provided a little more insight on the source of alternative conceptions as well as starting t. 'ress the third question, of how to change them. In a six-weeks period of 'ntense interaction with three college students we not only probed their learning styles but also tried to change habits that were causing the students to have difficulty in learning. Their styles can be described as geared to superficiality, with unfortunate characteristics such as premature closure and lack of reflection on meaning of information or how it relates to existing beliefs. These characteristics would allow them to maintain existing conceptions while adding new information (encompassing the scientists' conception, say) as a veneer of knowledge that they do not appreciate conflicts with their old beliefs. We had little success in our efforts to improve the students' learning styles.

Several researchers have attended to the third question, of how to change conceptions, though many people who have not taken part in this research are surprised that it is necessary. Surely, they feel, all that is needed is a clear exposition of the scientists' view, backed if necessary by appropriate experiments, and the students will discard their erroneous notions while accepting the proper ones. Unfortunately it is not that simple. Posner, Strike, Hewson, and Gertzog (1982) set out the conditions for change: the learner must be dissatisfied with his or her existing conception, and must find the new conception intelligible, plausible, and fruitful.

Posner et al. (1982) did not mention that fruitfulness depends on context, and that a person lives in diverse contexts. While the scientists' conceptions are useful in the science room in order to cope with new learning there and with examinations, they may not be as useful to the student in out-of-school contexts. Aristotlean mechanics may suffice quite well for everyday life. Thus, while it is relatively easy to get people to take on new beliefs it is much more difficult to get them to reflect on the conflicts between beliefs that they hold and to resolve them. Research on the effectiveness of a teaching program must therefore not be satisfied in testing for acquisition of new knowledge, but must also ensure that other beliefs have been discarded, a much more difficult measurement task.

The importance of context as an influence on fruitfulness is well illustrated by work on changing physics conceptions of graduate pre-service science teachers (Champagne, Gunstone & Klopfer, 1985). In that study, and in subsequent similar but unreported work with other pre-service groups, those involved in the teaching programme were only months away from having to teach physics concepts in junior high school science. In this context, the trainee teachers saw the struggle to come to some form of understanding of the physicist's perspective to be most fruitful.

We have seen that early attempts to change conceptions (e.g. Gunstone, Champagne, & Klopfer, 1981) did not succeed. Although students learned the scientists' views, they clung to their pre-existing beliefs as well and only slight resolution occurred. An alternative approach is to develop students' control over their learning so that it is more purposeful and reflective. This may be called training in meta-learning. The work of Champagne, Gunstone and Klopfer (1985) moved to this position from a beginning with alternative conceptions. This movement rose during the investigations mentioned above of strategies for changing physics conceptions of graduate pre-service science teachers, in which participants were asked to write their reactions to the instruction at the end of each session. This resulted in statements such as:

"[The session] enabled me to see how others view things and why they view them this way. Made one think hard to get a totally convincing argument for your side and any inability to do this gives you the suspicion that you are not in fact correct in your initial explanations."

"... some people fight hard not to change preconceived ideas."

"It feels strange to contradict oneself half an hour later .... [It's] as if we are trying to turn a blind eye to the truth. It's comforting to try to keep certain ideas forever even if there's a chance that they may be wrong."

"... I'm mentally exhausted after each session and the effort to hold out when I'm wrong is very draining."

(Champagne, Gunstone & Klopfer, 1985, pp. 175-176)

The physics conceptions of these students were changed by the instruction. The personal insights about their own learning, shown by quotes such as those above, were a significant factor in this conceptual change. This greater understanding of their own learning enabled students to more realistically approach the task of attempting to reconcile physics and their own perceptions. These trainee teachers saw real purpose and reward in better understanding their own learning, which again points to the contextual basis of fruitfulness.

The interactions of research and practice are once more shown by subsequent work with graduate pre-service science teachers. Instruction with the same focus on conceptual change is still part of the Monash pre-service course, but from a teaching rather than research perspective. Written reactions to each session are still required as part of the research-informed teaching strategies. On the most recent occasion of this teaching (September, 1985), student reactions to a session about the concept of "normal reaction" included:

"... we all think about things in different manners"

"a variety of observations helped me believe and understand this concept"

> "I don't believe anything until I see it ... others seem to be very lazy and allow themselves to accept whatever sludge is sent their way under the guise of 'fact' and not bother thinking about it."
>
> "[Before this session] I was taught the theory and could reproduce all the arguments but deep down I didn't really believe all of it."
>
> "I'm very slow in learning concepts ... and insecure with exploring new avenues."
>
> "My [past] confusion has not been all my fault and I'm not alone!"

Other reactions asserted the importance of concrete examples, the feelings of pers al insecurity in being probed to think, the role of genuine student questions in learning, difficulties in observing demonstrations and the lack of uniformity in observations made by individuals, and so on.

These reactions are collated, and fed back to the group. Some instructional time is then given to exploring the connections between these insights into learning and the difficulties in understanding the physics concepts being addressed.

The robustness of this approach in a school context is being explored with year 10 students in research currently in progress. The changed nature of fruitfulness in a year 10 classroom is, not surprisingly, a crucial issue.

Much of our research on meta-learning has followed a very different path from that preceding the studies of alternative conceptions. In the second case study mentioned above (Baird & White, 1982b), we found that six weeks of intensive effort was insufficient to change styles that had been built up over many years of schooling, so in a later study (Baird & White, 1984) we spent six months in one school, working with a teacher and three of his classes to promote purposeful and reflective learning. In order to obtain as complete as possible a picture of what was happening, we used many different form: of observation and measurement: video-tapes of lessons, audio-tapes of conversations between students and of interviews with them and with the teacher, concept maps, ratings of the styles of lessons by students and teacher, self-ratings of approach to learning in each lesson, and others. Although this study was moderately successful, the restriction to one teacher (when the students met from five to eight teac. :h week) and to six months of training (though much longer than most studies still not enough to bring about marked permanent change in learning style) left us wanting to do more. Now we are engaged in a two-year action research project with ten teachers of various subjects in the one secondary school. A year into the project, it is clear that significant advances in meta-learning are possible, though by no means easy to promote.

This school based project has a number of interesting characteristics. The initiator of the project is a member of the staff of the school (who also works part-time in the Education Faculty at Monash). The involvement of academics in the project within the school is at this teacher's request. The role played by academics is more in the direction of reactor than initiator - initiation and control of the project is much more in the hands of the teachers than is usual. As a consequence, the efforts contributed by teachers are directly relevant to questions of serious concern to them. Further, if researchers' suggestions about ways of thinking about and acting upon classroom problems do not contribute to a solution of that problem, then the teachers may say so. Hence the researcher is forced to reconsider the educational utility of the suggestion, or to rethink with the teacher the teacher's perception of the suggestion, or (more usually) an amalgam of both. Perhaps t. most powerful experience which this project has provided to both teachers and researchers is a greater understanding of students' perceptions of classrooms, learning and teaching.

The contrast between this action research project and the earlier experiments of sophisticated design but simple theory is great: difficult rather than simple learning goal; many complex observations rather than one or two tests; long-term rather than short; messy, not neat; done with teachers and students rather than on them; and above all relevant, with the potential to bring about a revolution in teaching.

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