THE PURPOSE AND ASSESSMENT

OF

PRACTICAL WORK

IN

SCHOOL SCIENCE

An enquiry into the purpose and assessment of practical work in High Schools and Matriculation Colleges in Tasmania as perceived by teachers of general science, physics and chemistry, and school students taking those subjects.

BY

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ABSTRACT

Practical work has always been considered by the majority of science teachers and educators to be fundamental to the teaching of the physical sciences. However, there has been less agreement by experts on the purpose, most suitable type of practical work, most suitable assessment procedures and the optimum time that should be spent on it. Inevitably, these differences in opinion have affected the nature and emphasis given to the assessment of practical work.

The last twenty years has seen a dramatic upsurge in curriculum development which in the physical sciences has been strongly oriented towards pupil-centred practical work. This 'curriculum phase' in the developed countries including Australia, would seem to have finished. The emphasis is now on consolidation. It would seem an opportune time to review the present situation with regard to the purpose and assessment of practical work and at the same time place it within historical perspective.

This thesis is mainly concerned with *purpose* and *assessment* of practical work in Tasmanian High Schools and Matriculation Colleges.

In considering the notion of purpose it was decided to examine the relative importance of the aims of practical work as perceived by teachers, then to establish the orientation of students towards these perceived aims (called influences by us) and finally to make a comparison of the

aims of teachers with the influences as perceived by students.

Regarding the assessment procedures of practical work, an examination of the current practices, its historical evolution and a study of preferences are made.

Three questionnaires were constructed in this descriptive survey in order to obtain the information necessary for the examination of the above mentioned problems. All High and Matriculation science teachers (N=256 response rate) received one set of questionnaires, a sample of High School students (N=459 response rate) received the second set, and all Matriculation students studying physics and chemistry at second year matriculation level (N=265 response rate) received the third set. The samples in the latter two cases are representative of the Tasmanian populations.

Also, it was possible to interview six of the seven supervisors/superintendents of science for the period 1950-1982, and they responded specifically to their role; prompts concerning: major changes in the science syllabuses; major changes regarding practical work; policy regarding assessment of practical work during their period of office.

Our findings would suggest that teachers' perceptions of the aims of practical work, appear, in some respect, to be misjudged or misguided at present, and when viewed against student perceptions indicate some major mis-matches. High School students would seem to perceive practical work as more of a visual aid than an experimental enterprise, while Matriculation students perceive their practical work to be much more technique-oriented than it was intended to be according to teachers and curriculum developers.

With regard to the assessment of pratical work, specifically, teachers and students in Tasmanian schools are strongly in favour of it being school based, with a particular strong preference for continuous assessment at all levels by teachers.

There is clearly considerable mistrust of external examinations in this area. On the other hand, Tasmanian teachers and and students favour a contribution of practical work to the students' overall mark which far exceeds its real weighting at present. There is a strong commitment to laboratory based teaching within the profession and a recognition that such skills must substantially affect the students' overall mark.

This study of aggregate perceptions of teachers and students, and the individual perceptions of science supervisors is hoped could provide an evaluative dimension for Australian teachers and educators regarding this particularly important aspect of science teaching - the assessment of practical work.

In conclusion a comparative examination is made of similar surveys of students' and teachers' perceptions regarding practical work in the U.K. and South Africa. There are some quite striking differences particularly in regard to orientations 'careful observation', 'finding out' and 'acquisiton of skills and techniques' which suggest that aggregate perception of the purpose of practical work is not the same in these three countries.

This thesis contains no material which has been submitted for examination in any other course or accepted for the award of any other degree or diploma in any university and, to the best of my knowledge and belief, contains no material previously published or written by another person except when due reference is made in the text.

Signed: ....

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CHAPTER ONE

SCIENCE TEACHING AND THE ROLE OF PRACTICAL WORK

1.0 INTRODUCTION

Practical work is by no means unique to the sciences. It is found in other subject areas within the school curriculum. For instance there is a practical element in fine arts and the manual arts. In fine arts (e.g. music) this is strongly linked as much with *appreciation* as with performance. In contrast, the manual arts tend to strongly emphasize *performance*. School sciences lie somewhere between these positions. The goal descriptions for school practical work in science, though somewhat blurred in the area of appreciation, are nevertheless not so technique orientated as one would find in the manual arts. Indeed, much modern curriculum development has attempted to de-emphasize the skill-techniques aspect of science practical work in favour of an investigational orientation.

The *relative* importance, of the aims or goals for practical work in the sciences has fascinated science educators since before the turn of the century. Inevitably these goals are related to the nature of the scientific enterprise itself.

In that content, modern science is considered a body of tested facts and relationships systematically organised, and being so broad it encompasses many fields of study; and some science educators favour a definition of science in terms of a search for knowledge through carefully controlled observation and experimentation: an *inductive* method of investigation. Collette (1973) for instance, in his review of science teaching in the secondary school in U.S.A., defines science as:

> "... a cumulative and endless series of empirical observations which result in the formulation of concepts and theories with both concepts and theories being subject to modification in the light of further empirical observations."

Collette's naive inductivist view of science is certainly not the whole story. Theories though related to observations do not result from them alone but it would seem to be a fair generalisation for the bulk of scientific research.

In 'Science for Children', (1974), Collette and Hubler consider the nature of science both historically and in recent times. They propose that science in the curriculum should reflect science as it is in the everyday world, in line with the popular argument that 'little' science should be like 'big' science in terms of its methods and procedures.

Amongst educational psychologists, there seems to be agreement that the role of experimental work is important for a number of reasons associated with the processes by which children learn. Piaget (1974) and his co-workers at Genera suggested that much early learning involves the internalization of physical actions performed by the learner implying that *concrete experience* is vital. Much of the current emphasis on 'activity methods' and practical experience stems from this type of theoretical rationale.

Bruner's concept of the heuristics or learning by discovery (1966) stresses the goals of science instruction to be the acquisition of inquiry skills and experimental discovery techniques. He also noted that small children are characterized by a propelling curiosity about the environment but their perception is concrete rather than schematic or abstracted. Hubler (1974) comments that the learning processes which occur in children are strikingly similar to the procedures of science whereby new understandings are obtained through observation and experimentation. Children also learn from their *own* investigations. According to Hubler this is the normal and most effective way for children to learn.

Piaget, Bruner, Hubler and Collette would contend in accord with many science educators that science teaching should reflect the *processes and methods* of science. Consequently, their writing would represent a powerful recommendation for a practically based science program, implicitly if not explicitly.

Burnett (1960) in his review Teaching science in the secondary school, in the U.S.A., claims that the laboratory should be the hub of activity in science instruction as it is in the work of the professional scientist:

> "The laboratory should be a place where thinking is done - critical thinking, reflective thinking, focussed thinking."

Oxenhorn (1972) in his study on 'Teaching Science to Under Achievers in Secondary School' in the U.S.A., stresses the role of experimental work in classes of low achievers. According to Oxenhorn, low achievers are not oriented towards the abstract so consequently the work that is most suitable for them is practical application. He stresses that practical application does not mean the elimination of theory and concepts. However, he does consider that manipulative skills are of considerable importance in using rulers, balances, thermometers, liquid measuring devices, glass-bending, assembly of apparatus and a host of other laboratory-type skills. Oxenhorn's concern for the under achievers raises the whole issues of for whom school science is actually designed. The needs of the under achievers are associated with the acquisition of basic scientific literacy rather than a mature understanding of science. And, there are far more students requiring scientific literacy than a preparation for a career in science and technology. Oxenhorn suggests that practical work is equally important for both under achievers and high achievers.

It is clear from recent writings that much present thinking has been influenced by findings of educational psychology. At the same time one is acutely aware that the 'nature of science' and the 'quality' of practical work are by no means a new topic for debate. The roots of both notions can be traced historically to their European origins.

It would seem appropriate therefore to examine both the historical development and the psychological aspects of learning which have a direct bearing on science teaching in regard to practical work, in some detail. These two perspectives of practical work teaching, the historical and the psychological are considered briefly in order to provide a background from which to interpret subsequent chapters in this thesis.

1.1 THE HISTORICAL DEVELOPMENT OF PRACTICAL WORK IN SCIENCE

Practical work was introduced into schools at the beginning of the nineteenth century in both the U.K. and the U.S. The development in the U.K. has been fairly well documented by comparison with events in the United States.

As early as 1802, Edgeworths in his work on 'Essays on Practical Education' wrote:

> "There is considerable pleasure in the pursuit of experimental knowledge; children especially enjoy this substantial pleasure ... They (the children) love to see experiments tried and to try them. They show this disposition not whenever they are encouraged but whenever they are permitted to show it."

Queenwood College, a relatively obscure Quaker School, was the first English school to introduce 'practical or laboratory teaching of science', to an extent which makes science teaching at Queenwood one of the most significant nineteenth century experiments in English education.

The achievement of Queenwood College were almost entirely due to a quite outstanding staff, of whom Frankland, Tyndall, Barrett, Galloway, Hirst and Debus in later years occupied Professorial Chairs and were active members of the influential X Club. The latter group formed in 1864 by nine eminent scientists served as a highly significant fraternity of scientists. One of the major aims of the nine men in the X Club was to change science education to one that was more practically based.

In the Queenwood Reporter, Thomas Edmonson (1848) a member of the X Club and teacher at Queenwood College wrote:

> "Schools and Colleges seldom do more than afford opportunities for the acquirement of knowledge; for its right application and its lasting retention, they scarcely profess to make any provision. One leading object at Queenwood is to remedy this defect. Our pupils' progress will be tested by their ability and not their amount of knowledge. So far as possible, everything will be taught and learned among us practically, that is, with a view to the business of life."

The students at Queenwood, unlike their counterparts in the traditional English schools learnt their science in the laboratory and lived in a genuine atmosphere or research.

Frankland and Tyndall carried into effect these principles of the teaching of science at Queenwood, expressed by T.H. Huxley (1869) in the following words:

> "If a man wishes to be a Chemist, it is not necessary that he should read chemical books and attend chemical lectures, but that he should actually perform the fundamental experiments in the laboratory for himself."

Robert Galloway, who later became Professor of Chemistry in the Royal College of Science for Ireland, comments on the excellence of the provisions at Queenwood for the teaching of chemical analysis:

> "Although only about four hours; in the week was devoted to the study of science, boys of 14 and 15 years of age became excellent analysts. Those of them, who on leaving the school became pupils with surgeons, could make medical, food and other analyses more accurate in every aspect than the surgeon to whom they were articled ..."

Tyndall also felt that the link between mathematics and physics was achieved with some success. Tyndall wrote:

> "It was pleasant to prove by mathematics, and verify by experiment that the angular velocity of a reflected beam is twice that of the mirror which reflects it. From the hum of a bee we were able to determine the number of times the insect flaps its wings in a second. Following up our researches on the pendulum, we learned how Colonel Sabine had made it the means of determining the figure of the earth; and we were also startled by the inference which the pendulum enables us to draw, that if the diurnal velocity of the earth were 17 times its present amount, the centrifugal force at the equator would be precisely equal to the force of gravitation, so that the inhabitant of those regions would then have the same tendency to fall upwards and downwards."

Thus it is not too much to say that the germs of what was later to become the influential *heuristic method* (in which the pupils were required to solve problems by experimentation) in English education were nurtured in the science teaching at

Queenwood.

The widespread acceptance of science into the secondary school curriculum at the turn of the century was influenced by the writings of Henry Armstrong. Armstrong had been a pupil of Edward Frankland at Queenwood College, himself, and was a firm believer and advocate of Heurism. Armstrong maintains that "all science teaching should be as far as possible, a process of discovery". There are strong evangelical overtones in his credo:

> "I believe that gradually a complete revolution must take place in school procedure", and that "instead of being a place fitted for the rearing of desk-ridden emasculates, the school will be for the most part modelled on the workshop."

He was also echoing what his teacher, Edward Frankland, and his friend, John Tyndall, had seen worked out in practice fifty years earlier at Queenwood College, Hampshire.

The teaching of science was to be an affair of the laboratory and workshop rather than of the classroom.

Edward Frankland (1825-99) maintained a strong interest in school science throughout his life. As incumbent of the Chair of Chemistry at the Royal Institute he persuaded the department of Science and Art to provide grants for school science laboratories. Out of Frankland's experience came his monograph 'How to teach Chemistry' (in 1875). The book describes 109 experiments that Frankland believed teachers should introduce to all pupils. These experiments became the chemistry practical syllabus for English schools for almost two decades.

Thomas Huxley (1869) also persuasively argued the case for first-hand experience in science. His work greatly influenced the use of individual laboratory work in the teaching of school science. Huxley himself was concerned with biological science both as a professional scientist and as a teacher. He saw a training in science as part of the education of a cultured man.

In general, a majority of outstanding scientists and science teachers by the turn of the century believed that if science teaching was to yield its most valuable results, it must be made practical.

The "heuristic' or practical discovery method of science teaching was favoured by leading science teachers and science educators until as recently as the second world war. To what extent it was genuinely adopted by the average science teachers in the U.K. is not recorded. There is no doubt that an unguided heuristic approach represents a highly sophisticated teaching mode which places great demands on the personal characteristics of the teacher and is extremely time consuming. Reservations of this sort were reported from time to time in the School Science Review from well respected 'authentic teachers'. It may well be that a full heuristic treatment was never adopted in practice other than by an elite group but nevertheless it represents an ideal for science teaching which remains quite deeply rooted in the English School system.

Misgivings about its general usefulness gathered momentum during the 1920's. One interesting government report on science teaching produced by the Thomson Committee in 1918, is openly critical of laboratory exercises:

> "...in many schools more time is spent in laboratory work than the results obtained can justify. We do not underrate the importance of such work, on the contrary, we regard it as an essential part of science teaching. But sometimes the performance of laboratory exercises has been considered too much an end in

> itself - such an exercise loses the educational value of a real experiment when it becomes a piece of drill ..."

Here is perhaps a clue to the nature of real practice in schools. One might have expected that a report chaired by an experimental scientist of the calibre of Thomson would have stressed the importance of the 'spirit of enquiry' - and so it did. However, according to the report, this quality was largely missing in school science and instead practical work was being interpreted as a series of essential experimental techniques. Maintaining a balance between these two emphases, *technique* and *inquiry* is an intractable problem and remains as acute an issue today as it was when the Thomson report was written.

Although no survey studies of school practice are available for that period the evidence is that the recommendations of the Thomson report were either ignored or could not be met. School practical work steadily metamorphosed further towards a technique dominated set of drills, so that by the 1950's the time was ripe for some reshaping of the laboratory enterprise. J.F. Kerr's survey 'Practical Work in Schools' published in 1963, was much referred to in the early development of Nuffield Science. It represents the first attempt in the U.K. to ascertain the actual practice and perceptions of pupils and teachers with regard to practical work. Although essentially a first-order descriptive survey it did much to clarify the real situation and has since been used as a reference in comparative studies.

The Nuffield Science Curricula that emerged in the U.K. once again laid considerable stress on extensive practical work, on 'finding out' and on the 'spirit of enquiry'. Heurism never did die out, and, indeed a number of the more influential members of the Nuffield team were active exponents of heurism in their own teaching. What appeared however were recommendations associated with a much more guided and controlled heurism than had been advocated more than half a century earlier by Henry Armstrong.

If the Nuffield schemes represent the distilled wisdom of outstanding teachers as has been claimed we must observe that this wisdom did not produce a new paradigm but attempted to reaffirm a set of values in science teaching which appear to be traditionally and almost uniquely British. European tradition is quite different in this regard, where commitment to a didactic/pedagogic framework of reference produces quite different orientation to teaching (and science teaching) as an enterprise. It is not within the bounds of this thesis to explore these differences but it should be noted that the high points of English Science teaching have always been strongly rooted in empiricism - and an empiricism which runs almost counter to an authority principle. It is not by chance one suspects that the prime movers in this tradition were 'low-churchmen'.

1.2 THE DEVELOPMENT OF SCIENTIFIC CONCEPTS AND THE SCHOOL LABORATORY

Over the years many publications have appeared on the subject of school practical work, but few studies could claim to be educationally significant. It is well known that much science in secondary schools is concerned with concept development and the relationship between concepts. In this respect the study of 'concept formation', what it is and how it takes place, is of considerable relevance. Recognition of the 'conceptual structure' of science and of 'concept learning' as an essential part of meaningful learning has had some considerable impact on more recent curriculum development.

It has been argued by Bruner, amongst others, that once concepts are grasped, they provide a framework which facilitates the learner's ability to cope confidently with new learning. He argues that as learning proceeds, the understanding of the concept itself grows steadily richer and more sophisticated.

Hence for curriculum developers, considerable attention has been focussed on the identification of the key concepts in order to establish an effective teaching order. In this respect it is important to know what counts as effective learning, educationally. Many science educators have attempted to define effective science learning.

The development of scientific concepts by children has been a major focus of interest of educational psychologists in the post-war period. Many major curriculum developments, particularly in the U.S. have been strongly influenced by the work of Bruner, Piaget etc. One should also add Benjamin Bloom to this list since Bloom's categorisation of domains implicitly raises the question of relative value of goals in a learning experience. If we were to single out perhaps the three major figures in this overall movement it would perhaps be Bloom, Bruner and Piaget. Their findings have sensitized teachers and educators to the notion of 'effective learning experiences'. A powerful justification for practical work in school science emerges as a consequence of the extremely wide range of possible learning experiences associated with this activity.

It is worthwhile to examine these justifications in some detail. Bloom's contribution to a theoretical rationale for effective learning is to present a classification of possible aims into three relatively distinct categories. These categories are associated with acquisition of skills in the areas of thinking, feeling, and doing, within what are termed the *cognitive, affective* and *psycho-motor* domains. For Bloom the distinctions are very clear and for science educators it means that all activities might be profitably reviewed in terms of how they contribute to each of these domains.

In this context, the cognitive domain encompasses objectives concerning thinking, knowing and problem solving. The affective domain is concerned with attitudes, values, interest, appreciation and social/emotional adjustment. The psycho-motor domain refers to objectives describing the sensori-motor effects (e.g. manipulating, observing, communicating).

TABLE 1.1

BLOOM'S TAXONOMY OF LEARNING AS PRESENTED BY HINCKSMAN (1973)

Cognitive domain	Affective domain	Pyscho-motor domain
(Highest) Evaluation	(Highest) Complex	(Highest) Naturalization
Synthesis		Articulation
Analysis	Organization	Precision
	Responding	
Comprehension		(Lowest) Imitation
(Lowest) Knowledge	(Lowest) Receiving	

Hincksman (1973) claims that science learning may be assessed as most effective if it reaches the level of *evaluation, 'complex'* and *naturalization* and least effective at the levels of *knowledge, receiving* and *imitation* in the respective domains. The tests of effective science learning are the taxonomical levels at which the various stated aims of the course are achieved by students. This is very debatable. One might argue that synthesis - *creation* of new ideas in science - is more valuable than *evaluation* (or just as valuable anyway).

Piaget's work has had a great influence in current developments in the teaching of science and mathematics. There are many examples of the influence of his work, especially in science education. The Nuffield Junior science materials use a predominantly Piagetian approach. Projects in Australia, America and the U.K. that directly acknowledge their use of findings from Pagetian Research include Science 5/13 (U.K.), Elementary Science Study (U.S.), the Science Curriculum Improvement (U.S.), and A.S.E.P. (Australia). The science 5/13 Curriculum and ASEP extend into the early secondary years but it is interesting to note that Piagetians have directly affected the development of primary science curricula which hitherto has been a somewhat neglected area.

Most educational psychologists would agree that the nature of the learning experiences is still very much a mystery and consequently the influences of practical work are not fully understood. They have very often devoted considerable attention to the identification of key concepts in order to establish an effective teaching order. Gagne[1] has for some years stressed the importance of recognising the most suitable sequence of concepts of learning, generally. Concept recognition is believed to influence the choice of practical work in an ordered and meaningful way.

Piaget has therefore contributed greatly to our understanding of concept development with his theory of four recognizable stages that children as learners pass through. Basically he claims that we all have to pass through four distinct periods of development. During each of these periods, our view of the world is qualitatively different.

There are certain important underlying points to Piaget's theory. A bright child might move fast from one stage to the next but no child could skip a stage or more through the stages in a different order, recently it has been well established that mental development does proceed along lines similar to those described by Piaget and that the four main stages can be clearly distinguished. The ages of transition have not yet been fully resolved. Although some psychologist such as Professor Peter Bryant (at Oxford) have criticized Piaget, they are still adamant that he made a huge contribution. No work in developmental psychology could ignore him. Piaget's observations caused recent

[1]Gagne, R (1965), The Conditions of Learning. Holt, Rinehart and Wilson

curriculum development to concentrate on the nature of the experience about which a concept is built.

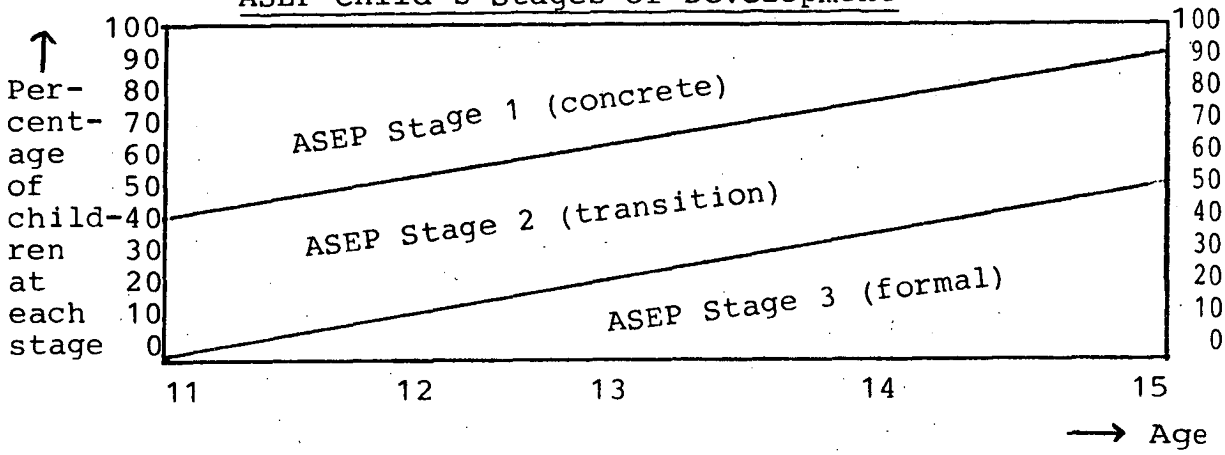
This is well illustrated by the structuring of the Australian Science Education project ASEP which involved the development of materials to suit children at three (Piagetian) stages of development.

ASEP Stage 1 approximates to Piaget's concrete stage

ASEP Stage 2 represents the transition between concrete and fully developed formal thinking

ASEP Stage 3 approximates to Piaget's formal stage.

Fig.1.1: ASEP Child's Stages of Development*



1.3 SURVEY MOTIVATION

It is clear that for many years science educators have argued in favour of the importance of laboratory work in science teaching and learning. It is acknowledged that with laboratory experience alone, one cannot promote all the goals of science teaching, but it is also generally accepted that they are important vehicles for attaining some of those goals. Yet, teachers have generally not incorporated laboratory goals within their system of grading and evaluation, though still they are expected to promote the development of specific skills in their students apart from evaluating their performance.

* Fig. 1.1 represents the pattern of change used by the ASEP Working party. The data was derived from unpublished research by Dale, 1975 ('Some implications from the work of Jean Piaget').

Though there is evidence that relatively sophisticated practical teaching is taking place in our schools, some science educators feel that much more has to be done in order to ensure that it is achieving its intentions. There is a need to know exactly what practical work is taking place in schools and what influence it does have on students. Does it reinforce the influences of school work or does it do something different?

Over the years, science teachers have sent students into the laboratory with the general conviction that good science courses provide experience in *doing* and not just words about science. Laboratory activities have always been time consuming for teachers and students and they have always presented teachers with management problems. There are also important economic constraints at work associated with the very considerable costs incurred in the provision of laboratories and apparatus necessitated by practical work. Clearly, great demands are made on the time and energy of teachers at school and university in order that students are able to derive the maximum benefit from practical work. Yet a recurring criticism of science teaching at school has been that experimental work is of limited value to the student by comparison with the demands made on teachers.

One reason why the case for the laboratory in science teaching is not as self-evident as it once seemed is the failure to research studies to provide clear support for laboratory work as an effective medium for science teaching, although it has always been regarded by the majority of science educators as an integral part of the study of science. Science teachers who genuinely want their students to develop problem-solving and laboratory skills see to it that those kinds of learning find their way into tests and other evaluation procedures.

Teachers understand that grading systems reflect the actual goals of teachers and schools, and that many students gear their best efforts to activities that will be rewarded at test time.

Unfortunately, researchers have not comprehensively examined the effect of laboratory instruction upon student learning and growth; thus we simply do not know enough to convincingly confirm or reject many hypotheses about the importance of laboratory teaching.

An examination of teachers' and students' perceptions of the aims and corresponding influences of practical work, together with a study of the nature and development of assessment procedures would seem to offer a useful starting point for obtaining a better understanding of the role and purpose of practical work. Tasmania is ideally suited for such a study. This relatively small state has all the complexities of a much larger state in terms of its population structure, its schools and its science curricula.

CHAPTER TWO

PLAN OF THE ENQUIRY AND DESCRIPTION OF THE SAMPLE

2.0 INTRODUCTION

Despite the widespread use of practical work in Tasmanian Schools, there have been no studies of the nature, perceived purpose, or organisation of this activity. In the Australian context, J. Ainley's study 'The Australian Science Facility Programme' is exceptional in this regard though its examination of the short term impact of upgrading facilities in schools is rather specific and it does not address itself to the notions examined in this thesis to any extent.

This study, extracted from a larger survey, of the nature, purpose and organisation of practical work in Tasmanian schools, represents an attempt to redress this imbalance.

It is mainly concerned with *purpose* and *assessment*, and some initial comment needs to be made about both these notions in so far as they relate to practical work in schools. The *purpose* of practical work has been defined in terms of *aims* by a considerable number of science educators and curriculum developers and the *perceived purpose* as reported by teachers has been examined in a number of survey studies, mainly in the U.K., Kerr (1963), West (1973), Thompson (1975), Lynch (1976), Gunning and Johnstone (1976). In this study the orientation of the *teacher* towards this purpose is defined in terms of the teacher's aims or simply, aims. The orientation of the *student* as a consequence of experiencing the practical work is referred to as course influences or simply, influences. It will be appreciated that the teacher's aims and the student's perception of them (influences) are not necessarily coincident.

The *assessment* of practical work is considered to be one of the areas most in need of improvement in science teaching. To the majority of teachers, it seems assessment is probably the singular most important determining influence on the school practical work. In this study, it is intended to investigate the extent to which teachers assess practical abilities of their students, the methods employed, the validity and reliability of such methods, and their assessment preferences.

2.1 STATEMENT OF THE MAIN PROBLEMS TO BE EXAMINED IN THIS THESIS

As far as a study of purpose is concerned, the main problems are delineated as follows:

1. To establish the relative importance, according to teachers, of a validated list of aims for school practical work at three teaching levels: grades 7/8 (age 12/13); school certificate (age 15/16); and matriculation (age 17+).
2. To establish the orientation of the students concerned towards these same aims (expressed as influences).
3. To compare the aims for teachers with the influences as perceived by students.

In regard to assessment the main problems examined are as follows:

1. Current practices regarding the assessment procedures of practical work in Tasmanian schools.
2. The historical evolution of assessment procedures of practical work in High Schools and Matriculation level in Tasmania.

2.2 CONSTRUCTION OF THE QUESTIONNAIRES

In order to obtain the information necessary to examine the problems outlined for this thesis, survey methods involving questionnaires were used. Three questionnaires were prepared as follows:

(i) a questionnaire for high school and matriculation *science teachers.*

(ii) a questionnaire for high school *students* (grade 9 level).

(iii) a questionnaire for matriculation level *students* (grades 11 and 12).

All the studies cited used questionnaire items which have been strongly influenced by those used by Kerr in the U.K. In most instances this was to allow comparisons with Kerr's original findings. This study is no exception in this regard and although some items have been adapted and extended in order to relate specifically to the Tasmanian school situation the final list of questionnaire items is very similar to that used by Kerr.

2.3 VALIDATION OF ITEMS

Questionnaire items were validated by 17 persons actively involved with the teaching, administration and assessment of science at matriculation and high school level. This steering committee contained the present science advisor, two previous science advisors, four university examiners associated with the appropriate subjects, a number of experienced senior masters, mistresses and assistant teachers, and a smaller number of outstanding science teachers who are now in the position of principal or vice principal. Members of the steering committee were required to examine the items from the point of view of syntax, appropriateness and completeness. As a consequence of these communications, items were modified and additions made.

2.4 RELIABILITY

Where appropriate, split halves tests (KR-20) were applied. Internal consistencies were evident from the responses to different questions, e.g.: for example in Q.19 in teachers questionnaire, teachers were asked "How did you assess your student's overall performance in science in 1980?" They were given four answers to choose from (i.e. *Theory only; Theory and prac., final exams, none of the above).* 209 (81%) teachers indicated *Theory and prac.* In question 20 they were asked "Did you assess the practical work done by your students in 1980?", 214 (82%) teachers indicated they did, confirming one example of internal consistence.

All the questionnaires were used, none showed any sign of facetious comment, careless or 'random' completion of data. This is no doubt a consequence of the procedures adopted for completion of the questionnaires, in the case of students, which were very specifically set out. Teachers' responses were generally thorough in all cases. Written comments given in the open sections were rarely at variance with the responses recorded in the scaled items.

The validated questionnaire for *teachers* (provided in the Appendix) elicited information concerning;

(i) age, sex, teaching experience, qualification, type of school etc.

(ii) current practice regarding school practical work

(iii) amounts and kinds of practical work used

(iv) use of basic science apparatus

(v) the aims of practical work

(vi) teaching preferences.

The validated questionnaires for *students* (provided in the Appendix) is a simpler version of the questionnaire to teachers but it required details of academic performance in regard to internal and external assessment. The questionnaire also elicited students' perceptions of assessment of practical work used (formal/informal), actual and preferred weightings, assessment criteria (actual and preferred) and attitude to assessment.

A trial of the questionnaires was carried out on a suitable sample of Tasmanian school students (30) and teachers (6). A number of changes were made as a consequence of this validation procedure and all questionnaires were revised and redrafted before they were finally adopted.

2.5 THE SAMPLE OF STUDENTS

The sample of high school students (N = 459) was obtained from a stratified cluster of all Tasmanian schools. In all, twenty one high schools were selected from a sampling frame stratified as rural/urban and state/catholic/independent, thus ensuring that the student sample reflects the various types of schools in the total population. Individual schools, if unstreamed, provided a sample of approximately 25 students (about one 'class worth' at grade 9 (age 14-15). In cases where grade 9 students were streamed a sample of 25 students was selected randomly from the total compliment of grade 9 at that particular school.

All matriculation level students in Tasmania attempting the Physic or Chemistry 'B' courses at Grade 12 (age 12+) completed the questionnaire (N = 265, response rate 90%). Almost all this group had completed the Physics and Chemistry 'A' courses in Grade 11, usually successfully, and were beginning the more specialized B courses which are usually only undertaken by those oriented towards university or tertiary studies in science and engineering.

The two samples (one a total population) describe two rather different groups.

The High School student sample represents the average 14-15 year old at Grade 9. The matriculation level population represents those academically successful students oriented towards tertiary studies in science or science-oriented fields.

2.6 THE SAMPLE OF TEACHERS

All science teachers in the state were asked to participate in this survey (hence this included all science teachers at high school and matriculation level). Questionnaires were sent out to 80 schools with an overall response of 79% or 259 teachers. Analysis of the returns suggests that the sample is representative of science teachers in Tasmanian schools and colleges. The 79% response rate calculated was based on the ratio of school that responded to the number of schools that received the questionnaires. It was not possible to obtain the total number of science teachers in Tasmania from the Education Department data.

In both teachers' and students' questionnaires, all respondents were asked to answer all items listed, frankly and honestly. They were also asked to refer to their own experience with practical work in the school situation, not what they think ought to be done, and questionnaires were completed independently.

The administration and collection of questionnaires was organised by senior science masters in each school involved in this survey. The students/teachers were asked to read the questionnaire items carefully before they made any decisions.

The form and wording of all three questionnaires used in this survey is given in the Appendix.

2.7 SOME OBSERVATIONS CONCERNING THE QUESTIONNAIRE METHODOLOGY EMPLOYED

The only convenient technique to obtain information from a large number of people who are spread over a wide geographical area is to use questionnaires. It is by no means a perfect technique, and it has limitations.

The following represent a range of possible orientations governing the responses given when students and teachers are answering many of the items in the questionnaire:

(i) take it seriously and answer it as truthfully and sincerely as possible

(ii) show oneself to be normal and well motivated, in case the results are used in some hidden form of assessment

(iii) the questions are trivial and hardly worth considering seriously - any response will do

(iv) why should I put myself out for someone else's research degree? - I'll make my responses as absurd as possible.

In order to minimise the last three orientations in the above list, all questionnaires were sent out by post and they were accompanied by three carefully worded letters and instructions to principals, science senior masters and science teachers respectively (see Appendix 4).

The Education Department was consulted beforehand, and permission was granted to carry out this survey in Tasmanian schools.

Another major problem of questionnaire technique is that of ensuring that the questions are understood and truthfully answered (orientation 4).

It is imperative that the intended meaning of explanations and questions is lucid to the respondents, and that the wording is arranged to remove ambiguities. In order to eliminate the tendency of an individual to make the response which he feels *is expected of him*, our questionnaire items were worded in a completely non-leading manner. All items were randomised and great attention was given to the 'cautionary phrases' preceding specific questions and in the introductory letter. For instance, the written preamble to the student questionnaire was as follows:

(1) It will be a great help to future students doing science if you could answer the following questions frankly and honestly. *Please refer to your own experience, not what you think it ought ideally to have been,* and complete the questionnaire independently of your fellow students.

In the section of amounts and kinds of practical work (teachers' questionnaire) the following statement was emphasized.

(2) Please note that the term 'practical work' is taken to include demonstrations, excursions, fieldwork, practical projects and experiments performed by students either in groups or individually. *Consider your experience in 1980.*

In both questionnaires, considerable stress was made of the necessity for an individual, and a *real* rather than *idealised* response as on the front of each questionnaire (e.g. for students)

> **IMPORTANT**
>
> "... PLEASE REFER TO YOUR OWN EXPERIENCE WITH PRACTICAL WORK IN THE SCHOOL SITUATION, NOT WHAT YOU THINK OUGHT TO BE DONE."

ANALYSIS AND INTERPRETATION OF DATA

2. 8 CHOICE OF SCALING TECHNIQUE

One aspect of measurement in which considerable success has been achieved in research in the social sciences is in measuring how people order a universe of concepts (e.g. what a group of students/teachers consider to be the most important influence/aim of practical work, which second, which third and so on to the last important ones). This typifies the research purpose of ordering, a purpose for which there are three different scaling techniques.

All three of the techniques have the same three components: a finite sample of specific concepts or items that a researcher wishes to order; a criterion continuum along which they are to be ordered; and procedure by which the respondent indicates his placement of each specific item on the continuum.

1. Rating scales. In the rating scales the task posed for the respondent is to rate each element separately

in terms of a criterion by selecting a verbal or numerical rating from among those offered (see question 35, teachers' questionnaire). This sometimes is termed a *Likert-type* response.

2. Rank Order Procedures. When a researcher has no concern whatsoever with the qualitative aspects of rating, but is totally concerned with ordering, he uses one of the ranking procedures available, generally either the rank-order scale or the Q-technique (Q-Sort). Both techniques offer the respondent a set of concepts or items to be ranked, and both state a criterion continuum along which they are to be ranked. In the rank order technique the respondent is asked to rank the items consecutively. In contrast, the Q-sort technique asks the respondent to rank the items in clusters (i.e. single most important items and least important items - see question 37 on aims/influences of practical work). (This is sometimes referred to as forced choice or selection).

3. The Paired-Comparison Scale. When the researcher is concerned with the ordering of a small sample of concepts and is anxious to achieve a maximum precision in developing this order, he is advised to consider the paired-comparison scale. In this procedure, the respondent is presented with all possible pairs of the items and asked to indicate which of the pair he would rate higher in terms of the criterion continuum.

The first two techniques were employed in designing the questionnaires and as an example, in the list of aims, a forced choice technique was used. In a similar list, Kerr, used a 4-point Likert Scale, Thompson used rank ordering, while Lynch used a 5-point scale. Each of these methods has its own limitations.

2.9 ANALYSIS OF DATA

Students were required to read the list of ten influences, carefully, for 5-10 minutes and think about them. They were then required to 'choose what you think were the four most important influences from the list below'. High school students referred to their experience of previous high school work while matriculation level students were instructed to consider their previous matriculation level course in Grade 11. Teachers were required to respond in a similar way to the list of ten aims.

Teachers and students chose 4 items from the 10. If an item is chosen it scores 1; if not chosen it scores 0. The total scores recorded for each item can then be expressed as a frequency.

2.10 STATISTICAL TESTS (Significant differences)

Statistical analysis of the items was carried out by computer using the programme, Statistical Package for the Social Sciences (SPSS). Mean scores, standard deviations and variances for samples were calculated where appropriate. The significances of the differences were assessed statistically, in some cases using χ^2 and in the majority of cases, using one-way analyses of variance (f-tests).

In the section on aims and influences of practical work a statistical method was used which would fairly simply give a measurement of the relative importance of the ten aims or influences and of the extent of agreement between respondents, but which is also a general method, making as few assumptions as possible about the distribution of answers. In the section of aims and influences observed frequencies are compared with a random choice of items. A random choice would correspond to a frequency of 0.4 or 40% (the probability of choosing each item from a list of ten, since only four items were to be chosen).

The χ^2 was used to test whether the observed frequencies were significantly different from the frequencies expected from random choice.

$$\chi^2 = \sum_{i-1}^{K} \frac{(O_i - E_i)^2}{E_i}$$

where O_i = observed frequencies, E_i = expected frequencies.

To establish whether each aim or influence is statistically significant from the random value of 0.4 a Z-score for each item was obtained as follows:

$$Z = \frac{X-\mu_X}{\delta_X} = \frac{X-NP}{\sqrt{NPQ}}$$

where μ_X = mean, δ_X = standard deviation, NP = expected value

N = Total number of cases observed

P = proportion of cases expected in one of the categories (probability).

Q = 1-P = Proportion of cases expected in the other categories.

Again in the section on aims and influences of practical work, the results obtained (for both teachers and students) required a test of significance of the difference between two independent proportions (e.g. boys/girls)

This was accomplished using a standard Z-test, as follows:

$$Z = \frac{P_1 - P_2}{S_{P_1 - P_2}} = \frac{P_1 - P_2}{\sqrt{pq\,[(\frac{1}{N}) + (\frac{1}{N})]}}$$

where $S_{P_1 - P_2}$ is the standard error of difference between two proportions based on independent samples.

p = sample value of a proportion, and is an estimate based on the two samples combined.

q = 1-P; P_1 & P_2 are two independent proportions (i.e. for boys and girls respectively). N_1 & N_2 are number of cases in each sample.

The value of Z is then interpreted as a deviate of the unit normal curve.

2.11 DESCRIPTION OF SAMPLE OF TEACHERS

2.11.1 Distribution of Returns of Completed Questionnaires from Teachers by type of school.

The questionnaire to science teachers was distributed to 82 schools in Tasmania. Table 2.1 shows the distribution of returns by type of school.

Table 2.1

DISTRIBUTION OF RETURNS OF COMPLETED QUESTIONNAIRES FROM TEACHERS BY TYPE OF SCHOOL.

Type of School	Number of schools within the state	Number of schools reponded	Number of question-naires returned	Per-centage Return (%)
Matric.College	7	6	29	86
Urban and rural high schools (state)	34	31	147	91
District High Schools (state)	25	16	40	64
Catholic	10	6	21	60
Independent	6	6	22	100
Total	82	65	259	79

2.11.2 The Main Teaching Areas of the Science Teachers Involved in This Study.

Table 2.2 shows that the majority of teachers (56%) specialize or concentrate their teachings in particular grades, while 44% have teaching areas about equally distributed either in grade 7-10, or in grade 7-12.

Table 2.2

THE MAIN TEACHING AREAS OF THE SCIENCE TEACHERS INVOLVED IN THIS STUDY

Teaching Area	Number of Teachers	Percentage of Teachers
Mainly Grade 7 & 8	33	13
Mainly Grade 9 & 10	72	28
Teaching is about equally distributed over the two areas above	75	29
Mainly Grade 11 & 12	39	15
Equally distributed over Grades 7-12	40	15
Total	259	100

2.11.3 The Science Areas of which Teachers Prefer to Teach in Their Science Teaching.

Table 2.3(i) (at Grade 7-10)

THE SCIENCE AREAS OF WHICH TEACHERS PREFER TO TEACH IN THEIR SCIENCE TEACHING

Teaching Area	Number of Teachers	Percentage of Total Respondents
Chemistry	59	23
Physics	41	16
Biology	69	27
Geology	15	6
No particular preference	64	29

The majority of High School Teachers (72%) expressed subject preferences even though they are required to teach General Science.

Table 2.3(ii)

(At Grade 11-12)

Teaching area	Number of Teachers	Percentage of Total Respondents
Chemistry	37	28
Physics	26	20
Biology	42	32
Geology	17	8
No particular preference	15	12

The majority of Matriculation Teachers (88%) indicated subject preferences, which is understandably higher compared to High School Teachers.

2.11.4 GENERAL INFORMATION ON SCIENCE TEACHERS REGARDING THEIR TEACHING EXPERIENCE AND CLASS SIZE

Fig. 2.1

General Information on Science Teachers Regarding Their Teaching Experience and Class Size.

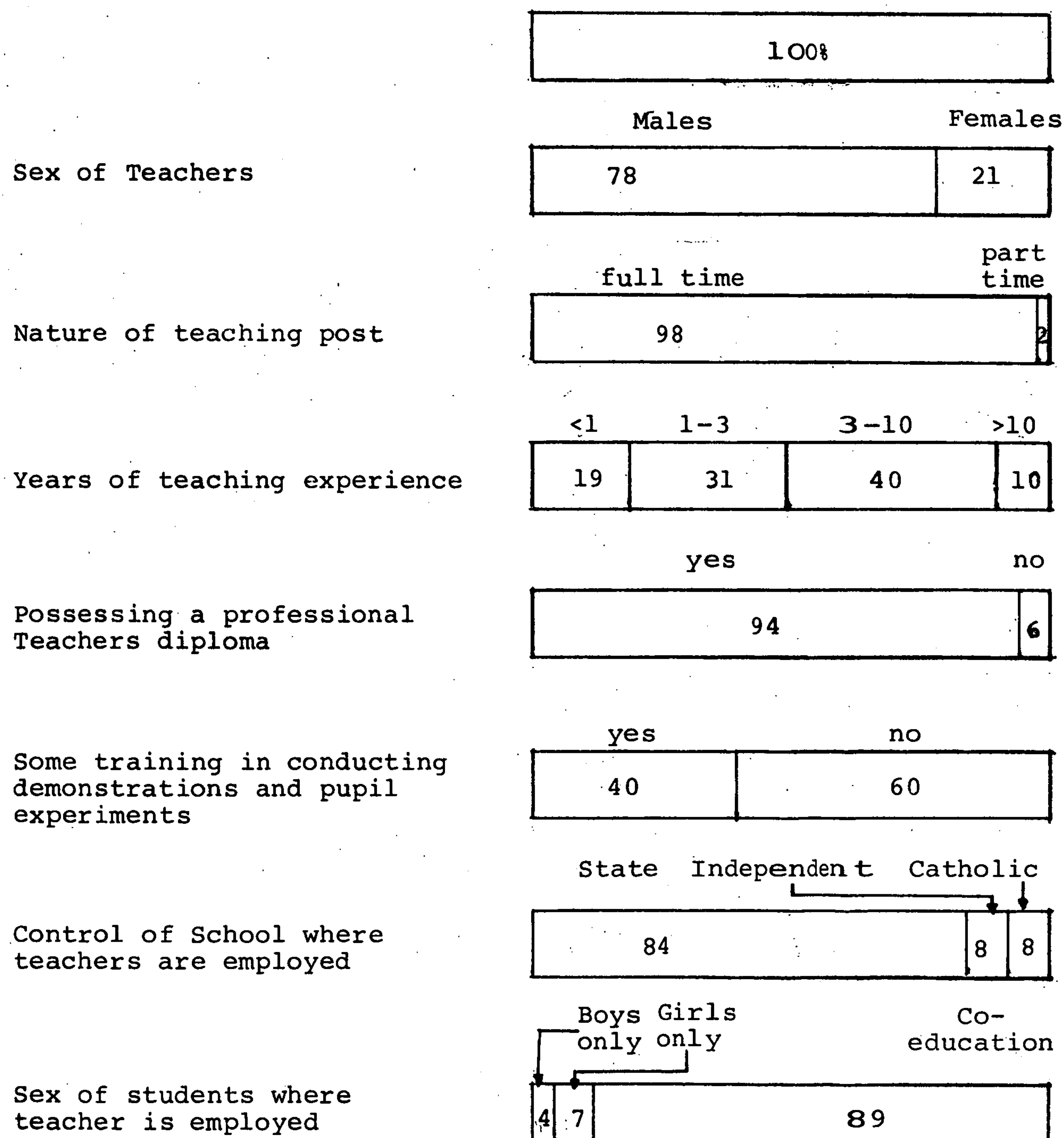
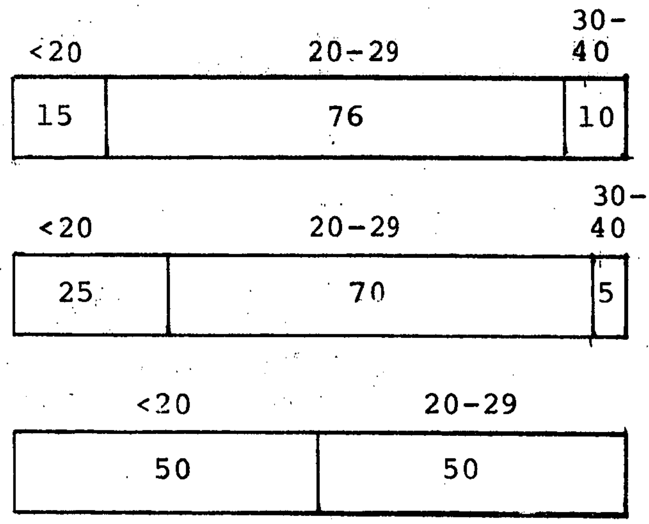


Fig. 2.1 (continued)

Average size of science class at Grade 7

Average size of science class at Grade 10

Average size of science class at Grade 12



<u>Comment</u>: The majority of teachers are males (78%) and most of the teachers are full timers (98%). There is a relatively small number of teachers with long experience (>10 years), and short experience (<10 years) compared to those with medium experience (3-10 years). Most of the teachers possess a professional teachers diploma and have undergone some training in conducting demonstrations and pupil experiments. About 60% of the teachers indicated that they are not readers of science teachers journals.

It was indicated that most of the teachers are involved in teaching in State schools (84%) compared to (16%) in both Catholic and Independent Schools; and most teachers are teaching in Co-education Schools (89%) compared to (11%) in boys only and girls only schools.

The average sizes of science classes at High School level seems to be between 20-30, while at matriculation level, gross size is evenly divided between less than 20 and 20 to thirty.

2.11.5 Highest Academic Qualifications of Science Teachers in Particular Subjects.

Table 2.4

HIGHEST ACADEMIC QUALIFICATIONS OF SCIENCE TEACHERS IN PARTICULAR SUBJECTS.

Highest Academic Qualification %	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)
Physics (N = 241)	16	10	33	15	14	5
Chemistry (N = 238)	24	15	24	17	9	3
Botany (N = 241)	19	5	13	16	10	30
Zoology (N = 241)	24	5	12	15	8	31
Geology (N = 236)	11	7	9	14	8	43

Where A = University Course: 3 years or more

B = University Course: 2 years

C = University Course: 1 year

D = Specialization Course during full time teacher training at a College of Education

E = Subject passed at Matriculation level

F = Subject not studied at Matriculation level.

Comment: If University first year study is used as a marker then we find that science teachers are more qualified in chemistry (63%) and physics (59%) than in botany (37%), zoology (47%) and geology (27%).

2.12 DESCRIPTION OF SAMPLES OF STUDENTS

2.12.1 General Information on High School Students who replied to the questionnaire in this survey.

fig. 2.2 (i)

High School Level

Single sex/co-educational characteristics of school:

Boys only	Girls only	Co-ed	No. in Samples
12	13	75	458

Sex of student

Boy	Girl	No. in Samples
50	50	458

Control of school

State	Pri-vate	Catho-lic	No. in Samples
64	18	18	458

Main income earner in student's home

Father	Mother	Sibl-ing	No. in Samples
87	12	1	454

Intentions of student after school

Will study science subjects at:

Uni.	Tech.	Not at all	Undecided	No. in Samples
15	12	29	44	457

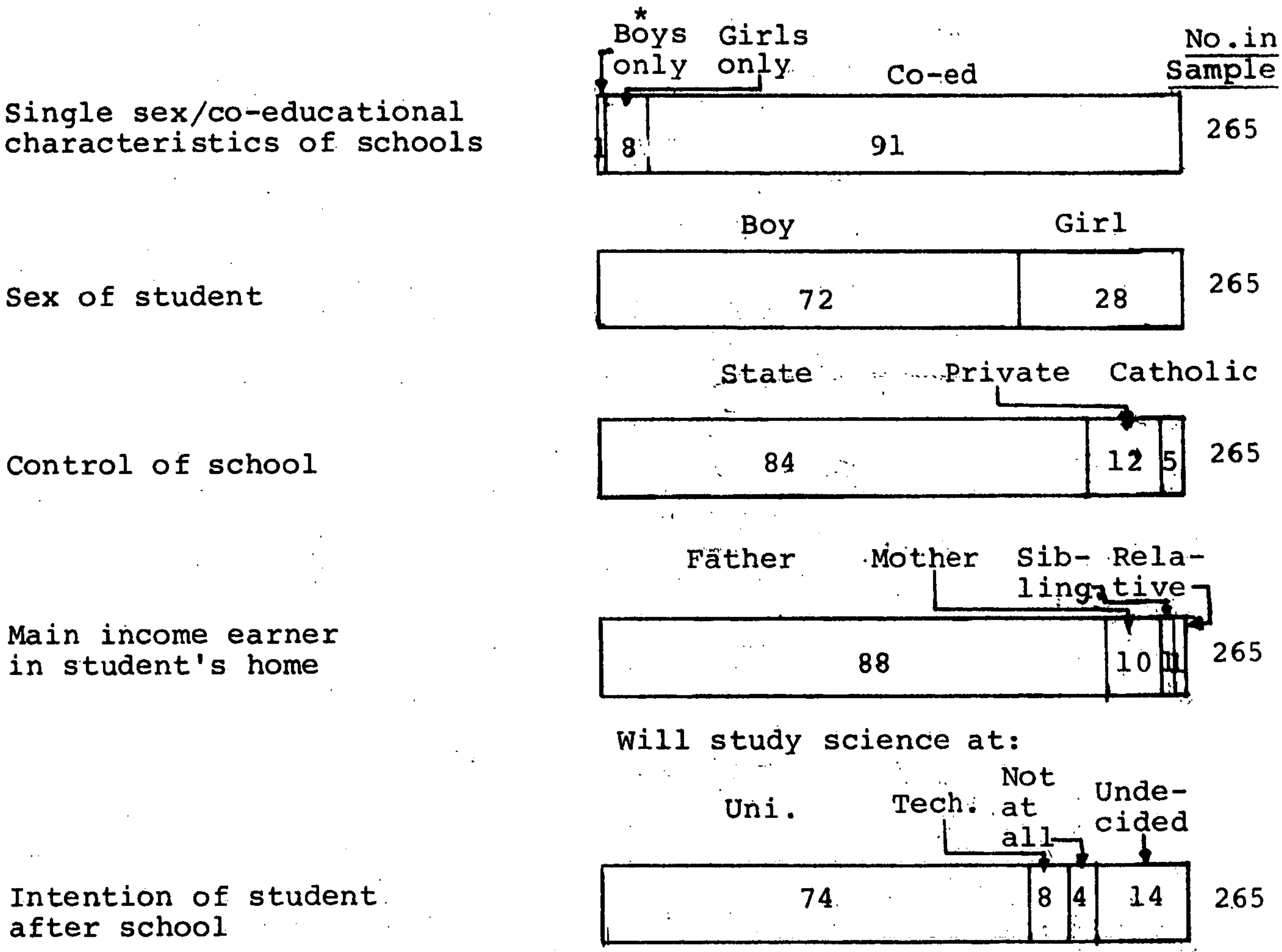
Comments: At high school lvel, most students are in Co-educational schools (75%) compared to 25% in single sex schools. The percentage ratio of male to female students in the state schools is 50%/50%. The majority of schools are under state control (65%) compared to 36% under private and catholic control. Most students (87%) are financially supported (main income earner) by their fathers and only (12%) by their mothers.

Most students at High School level indicate that they are undecided on what they intend to do after their high school certificate. A small percentage indicated they would like to continue studying science up to University level (15%) but 29% were definitely sure that they do not intend to study science at all in their future.

2.12.2 General Information of Matriculation Level Students who Replied to Questionnaire.

Fig. 2.2. (ii)

Matriculation Level:



* Where possible, independent schools combine teaching at matriculation level work which explains the higher percentage of co-educational activity at this level.

<u>Comment</u>: At matriculation level, the majority of students (91%) were in co-educational schools. Most of the students are boys (72%) compared with girls (28%) and the majority of students are in state schools (84%) compared to (17%) in Catholic and Private schools. The majority of students indicated that they are being supported financially by their fathers (88%) and only (10%) were being supported by their mothers. At this level, most of the students indicated their intention to study science at university level (74%) and only (4%) indicated they did not wish to study science at all when they complete their H.S.C.

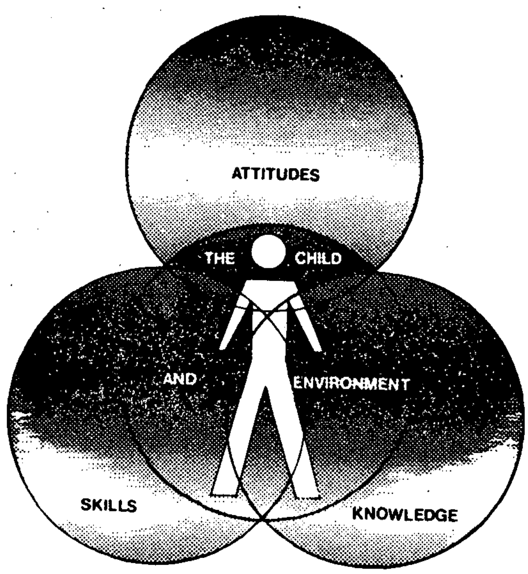
CHAPTER THREE

THE AIMS OF PRACTICAL WORK AND THE FREQUENCY AND METHODS EMPLOYED FOR ITS IMPLEMENTATION IN TASMANIAN SCHOOLS

In Chapter One we noted that the majority of science educators agree that science offers a comprehensive range of learning activities. In line with this, the Schools Board Manual of Tasmania (1980) states that the basic aim of science education is to provide experience which contributes to the development of the child in three main areas: Interest and attitudes; Knowledge and understanding; Skills.

The approach is represented diagramatically in Fig. 3.1:

Fig. 3.1



The Child and His Environment

and it is stated that: "The child and child's environment, his interests and potential interests are at the centre of all science education. Science involves exploration, and exploration involves the gathering of experience - an examination of what is there."

The Tasmanian syllabus statement thus links learning activities provided by science to the notion of child centredness. The Schools Board again states

> "... a great deal of useful information will be acquired through active participation in exploring the physical environment. Children learn best through their own spontaneous behaviour relative to objectives and events, that is, by handling objects and by experimenting with them".

Thus the syllabus recommends that the sciences, particularly the physical sciences must not be taught without experiments, and regardsindividual or group practical work as being an important part of science teaching.

Although it has always been accepted that practical work is an essential part of any science activity, there has not always been adequate attention to the question of what educational benefits a pupil should derive from being involved in such work. This could be due to the fact that there has been less agreement by experts on the purpose, most suitable type of practical work, and the optimum time that should be spent on it (Kerr 1963, Thompson 1975). One of the main purposes of this survey, is to investigate the opinion of teachers in Tasmania in that regard.

Kerr's work, for instance, indicated a considerable divergence of opinion amongst teachers about the major objectives related to practical examinations, although teachers reacted strongly against the suggestion that the aim of practical work should be to prepare students for practical examinations.

As mentioned earlier the construction of the list of aims of practical work was based on Kerr's list and then modified accordingly. Kerr's list of ten general aims referring to practical work is given in Table 3.1.

Table 3.1

The Aims of Practical Work (as used by Kerr, 1963)

1. To encourage accurate observation and careful recording.
2. To promote simple, common-sense, scientific methods of thought.
3. To develop manipulative skills.
4. To give training in problem solving.
5. To fit the requirements of practical examinations regulations.
6. To elucidate the theoretical work so as to aid comprehension.
7. To verify facts and principles already taught.
8. To be an integral part of the process of finding facts by investigation and arriving at principles.
9. To arouse and maintain interest in the subject.
10. To make biological, chemical and physical phenomena more real through actual experience.

Kerr found in his survey of teachers that the emphasis on each of the 10 listed aims varied with the subject (physics, chemistry and biology) and with the age of the pupils. However, certain common ground was noted, for example, all teachers stated that the aim 'to arouse and maintain interest in the subject' was the most important for the first two years of secondary schooling. Nearly all teachers felt that aims, such as developing observation, elucidation, and scientific thinking, were important and all received relatively high weightings.

Replication studies in the U.K. such as those of West (1972) (Objectives for practical work in school chemistry) and Thompson (1975) (Practical work in sixth form science), have attempted to establish evidence for any changes as a consequence of recent curriculum developments. West observed a shift in the emphasis of some of the aims. Aims such as developing scientific thought, part of process of fact finding, arouse and maintain interest were later found to occupy higher positions at both the first and second age levels. West also pointed out that the aim of training in problem solving still occupies a very low position in the order of priorities, but generally the trend appeared to be in the direction recommended by contemporary curriculum innovations.

Kerr's list of ten aims has been used by a number of authors in their surveys and they have always been used with some major or minor modifications. For instance Thompson used an extended list of twenty aims based on Kerr's list. Table 3.2 gives the list of aims of practical work in science as used by Thompson (1975).

Table 3.2

The Aims of Practical Work in Science (as used by Thompson 1975)

1. As a creative activity.
2. To make phenomena more real through experience.
3. To help remember facts and principles.
4. To practice seeing problems and seeking ways to solve them.
5. To indicate the industrial aspect of science.
6. To promote a logical, reasoning method of thought.
7. To encourage accurate observation and description.
8. For finding facts and arriving at new principles.
9. To become able to comprehend and carry out instructions.
10. To elucidate theoretical work as an aid to comprehend.
11. To develop self-reliance.
12. To arouse and maintain interest.
13. To develop an ability to communicate.

14. To develop an ability to cooperate.
15. To develop certain disciplined attitudes.
16. To develop specific manipulative skills.
17. To verify facts and principles already taught.
18. To develop a critical attitude.
19. To give experience in standard techniques.
20. To prepare the student for practical examinations.

The main purpose of practical work in school is one of accomplishing a wide variety of these aims. Precisely how to achieve these aims depends mainly on the teacher's pedagogical emphasis for laboratory work.

In order to clarify possible emphases, science educators such as Lunetta have grouped these practical aims into three distinct domains i.e. cognitive, practical (psychomotor) and affective. Lunetta (1981) summarised the aims of practical work into those three categories as shown in Table 3.3.

Table 3.3 THE AIMS OF PRACTICAL WORK SUMMARISED BY LUNETTA INTO THREE CATEGORIES.

Domain	Goal
Cognitive	- To promote intellectual development - Enhance the learning of scientific concepts - Develop problem-solving skills - Develop creative thinking - Increase understanding of science and scientific method
Behavioural (psychomotor)	- Develop skills in performing science investigations - Develop skills in analysing investigative data - Develop skills in communicating - Develop skills in working with others
Affective	- Enhance attitude towards science - Promote positive perceptions on ability to understand and to affect one's environment.

In the present survey, a similar approach to that used by Lunetta can be adopted, and the list of ten aims/influences grouped into the same categories (see Table 3.4). There are occasions in this thesis where this categorisation is referred to though it was not made obvious on the questionnaire to teachers or students. However, it was implicit to many of the discussions associated with the findings of the various part searches.

Table 3.4 THE AIMS OF PRACTICAL WORK IN THE PRESENT SURVEY SUMMARISED INTO TAXONOMICAL CATEGORIES

Domain	Aim
Cognitive aims: (1, 2, 3, 5 and 8)	- To encourage accurate observation - To promote simple commonsense scientific method of thought - To clarify the theoretical parts of science for the pupils - To enable pupils to solve practical problems and to discover facts and principles for themselves - To satisfy the minimum requirements for practical work laid down or suggested in the syllabus
Behavioural (psycho-motor) aims: (6, (7) and (8))	- To train pupils in the skills and techniques of laboratory work - To show pupils how to conduct laboratory experiments in an organised way - To satisfy the minimum requirements for practical work laid down or suggested in the syllabus
Affective aims: 4, (7), 9 and 10	- To make the subject more interesting through actual experience - To show pupils how to conduct laboratory experiments in an organised way - To give pupils a personal interest in scientific experimentation - To make scientific teaching more enjoyable/stimulating for the teacher. Also to encourage the study of science or related subjects further after leaving school.

3.0 THE AIMS/INFLUENCES OF PRACTICAL WORK USED IN THIS SURVEY

Each of the ten aims/influences referred to in this study emerged as a consequence of literature reviews and the input from a number of 'enquiry teams'. The list is not exhaustive but the items represent a comprehensive coverage as far as teachers, lecturers and educators are concerned. It would seem appropriate, therefore, to comment on each item and its relation to science and to science teaching.

1. To encourage accurate observation

According to Thompson, this notion is fundamental to real science. He writes "Laboratory work may be designed to teach students to observe or measure a system with care, such that it is a methodical activity. A skill in thorough observation must be accompanied by an ability to record adequately the information for later use". Hence the statements indicate that practical work could improve or encourage observation and measurement. Recording results, taking notes when needed and drawing actual specimens are necessarily associated with accurate observation. The observation skill is a foundation for the learning process in science and involves far more than just looking.

2. To promote simple, commonsense, scientific methods of thought

Through observation and careful recording one is able to make conclusions when there is evidence to do so, or change the interpretation when further evidence becomes available. This again is a fundamental feature of much scientific research. Thompson writes "... Laboratory work, by frequent contact with experiments whose results need explanation, can promote a logical method of thought. If the work is suitably arranged the student may be made familiar with deductive reasoning in handling experimental data and in investigating phenomena ...". Hence through this aim, practical work is a special means of actively promoting scientific thinking, and could improve the ability to interpret observations in a logical way.

3. <u>To clarify the theoretical parts of science for students</u>

According to Kerr, Practical work can aid learning by making the theory more clear. Lynch suggests that practical work could reinforce learning in the lecture and classroom. He explains this aim as follows "... For instance, a direct experience of chemicals could reinforce the distinction between solids, liquids and gases, between solutions and precipitates, to the extent that the students would be highly unlikely to describe silver chloride as a green gas ..." Hence practical work may be used to provide material examples of wider theoretical principles in order to clarify the theory. Thompson makes a comment that "... Illustration leads to a deeper understanding of a concept in the sense of 'getting a feel' for it ..." It should be noted that this aim is directed much more towards the processes of teaching and learning than towards research. The experience could be 'hands-on' but equally it could be considered in the mode of a visual aid.

4. <u>To make the subject more real and interesting through actual experience</u>

Lynch suggests that practical work could add considerably to the interest of the subject as perceived by the students, and he indicates that in this sense its influence is motivational - towards further learning, and in some cases, towards pursuing further work in science. Kerr also comments that "... Further learning is more likely to take place if interest develops as knowledge increases. Interest is an avenue to science learning; it is a means of motivating the student to learn.

5. <u>To enable students to solve practical problems and to discover facts and principles for themselves</u>

Kerr indicates that practical work can help students to discover facts and principles for themselves. Thompson comments "An ability to solve problems is an essential scientific one" and he adds "... the ability to identify the crux of a problem in a new situation, and recognise which method to select to best tackle the problem ..." He also indicates that practical work may be organised to give scope to students' imagination and initiative and to encourage inquisitiveness. Lynch claims that problem solving is an activity, essential, though not exclusive, to science. He comments "... It is the ability to recognise a problem and then to identify and deal with the constituent parts that make the whole. The problem may be extremely complex with many variables to consider, or relatively simple ..." Therefore practical work is important in this aspect and would seem an ideal vehicle for helping the student to grapple mentally with ideas and make decisions in situations which are new to him.

6. <u>To train students in the skills and techniques of laboratory work</u>

According to Thompson "practical work may be effective in developing certain disciplined attitudes ..." Kerr claims "practical work could simply train the pupil in generally useful skills of value in daily life, or it could result in the development of skills in the design and making apparatus, or it could provide the sort of practical education, appropriate to engineering and agriculture ..." Therefore practical work could be viewed as important in that it could be used to develop particular skills and techniques, and dexterity in handling apparatus.

7. <u>To show students how to conduct laboratory experiments in an organised way</u>

Through practical work, a student gains an ability to plan an experiment. Lynch claims that "working in an 'organised way', involves decision making, perhaps co-operating with others, interpreting written and verbal instructions, and developing the self reliance necessary to deal with these activities. It is partly a skill and partly an attitudinal response, and one suspects that practical work activities in science are particularly suitable for its development". Thompson also emphasizes that "If laboratory work is suitably arranged it may give the student experience and practice in team work. Both planning and working with others are important, and this aim involves co-operation with colleagues both in the carrying out of an experiment, and in the utilization of the results of one particular exercise as part of a large project". Hence practical work is very important in this aspect of promoting the ability of working in an organised way, ability to select and assemble apparatus to perform a standard/novel function, ability to determine whether the apparatus is functioning correctly, ability to appreciate the need for care and for economy in time and materials, ability to devise/select a procedure/technique, ability to follow and comprehend written/verbal instructions etc.

8. <u>To satisfy the minimum requirements for practical work laid down or suggested in the syllabus</u>

Lynch suggests that practical work could be carried out mainly for the purpose of satisfying syllabus requirements in which case the educational value of the activity may be determined chiefly by the nature of the examination or the specific syllabus requirements. Thompson indicates that "emphasis is often placed on those aspects of laboratory work which are appropriate to practical examinations. Concentration is applied to practice of techniques and thorough learning of those considerations that are frequently examined ...". Kerr also comments that "practical work can be carried out solely for the purpose of preparing for an examination. The educational value of such a practice will depend on the nature of the practical tests." Although some educators are sceptical about the work of practical examinations in science, in some places this aim has some important positive effects in science teaching.

9. <u>To give students a personal interest of scientific experimentation</u>

Practical work can arouse and encourage the student's interest, awareness, sensitivity, wonder, concern, care and curiosity. Lynch comments that "practical work could be used to develop an interest in it for its own sake, i.e. as a hobby, a 'tinkering' activity, the desire to investigate a phenomenon (quite apart from interest in the theoretical and conceptual structure of the subject) ..."

Kerr also comments "Practical work can promote learning by dealing with matters in which the pupil is interested ..." It would be interesting to see how important this aim is considered in school situations (see Chapter Six).

10. <u>To encourage the study of science or related subjects further after leaving school</u>

Lynch argues that 'experience of practical work could provide an important career motivation for the student'. This is more likely to be the case with Matriculation level than High School students. Perhaps students are attracted to a career in Science by the very nature of experimentation. This is very much an 'experimenter's' point of view and would certainly meet with the approval of the early heurists but to what extent is it a reality for the average student? - even the average Matriculation student?

3.1 METHODS OF INTRODUCING PRACTICAL EXPERIENCES TO STUDENTS

So far, much has been written about practical work, but no clear definition has been given, to distinguish between laboratory work and practical work. To some, these two terms mean the same thing, but in reality they are different terms. Practical work is taken to include any activity involving students in real situations, using genuine materials, and properly working equipment. The concept of practical work may be extended to include simulated experiences and even students' exercises involving pencil and paper calculations based on real examples. Practical work may be performed in the laboratory but clearly practical activities are not confined to the laboratory. Laboratory work may be regarded as practical work performed in the laboratory with a range of activities from true experimental investigations to confirmatory exercises and skill learning.

It is well understood that different science teachers believe in different methods of teaching science, in order to achieve the stated objectives. There have been numerous attempts to test the relative merits of teacher lecture/

demonstration lessons and student laboratory work, the evidence reported in these studies is sometimes contradictory and hard data is scarce. Even careful reviews covering many experimental studies draw very tentative conclusions in view of this uncertainty.

Lynch (1976) in his extensive survey in South Africa found no evidence that practical work reinforces learning. He proposed that the lecture/demonstration method is equally as efficient and generally more convenient as well as less expensive.

Yager, Engen and Snider (1969) after carrying out a carefully designed, statistically valid experiment, with students studying secondary biology by one of the three methods 'Laboratory', 'demonstration' or 'non-laboratory' came to the conclusion that, except for skills in handling apparatus, there was no significant difference in both *knowledge* and *attitude* to biology between students taught by the different methods. It is emphasised that this experiment was carried out with great care to control all relevant variables (e.g.variations in teachers' competence for example) and that the results were analysed with considerable statistical rigour. Here we have an unambiguous demonstration that the laboratory is only essential for teaching of laboratory skills and that effective science learning may take place outside the laboratory.

Cunningham (1946) summarises the research findings on lecture demonstration versus individual laboratory method in science teaching for the twenty-five years to 1946. His sources were Masters and Doctors' theses from American Universities and articles ineducational journals. His conclusions were that research showed that both methods should be employed, that individual laboratory method was more effective in teaching laboratory skills, and laboratory resourcefulness and that demonstration was economic in time and equipment and effective.

The comment by Miles and Van Deventer in the article 'The Teaching of Science at College and University level' is worthy of note:

> "... no one method of instruction, in and of itself, is better than others. Success is dependent on the instructor and what he does."

This generalisation is a recognition of the crucial importance of the teacher as a variable in such studies.

Faults found in many studies include the smallness of the samples, the lack of control of variables, the lack of clear objectives, lack of validity of the criterion tests as measures of the objectives, the failure to identify different types of laboratory work and failure to conduct replication studies. But in general terms, the changes that have affected the nature of practical work have been accompanied by changes in the organisation employed in its teaching. So that now, one distinguishes between demonstrations, where the learners are by and large passive; and individual/group practical work, where the learners are active. Practical work is also seen to be a vehicle for distinctive differences in teaching methods, between at one extreme the instructional, and the other extreme the investigational.

Boylan (1977), discusses different methods which could be used by teachers in the laboratory in order that students can acquire laboratory/practical skills in science. He writes:

> "There are various methods in which a teacher can introduce practical experience to the pupils, ranging from teacher directed practical lessons through to teacher undirected practical lessons which includes such activities as field studies, student centred practical exercises and open ended laboratory sessions."

He describes the former method as the most structured format, and that it is characterised by the teacher exercising a high degree of control on all aspects of the laboratory activity. A range of possible variations within this category is evident which extend from the traditional teacher demonstration lesson through to pupils all working through a practical activity under the supervision of the teacher. He argues that the most directed form of a practical lesson would be the demonstration practical lesson and this demonstration lesson is one in which the teacher shows some practical activity to the whole class. This is for the purpose of showing the pupils the apparatus they are to use, or demonstrating to the pupils the prerequisite skills necessary to satisfactorily complete the practical activity, or demonstrating to the pupils the method of conducting the practical activity, or performing an experiment which is either too dangerous or too expensive for the pupil to carry out.

Anderson and Koutnik (1972) also claim that a demonstration practical lesson could also be for the purpose of performing an experiment which establishes a discrepant event, an event that a pupil cannot predict in spite of the fact that he knows several facts which should explain what should occur.

Anderson and Koutnik point out that individual/group practical work is the simplest format for practical activities which involve active pupil participation. Here the teacher organises the whole class to perform the same experiment at the same time, usually grouped in pairs, threes or fours. This teaching style allows the teacher to give individual attention to each group of pupils once the instructions on practical exercise are given. The instructions should permit the pupil to conduct the experiment and understand how the results fit into the purpose of the particular practical exercise.

They also suggest another method in which a teacher can introduce practical experience to his pupils, and call it "the teacher undirected practical lesson".

The teacher undirected practical lesson is grouped into the teacher organised practical experience, and pupil centred and organised practical experience. In the former the teacher acts as a source of practical oriented problems to which the pupil must attempt to find a solution during the laboratory session. The teacher poses the problem and then, depending on the ability level of the class and the difficulty of the problem under investigation, the teacher promotes group discussions around the classroom to ensure that every member of the group within the class clearly understands the problem, formulates a hypothesis to its solution, designs the experimental procedures appropriate to a safe and successful solution to the problem and then proceeds to carry out the experiment. In this approach the teacher acts as the stimulus for the class to become engaged in a practical activity. This teaching style has been described as guided discovery learning by Ausubel (1968) and Rowlands (1969).

The latter (the pupil centred and organised practical lesson) is designed for the individual pupil or small groups of pupils. These pupils are presented with stimulus material, often in the form of booklets, through which they proceed at their own pace. This is the method used in the Australian Science Education Project (A.S.E.P.) and the Junior Secondary Science Project (J.S.S.P.) science courses. The students are provided with practically based questions which they then design appropriate methods for solving based upon their individual discussion with the teacher or from discussion with their group.

3.2 FREQUENCY AND METHODS EMPLOYED FOR PRACTICAL WORK IN TASMANIAN SCHOOLS ACCORDING TO TEACHERS AND STUDENTS

In this survey teachers were asked to indicate how often did your students *see* or *do* practical work of any kind in your science teaching in 1980 (i.e. in the grade which occupied most of your science teaching time). Also students were asked to indicate 'how often did you see or do practical work of any kind in science course or courses you are studying?' Their responses are as follows:

Table 3.5

FREQUENCY OF PRACTICAL WORK ACCORDING TO TEACHERS AND STUDENTS

	High School Teachers	Matric. College Teachers	High School Students	Matric. level	Matric. level
Frequency of Practical Work	Responses (%)	Responses (%)	General Science (%)	Physics Students Responses (%)	Chemistry Students Responses (%)
About every science lesson	28	13	6	2	1
About once in two science lessons	56	39	34	17	24
About once in four science lessons	29	43	43	75	70
Rarely	2	5	16	6	5
Never	1	0	1	0	0
	N = 203	56	459	244	255

From Table 3.7, the majority of High School teachers (84%) claim to have let their students see or do practical work at least once in two science lessons. Only (40%) of High School students indicated this frequency. At Matriculation level about (52%) of the teachers indicated that their students see or do practical work at least once in two science lessons, while only (19%) of physics students and (25%) of chemistry students indicated this frequency. In both cases students indicated a frequency lower than claimed by teachers. By comparison, teachers and students at High School level indicated that they have about twice as much practical work as indicated by Matriculation College teachers and students.

The fact that the responses from teachers and students is different may be explained by the fact that much simple experimentation of the object lesson type is not recognised to be 'practical work' by the students. Generally, at High School level, about (93%) of the teachers and (83%) of students agreed that there is some kind of practical work taking place in schools at least once in four science lessons. At Matriculation level about (95%) of teachers and (94%) of physics students and (95%) of chemistry students indicated a similar frequency.

In Thompson's survey (1975), teachers were asked what proportion of time in six-form courses was spent on practical work. As a rough guide matriculation level is equivalent to the first year of the two year sixth form course given in the U.K. The findings were that the proportion of time spent was more in chemistry and biology than in physics. The physics teachers seemed equally divided between those who spent less than 30% of the time doing practical work and those spending more than 30%.

More than three-quarters of chemists and biologists spent more than 30% of the course time on practical work.

In Lynch's survey (1976), the majority of first year students (at all universities) indicated that practical work took place at least once a month at High School. Again the responses of teachers were higher than those of students, and a similar argument was advanced, that much simple experimentation of the demonstration/object lesson type is not recognised to be 'practical work' by the students.

Students in this survey were also asked to indicate how often the practical work done was performed either as demonstrations or by individual/group work. The findings are provided in Table 3.6.

Table 3.6

TEACHING METHODS EMPLOYED AT HIGH SCHOOL ACCORDING TO STUDENTS

For High School Science

	About every science lesson (%)	About once in two lessons (%)	About once in four lessons (%)	Rarely (%)	Never (%)
Demonstrations performed by the teacher	9	24	28	38	1
Laboratory work done by students individually or in groups	7	32	43	18	0

This shows that demonstrations performed by the teacher and laboratory work done by students individually or in groups are both employed extensively by teachers in their practical teaching at High School level in Tasmania.

At Matriculation Level

Table 3.7

TEACHING METHODS EMPLOYED IN MATRICULATION PHYSICS ACCORDING TO STUDENTS

For Matriculation Physics

	About every science lesson (%)	About once in two lessons (%)	About once in four science lessons (%)	Rarely (%)	Never (%)
Demonstrations performed by the teacher	5	20	25	47	3
laboratory work done by students individually or in groups	0	9	83	9	0

At Matriculation Level (in physics) both methods are used but demonstrations are used more frequently.

Table 3.8

TEACHING METHODS EMPLOYED IN MATRICULATION CHEMISTRY ACCORDING TO STUDENTS

For Matricultion Chemistry

	About every science lesson (%)	About once in two science lesson (%)	About once in four science lesson (%)	Rarely (%)	Never (%)
Demonstrations performed by the teacher	3	12	27	58	0
Laboratory work done by students individually or in groups	1	19	77	3	0

In chemistry at Matriculation level, both methods are used but demonstrations are much less popular than in physics.

Students were also asked to indicate the most typical size of the 'practical group' involved. Findings are presented in Table 3.9.

Table 3.9

TYPICAL GROUPS SIZE FOR PRACTICAL WORK ACCORDING TO STUDENTS

	High School	Matriculation Level	
Group Size Employed for Practical Work	General Science (%)	Physics (%)	Chemistry (%)
Single student	0	0	2
2 students	31	44	80
3 students	31	43	17
4 students	32	12	1
More than 4 students	6	1	0

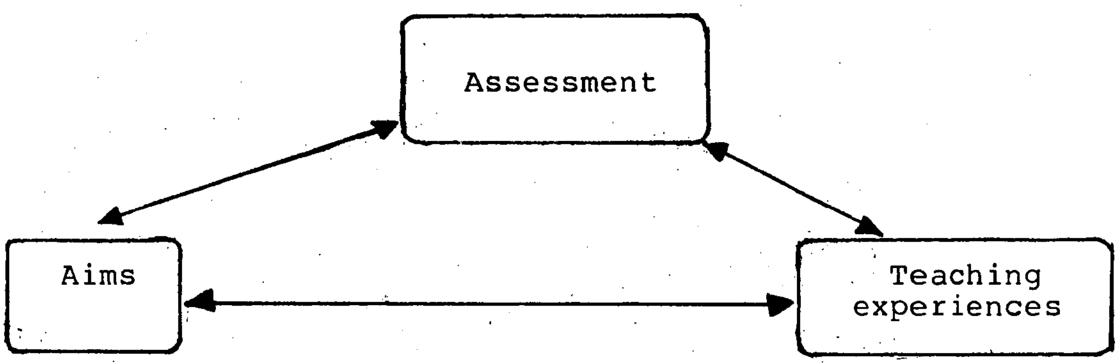
From Table 3.8, it seems most of the practical work at both High School and Matriculation levels place in groups 2-4 students, and individual practical work is not very common.

3.3 THE RELATIONSHIPS BETWEEN AIMS, TEACHING EXPERIENCES, AND ASSESSMENT OF PRACTICAL WORK.

In this chapter much has been written concerning the aims of practical work and their importance in science teaching. When one arrives at an acceptable taxonomy of aims, however, the task of curriculum evaluation or reform has only just begun. The major part of the work must then be concerned with the ways in which these aims can be made operational, and this will mean the ways in which they are realised through the syllabus content, teaching method and assessment techniques for the science courses.

Figure 3.2 shows the relationship between aims, teaching experiences and assessment of practical work in schools (usually attributed to Fuoss).

Fig. 3.2 The Relationship Between Aims, Teaching Experiences and Assessment of Practical Work



The important point to notice is that the aims, teaching experiences and assessment of practical work are mutually tied together.

Consequently it is unwise to consider the aims in isolation since implicitly or explicitly they will be affected by 'assessment' and 'teaching experiences'. Indeed it is often argued that in a causal sense assessment determines the real aims and the teaching experience to a very great extent.

In the last decade, many changes have occurred in the structure and administration of schools in Australia. In general, the result of the changes has made schools more autonomous than before, and increased the responsibilities for making decisions at the school level. The teachers' responsibility for the curriculum offered is one particular aspect which has altered during this period. Although some assessment is still controlled by authorities outside the school, a much larger proportion of the decision about courses and assessment is now the responsibility of teachers. Thus, as well as carrying out their normal teaching activities, teachers are now required to perform additional tasks which have resulted from the devolution of decision making. The teachers are now undertaking tasks associated with the assessment of the progress of pupils and the evaluation of the teaching programs.

CHAPTER FOUR

THE AIMS OF SCHOOL PRACTICAL WORK AS REPORTED BY TEACHERS

This chapter is concerned with teachers' perceptions of the *aims* of practical work. For clarity and comparative purposes the data for teachers at grades 7 and 8 (High school), grades 9 and 10 (High school) and grades 11 and 12 (Matriculation level) are presented conjointly, initially for 'all' teachers and subsequently to examine any possible associations with the variables: sex difference, academic qualifications, type of school, control of school, years of teaching experience etc.

4.0 SOME BACKGROUND INFORMATION REGARDING SCIENCE TEACHING IN TASMANIAN SECONDARY SCHOOLS

It should be noted that the high school teachers are engaged in teaching students in the 11-16 years age range, while the matriculation level teachers are engaged almost exclusively in teaching students in the 16+ age range.

In the Tasmanian school system, grades 7 and 8 represent the first two years of high school. For the majority of students this involves a transfer from a relatively small primary school to a large, separately located high school staffed by a wide range of specialist teachers. Streaming is uncommon at grades 7 and 8.

At the end of high school, grade 10, all students receive a school leaving certificate in which each subject on the certificate is given quite well defined awards (performance ratings). The majority of science teachers respond to these award requirements by streaming the students from grade 9, onwards.

Grades 11 and 12 are associated with matriculation studies which are optional and have been used traditionally to select for entrance to tertiary institutions. However, in the last decade there has been an increasing tendency for matriculation examinations to be seen as general certification for employment purposes. In the state school sector, matriculation level studies are undertaken at large and quite separate institutions called Matriculation Colleges.

4.1 TEACHERS' RESPONSES TO THE LIST OF AIMS OF PRACTICAL WORK

In order to obtain teachers' perception of the purpose of practical work, a list of ten aims was included in the questionnaire (see Table 4.1). For the purpose of comparisons, this list was based on the list of aims used in surveys by Kerr (1963), Thompson (1975) and Lynch (1976) and is discussed in detail in Chapter 2.

Teachers were asked to note that the term 'practical work' includes demonstrations done by the teacher as well as experiments performed by their students either on their own or as part of a group.

Table 4.1

POSSIBLE AIMS OF PRACTICAL WORK

1. To make observations more carefully.
2. To interpret observations in a logical way (e.g. to ask questions and not to make decisions unless there is suitable evidence for doing so.)
3. To make the theoretical parts of science clearer.
4. To make the theoretical parts of science more real and interesting.
5. To enable students to find out facts and principles themselves (i.e. new ideas and information are acquired through experiments first rather than from explanations from text books and teachers.
6. Give training in the skills and techniques of laboratory work.
7. To teach how to conduct laboratory experiments in an organised way.
8. To prepare students directly for final examination.
9. To give a personal interest in practical work and experimentation.
10. To encourage the study of science or related subjects further after leaving school.

Teachers were required to read the list of ten aims, carefully, and think about them. They were asked to refer to the *real* situation in their schools rather than an *idealised* one, i.e. "Please refer to your own experience with practical work in the school, not what you think ought to be done". They were then required to *"choose what you think are your four most important aims from the list of ten possible aims"*. If an item is chosen it scores '1', if not chosen, it scores '0'. The total number of responses recorded for each aim was then expressed as a frequency (percentage). Differences between response frequencies were ascertained using Z-tests to establish the 0.01 significance level.

The responses of Tasmanian teachers at high school (grades 7 and 8, grades 9 and 10) and at matriculation level (grades 11 and 12) are shown in Table 4.2.

Table 4.2

TEACHERS' PERCEPTIONS OF THE RELATIVE IMPORTANCE OF THE AIMS OF PRACTICAL WORK AT HIGH SCHOOL AND MATRICULATION LEVELS

Possible Aims	Percentage response at grades 7 & 8	Percentage response at grades 9 & 10 *	Percentage response at grades 11 & 12 **
1. Careful observation	70	42	45
2. Interpret observations logically	69	80	80
3. Makes theory clearer	54	57	55
4. Makes theory more real and interesting	68	66	66
5. Enables students to find out for themselves	64	71	65
6. Gives training in skills and technique	78	56	55
7. Teaches to experiment in an organised way	26	23	20
8. Prepares students for final examinations	1	3	9
9. Gives personal interest in practical work	26	21	23
10. Encourages to study science further	7	17	29
N =	168	181	55

* Also referred to as 'School Certificate level'.

** Also referred to as 'Matriculation level'.

4.2 THE AIMS OF PRACTICAL WORK ACCORDING TO SCIENCE TEACHERS

The results in Table 4.2 show that teachers perceive the aims of practical work to be different in terms of their relative importance. A clear rank ordering of aims is evident for all three groups of teachers, and percentage responses to individual aims range from 1% to 80%. To quantify the discrimination between aims the observed responses were compared with what would have resulted had the choices been non-discriminatory (i.e. 40% for each aim: based on a selection of 4 items from 10). A response of 40% for each aim would have been achieved if the teachers had chosen randomly or if the variation between teachers was very extensive. Application of standard Z-tests show that for each of the three groups at least 9 aims are significantly different from the random response level of 40%.

An ordered response from teachers is of immediate interest since it indicates a consensus of opinion that implies the operation of specific orientations towards practical work. Such orientations may be a consequence of tradition, modern curriculum innovations, centralized policies etc. and these notions are discussed in some detail in subsequent chapters.

4.3 THE AIMS OF PRACTICAL WORK ACCORDING TO HIGH SCHOOL TEACHERS

The responses for each aim, expressed as percentages, are provided in Table 4.2.

At Grade 7/8: 'Give training in skills and techniques' is acknowledged to be the single most important aim of practical work at this level. Four aims, 'careful observation', 'interpret observation logically', 'makes theory more real and interesting' and 'enables students to find out for themselves' received virtually the same responses. 'Makes theory clearer' is also considered to be a relatively important aim, after which aims 7-10 are all considered to be relatively unimportant by the teachers concerned (these are: 'teaches to experiment in an organised way', 'prepares students for final examination', 'gives personal interest in practical work', 'encourages to study science further').

Teachers at grades 7 and 8 have aims for practical work which differ from those at school certificate and matriculation level in that:

(1) 'give training in skills and techniques' and 'careful observations' are considered to be relatively more important for grades 7 and 8.

(2) 'interpret observations logically' is considered to be relatively less important for grades 7 and 8.

At Grades 9 and 10: High school teachers' aims for practical work at school certificate level are virtually identical with the aims for university matriculation level work recorded by matriculation college teachers, except for 'encourages to study science further' (see section 4.4).

4.4 THE AIMS OF PRACTICAL WORK ACCORDING TO MATRICULATION LEVEL TEACHERS

Both high school teachers at school certificate level and matriculation college teachers regard 'interpret observations logically' as the single most important aim. 'Makes theory more real and interesting' and 'enables students to find out for themselves' also received substantial responses and are thus relatively important in the minds of teachers. Again, aims 7-10 (teaches to experiment in an organised way; prepares students for final examinations; gives personal interest in practical work; and encourages to study science further) are all regarded as being relatively unimportant by both groups of teachers.

4.5 THE ASSOCIATION OF TEACHERS' PERCEPTION OF PRACTICAL WORK WITH SEX DIFFERENCE: FREQUENCY (PERCENTAGE)

In recent years there has been considerable interest in possible differences between boys and girls with regard to perception of and performance in science. Studies carried out by Maccoby and Jacklin (1974), Walberg (1969) show that differences are observed in scientific concept recognition and achieved understanding between boys and girls. For example, Maccoby and Jacklin found out that beginning at about age 12-13, boys' mathematical skills increase faster than girls'. It is not clear whether these differences in perception and performance are due to fundamental cognitive differences or are a consequence of socialization.

That apparent equality of opportunity does not inevitably lead to equality of achievement is no news to many under-privileged groups in society. The progressive drop-out of girls from the higher levels of education and in particular the massive drop-out from physical science are examples dealt with in review studies by Spender and Sarah (1981) "Learning to Lose" and by Kelly (1981) "The missing half". Kelly points out that in the physical sciences, female underachievement is alarmingly high. Spender and Sarah claim that bright, intelligent primary school girls are converted in the secondary school to passive creatures who 'can't' do science and who are destined for careers in the kitchen and the nursery or in lower paid jobs.

The literature contains very little on the orientation: of male vs. female science teachers towards science, and perceptions of the aims of practical work would appear to be an important criterion to examine in this regard. The findings are presented in Table 4.3.

Table 4.3 THE ASSOCIATION OF TEACHERS' PERCEPTION OF THE AIMS OF PRACTICAL WORK WITH SEX DIFFERENCE

	Percentage Response at grades 7 and 8			Percentage Response at grades 9 and 10			Percentage Response at grades 11 and 12		
Possible Aims	males	females	SD	males	females	SD	males	females	SD
1. Careful observation	59	51		39	31		41	33	
2. Interpret observations	57	56		68	69		63	83	
3. Makes theory clearer	41	70	*	48	58	*	58	42	
4. Makes theory more real and interesting	58	57		46	67	*	58	41	
5. Enables students to find out for themselves	56	57		61	71	*	53	66	
6. Give training in skills and technique	62	73	*	51	47		63	25	
7. Teaches to experiment in an organised way	21	16		21	19		19	0	
8. Prepares students for final examinations	1	0		3	0		9	8	
9. Gives personal interest in practical work	24	14	*	12	19		23	9	
10. Encourages to study science further	7	5		14	18		21	25	
N =	131	37		145	36		43	12	

* = items marked thus indicate that differences are significant at $p \leq 0.01$

Results:

The data provided in Table 4.3, indicates, that at grade 7 and 8 the responses of male teachers and female teachers are the same for 7 out of the 10 possible aims. Differences in response are observed for three items (aims 3, 6 and 9). Female teachers were associated with a much higher response towards aim 3 (makes theory clearer) and a higher response towards aim 6 (giving training in skills and technique). Aim 9 (give personal interest in practical work) is associated with higher response for males than for females, though this particular aim is considered to be relatively unimportant by both groups.

At grade 9 and 10 responses of male and female teachers are significantly different for three aims: 3, 4 and 5 (makes theory clearer; makes theory more real and interesting; enables students to find out for themselves). For all three aims, the responses of female teachers are higher than the male teachers.

At grade 11 and 12, the number of female science teachers involved is relatively small and hence no valid statistical significance differences were determined. But there are some differences in the response percentages (male V. female) which are worth comment. In particular these refer to aims 2, 4 and 9. Female teachers are associated with a higher response towards aim 2 (interpret observations). Male teachers are associated with a much higher response towards aims 6 and 7 (gives training in skills and technique; and teaches to experiment in an organised way).

Comment:

The results in Table 4.3 would suggest that generally male and female science teachers have very similar orientations towards school practical work. Where differences in orientation exist they are associated with a more positive orientation of females towards 'make theory clearer' and 'makes theory more real and interesting'.

4.6 THE ASSOCIATION OF TEACHERS' PERCEPTION OF AIMS OF PRACTICAL WORK WITH YEARS OF EXPERIENCE: FREQUENCY (PERCENTAGE)

The extent of teaching experience was considered to be a variable that might influence the responses of teachers. This 'experience' is no doubt affected by pre-service courses (completed by the majority) in-service courses, and a decade of quite extensive curriculum development. One must add to these factors the affect of teaching tradition and the individual teacher's personal development and preferences. In spite of the complexities of interpretation, the aggregate responses of teachers over a time scale would seem to be well worth examining.

Teachers were asked to indicate in the questionnaire their years of *full-time* teaching experience. For the purpose of discussion teachers were categorised as follows:

Years of teaching experience	Category
1-3 years	'New teachers'
4-10 years	'Experienced teachers'
>10 years	'Very experienced teachers'

Table 4.4.

THE ASSOCIATION OF TEACHERS' PERCEPTION OF AIMS OF PRACTICAL WORK WITH YEARS OF EXPERIENCE: FREQUENCY (PERCENTAGES)

Possible Aims	Percentage Response at grade 7 & 8			Percentage Response at grade 9 & 10			Percentage Response at grade 11 & 12		
	1-3 yrs	4-10 yrs	>10yrs	1-3 yrs	4-10 yrs	>10yrs	1-3 yrs	4-10 yrs	>10yrs
1. Careful observation	50	61	56	30	38	45	53	50	62
2. Interpret observation logically	41	62	65	64	70	71	67	64	77
3. Make theory clearer	63	44	38	56	47	52	20	50	62
4. Make theory more real and interesting	68	53	60	68	49	57	47	60	54
5. Enables students to find out for themselves	59	54	57	63	65	60	46	61	62
6. Give training in skills and techniques	61	67	62	47	52	50	54	61	38
7. Teaches to experiment in an organised way	15	24	19	15	20	26	13	15	16
8. Prepares students for final exams	0	0	3	0	2	5	0	7	24
9. Gives personal interest in practical work	15	22	27	10	18	23	27	21	7
10. Encourages to study science further	9	8	0	21	15	7	12	21	23
N =	46	85	37	47	92	42	15	28	13

Aims for which differences are statistically significant at $p \leq 0.1$ are indicated by arrows. The latter also show the direction of any trend.

Results:

From the data provided in Table 4.4, teachers' responses at grades 7 and 8 are significantly different for three aims: 2, 3 and 9 (interpret observation logically; makes theory clearer; and gives personal interest in practical work). For aim 2 the percentage responses increased with teaching experience, similarly for aim 9, while for aim 3 the responses decreased with years of teaching experience.

At grades 9 and 10, four aims 1, 4, 7 and 10, were significantly different. For aims 1 and 7 (careful observation; teaches to experiment in an organised way) the responses increased with years of teaching experience; while aims 4 and 10 (makes theory more real and interesting; encourages to study science) further decreased with years of teaching experience.

At grades 11 and 12, four aims 3, 6, 8 and 9, were significantly different. For aims 3 and 8 (makes theory clearer; prepares students for final examinations) percentage responses increased with years of teaching experience (gives training in skills and techniques; gives personal interest in practical work) were in a decreasing order.

Comment:

There are some interesting differences associated with years of teaching experience and trends seem to be maintained over the full range of years of experience.

There is a very considerable change in orientation towards 'makes theory clearer' with years of experience and curiously it is viewed quite differently by teachers at grades 7 and 8 compared with those at grade 11 and 12, with diametrically opposed trends.

4.7 THE ASSOCIATION OF TEACHERS' PERCEPTION OF THE AIMS OF PRACTICAL WORK WITH TYPE OF SCHOOL (STATE Vs. INDEPENDENT Vs. CATHOLIC).

Tasmanian High Schools, in common with Australian schools, can be classified as being either Private or State controlled. The proportion of Private schools is sizable, and out of a total of 82 schools, there are more than 20 private schools, the remainder being state schools. However, the private school group can be further subdivided into what we have termed *Independent* and *Catholic* schools. Although both are strictly private there are characteristics associated with these schools which suggest that they should be treated separately. For instance, there are substantial differences in charged 'fees' and Catholic schools drawing from a much wider spectrum of social class than do the Independent schools. Another reason why they have been classified separately is that there is some evidence that differences exist between groups of government and non-government schools in regard to students' performance in science, ACER (1973), 'Science Achievement in Australian Secondary Schools'.

Table 4.5.

THE ASSOCIATION OF TEACHERS' PERCEPTION OF AIMS OF PRACTICAL WORK WITH TYPE OF SCHOOL

	Percentage Response at grade 7 & 8				Percentage Response at grade 9 & 10				Percentage Response at grade 11 & 12			
Possible Aims	State	Indep.	Catholic	SD	State	Indep.	Catholic	SD	State	Indep.	Catholic	SD
1. Careful observation	59	50	40		38	35	38		42	36	44	
2. Interpret observations logically	56	60	70		68	65	75		79	43	67	*
3. Makes theory clearer	47	50	50		51	65	25	*	39	64	34	*
4. Makes theory more real and interesting	59	60	50		52	65	81	*	58	50	42	
5. Enables students to find out for themselves	55	60	60		62	65	69		61	50	56	
6. Gives training in skills and technique	64	60	70		50	41	63		60	50	43	
7. Teaches to experiment in an organised way	20	30	10		21	24	13		17	31	16	
8. Prepares students for final exams	1	0	0		2	6	0		3	21	20	
9. Gives personal interest in practical work	20	10	50	*	16	24	25		18	36	8	*
10. Encourages to study science further	6	20	0		14	29	13		15	29	33	
N =	148	10	10		148	17	16		33	14	9	

Results:

The data provided in Table 4.5, indicates that at grades 7 and 8 the responses of teachers in State, Independent and Catholic Schools are the same for 9 out of the 10 possible aims. Differences in responses are observed for one item (aim 9). Catholic school teachers were associated with a much higher response towards aim 9 'gives personal interest in practical work'.

At grades 9 and 10 responses of teachers are significantly different for two aims: 3, 4 'makes theory clearer;' 'makes theory more real and interesting'. For aim 3, the responses of Independent school teachers are higher than the State and Catholic teachers. For aim 4, the responses of Catholic teachers are higher than the rest.

At grades 11 and 12, responses of teachers are significantly different for three aims: 2, 3 and 9 'interpret observation logically;' 'makes theory clearer;' 'gives personal interest in practical work'.

For aims 3 and 9, the responses of Independent school teachers are higher than the State and Catholic teachers, and for aim 2, the State school teachers responded higher than the rest, this being the only aim where State teachers have recorded the highest response in respect to all aims.

Comment:

Generally and perhaps quite surprisingly teachers in each type of school have very similar orientation towards practical work. There are minor differences at grades 9 and 10 regarding two aims 'makes theory clearer' and 'makes theory more real and interesting' while at grades 11 and 12, differences are observed in three aims (2, 3 and 9).

4.8 THE ASSOCIATION OF TEACHERS' PERCEPTION OF THE AIMS OF PRACTICAL WORK OF HIGH SCHOOL AND MATRICULATION LEVELS WITH THEIR PREFERRED SCIENCE TEACHING AREAS

In Tasmanian schools considerable concern has been expressed over the distribution of *teaching experts* among schools and within subject areas. Studies reveal that some schools have more qualified teachers than others in particular subjects in science. Due to difference in orientations one might expect a difference in their science teaching. Thus it was considered important to investigate the responses of teachers of the three sciences (Chemistry, Physics and Biology) in regard to the aims of practical work.

High School science teachers are involved in the teaching of General Science while Matriculation level science teachers are involved in the teaching of separate subjects, i.e. physics, biology, chemistry, etc. In a similar survey conducted by Thompson (1975), he found that there were striking similarities in the response of teachers as regards the aims of sixth-form practical work, in separate science subjects. In this survey all teachers (high school and matriculation levels) were asked to indicate which science area 'do you prefer to teach in your science teaching' at school. Their responses are shown in Table 4.6.

Table 4.6

THE ASSOCIATION OF TEACHERS' PERCEPTION OF THE AIMS OF PRACTICAL WORK WITH PREFERRED SCIENCE TEACHING AREAS (AT HIGH SCHOOL AND MATRICULATION LEVELS)

	Teachers' Percentage response at grade 7-10 (High School)				Teachers' Percentage response at grade 11-12 (Matriculation)			
Possible Aims	Chemistry Teachers	Physics Teachers	Biology Teachers	Significance of difference	Chemistry Teachers	Physics Teachers	Biology Teachers	Significance of difference[a]
1. Careful observation	47	46	55		63	23	21	*
2. Interpret observations logically	49	41	62	*	74	46	71	*
3. Makes theory clearer	41	29	48	*	42	62	29	*
4. Makes theory more real and interesting	54	39	58	*	62	62	50	
5. Enables students to find out for themselves	44	54	48		53	31	71	*
6. Gives training in skills and techniques	56	46	67	*	79	77	21	*
7. Teaches to experiment in an organised way	25	20	19		5	38	14	*
8. Prepares students for final exams	0	2	1		0	15	13	
9. Gives personal interest in practical work	10	22	20		11	23	14	
10. Encourages to study science further	1	1	2		10	15	43	*
N =	59	41	69		19	13	14	

(a) Z test should be interpreted with caution in view of the small size of samples.

Results:

From the data provided in Table 4.6, teachers' responses at grades 7-10 in the three disciplines (Chemistry, Physics and Biology) are significantly different for four aims: 2, 3, 4 and 6 (interpret observations logically; make theory clearer; makes theory more real and interesting; gives training in skills and techniques). Biology teachers are always associated with a much higher response for each aim.

Generally, the responses of Chemistry and Physics teachers are the same, except for aims 3 and 4, while for all three disciplines, the responses of teachers are the same for 6 out of the 10 possible aims.

The sample sizes of teachers are very small at matriculation level and Z tests need to be interpreted with caution. Given that, then, the responses of chemistry, physics and biology teachers are significantly different for seven out of the ten aims (careful observation; interpret observations logically; makes theory clearer; enables students to find out for themselves; gives training in skills and techniques; teaches to experiment in an organised way; and encourages to study science.

Comment:

There are some differences at High School level which are associated with teachers whose main teaching 'strength' is in physics. Most notably, at grades 7-10, aims 2, 3, 4 and 6 and at grades 11-12, aims 2 and 5.

The group sizes at matriculation level are small but in almost all cases we have a situation in which teachers are teaching their subject speciality, differences are now very pronounced and seven out of the ten aims are perceived differently by subject specialist for matriculation level studies. There are no obvious trends and it would appear that physics, chemistry and biology teaching at matriculation level is associated with quite different orientations towards practical work. For instance, chemists respond quite differently to physicists or biologists with respect to 'careful observation' while biologists repond quite differently with respect to 'gives training in skills and techniques'.

4.9 GENERAL DISCUSSION

It seems somewhat surprising that teachers' aims for school certificate practical work should be virtually the same as those for matriculation work in view of the age difference and very different student populations involved. One observes that teachers indicate a shift of emphasis from 'careful observation' at grade 7 and 8 to 'interpret observations logically' at school certificate and matriculation level. This is paralleled by a de-emphasis of 'gives training in skills and technique'. These are the only major changes in their aims according to teachers and can be easily identified in Table 4.2.

The relative importance of the list of aims as reported by teachers produces a clear rank ordering for school certificate and matriculation level work. 'Interpret observations logically' is the single most important aim followed by 'enables students to find out for themselves' and 'makes theory more real and interesting'. Aims 7, 8, 9 and 10 are considered to be relatively unimportant by teachers at all levels, with scores of 25% or less - and form a distinctly separate group.

It is interesting to note that teachers do not consider that 'prepares students for final examinations' is important, which may be a reflection on a system which makes very little allowance for practical work for overall assessment purposes. There are no formal practical examinations given at any level by either teachers or examination boards in Tasmanian schools.

Aims 9 and 10, 'gives personal interest in practical work', 'encourages to study science further', respectively, are affective aims which perhaps, surprisingly, are not considered to be important by teachers. There is some recognition of aim 10 at matriculation level though it is still associated with a low choice of response (29%) from teachers.

Aim 7, 'teaches to experiment in an organised way' remains a low priority aim across the age groups (~21%). School practical work involves considerable 'organisation' on the part of the student and there could be some failure here on the part of teachers to recognise the demands made on students. This is borne out by the student's response to the corresponding influence as shown in Chapter 5.

CHAPTER FIVE

THE INFLUENCES OF SCHOOL PRACTICAL WORK IN SCIENCE AS PERCEIVED BY HIGH SCHOOL AND MATRICULATION LEVEL STUDENTS

This chapter examines students' perceptions of the outcomes of practical work, termed influences. The analysis of the responses of the students to the list of influences was conducted in an analogous manner to that used for the aims of practical work according to teachers, discussed in chapter four.

A list of ten possible influences (Table 5.1) was obtained by considering the stated aims of practical work derived from modern curriculum programmes and educational writings. Minor syntactical changes convert the aim (according to educators) into an influence (as perceived by students), e.g.:

Aim: To train students in the skills and techniques of laboratory work

Corresponding influence: Gave me training in the skills and techniques of laboratory work.

In this study, practical work means experiments performed by the teacher as demonstrations, co-operative demonstrations by groups, as well as experiments and observational exercises carried out by students. The activities may take place in the laboratory or elsewhere (i.e. field work).

Table 5.1

POSSIBLE INFLUENCES OF PRACTICAL WORK AS PERCEIVED BY THE STUDENTS

1. Helped me to make observations more carefully.
2. Helped me to interpret observations in a logical way (e.g. to ask questions and not to make decisions unless there is suitable evidence for doing so).
3. Made the theoretical parts of science *clearer* to me.
4. Made the theoretical parts of science *more real and interesting* to me.
5. Led me to find out facts and principles for myself (i.e. new ideas and information were acquired through experiments first rather than from explanations from the text books and teachers).
6. Gave me training in the skills and techniques of laboratory work.
7. Has taught me how to conduct laboratory experiments in an organised way.
8. Has prepared me directly for final examinations (i.e. my overall mark will probably be higher because of the practical work I have seen or done at school).
9. Gave me a personal interest in practical work and experimentation.
10. Has encouraged me to study science or related subjects further after leaving school.

The study took into account variables such as sex difference, size and type of school, social class of parents and final academic performance of students. Thus it is possible to investigate the relationship, if any, between perceptions of practical work and some important background and performance variables.

5.0 STUDENTS' RESPONSES TO THE LIST OF INFLUENCES OF PRACTICAL WORK

Students were required to read the list of ten influences, carefully, for 5-10 minutes and think about them. They were then required to 'choose what you think were the four most important influences from the list below'. High School students referred to their experience of previous High School work while Matriculation level students were instructed to consider their previous Matriculation level course in Grade 11.

Thus each student chose 4 items from 10. If an item is chosen it scores 1, if not chosen, it scores 0. The total scores recorded for each item can then be expressed as a frequency and items rank ordered if necessary. More emphasis was placed on percentages than rank order and where differences between groups are considered, the statistical significance has been ascertained using Z-tests to establish the 0.01 significance level. To quantify the discrimination between influences, the observed responses were compared with what would have resulted has the choices been non-discriminatory (i.e. 40% for each influence: based on a selection of 4 items from 10). A response of 40% would have been achieved if the students had chosen randomly or if the variation between students was very extensive.

For clarity and comparative purposes the data for both High School and Matriculation level students are presented conjointly, initially for 'all' students and subsequently for the effect of the variables, sex difference, academic performance, type of school and specific discipline.

The percentage of students' responses for each influence is given in Table 5.2.

Table 5.2

STUDENTS' PERCEPTIONS OF THE RELATIVE IMPORTANCE OF THE INFLUENCES OF PRACTICAL WORK AT HIGH SCHOOL AND MATRICULATION LEVEL

Possible Influences	High School Students (% response)	Matriculation level students (% response)
1. Careful observation	57	35
2. Interpret observations logically	44	46
3. Made theory clearer	50	59
4. Made theory more real and interesting	41	57
5. Find out for myself	46	32
6. Training in skills and techniques	38	64
7. Experiment in an organised way	45	40
8. Prepared me for final examination	17	11
9. Personal interest in practical work	40	39
10. Has encouraged me to study science further	9	12
N	459	265

5.1 THE INFLUENCES OF PRACTICAL WORK ACCORDING TO STUDENTS

In the case of High School students, four influences, 'careful observation', 'made theory more real and interesting', 'prepared me for final examinations', 'has encouraged me to study science further' are significantly different from a random response level. The first two influences named, receive a response percentage *greater* than, and the last two influences *less* than the random response level of 40%. In other words, influences 1 and 3 are considered to be particularly important, relatively while influences 8 and 10 are considered to be relatively unimportant.

In the case of Matriculation level students, 6 influences 'made theory clearer', 'made theory real and interesting', 'training in skills and techniques', 'finding out for myself', 'prepared me for final examinations', 'has encouraged me to study science further' are significantly different from a random response level. The first three influences named are considered to be relatively important and the last three influences are considered to be relatively unimportant by this student group.

Comment:

A comparison *between* the two student groups indicates that major changes in student perception of the importance of four influences occur: 'careful observation', 'made theory more real and interesting', 'finding out for myself', 'training in skills and techniques'. Both student groups are in agreement about the relative importance of influence 3 'made theory clearer' and about the relative unimportance of influences 8 and 10 'prepared me for final examination', 'has encouraged me to study science further'.

Judged by the range of responses for the whole list of items, Matriculation College students have a considerably more discriminating perception of the relative influences of practical work than do High School students.

5.2 THE ASSOCIATION OF STUDENTS' PERCEPTION OF THE INFLUENCES OF PRACTICAL WORK WITH SEX DIFFERENCES

There has been some recent interest in comparing the achievement of boys and girls in mathematics and science (Maccoby and Jacklin, 1975, Walberg, 1969) and where differences have been observed, inevitably there has been debate as to whether they are due to cognitive differences or social stereotype. Some sex differences that are fairly well established according to Maccoby and Jacklin, are such as:

(i) that girls have greater verbal ability than boys
(ii) that boys excel in visual-spatial ability
(iii) that boys excel in mathematical ability
(iv) that males are more agressive.

As a consequence of these observations it was considered worthwhile to investigate the association of students' perception of influences of practical work with sex differences and the results are shown in Table 5.3 for both high school and matriculation students as a percentage response for each influence.

Table 5.3

THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF THE INFLUENCES OF PRACTICAL WORK WITH SEX DIFFERENCE

	High School Students (% response)		SD	Matriculation Level Students (% response)		SD
Possible Influences	Boys	Girls		Boys	Girls	
1. Careful observation	53	60		37	31	
2. Interpret observations logically	43	46		46	45	
3. Made theory clearer	46	53		56	68	
4. Made theory more real and interesting	42	41		56	61	
5. Finding out for myself	51	51		33	29	
6. Training in skills and techniques	40	35		60	75	
7. Experiment in an organised way	49	42		44	29	*
8. Prepared me for final examinations	17	6	*	12	11	
9. Personal interest in practical work	44	38		39	39	
10. Has encouraged me to study science further	9	8		12	11	
N	228	229		190	75	

* = differences between groups are statistically significant at $p \leq 0.01$

Results:

At High School level, there is only one influence which is associated with a difference that is significant at $P \leq 0.01$ that is 'prepared me for final examinations'. The girls are more negative (the response rates are significantly lower than the random response level) than boys, for this influence. There are smaller differences associated with influences 'careful observation', 'made theory clearer', and 'experiment in an organised way', but strictly they are not within the criterion of 1% statistical significance.

Girls at Matriculation level are more positive about influence 'training in skills and techniques', and are more negative about influence 'experiment in an organised way'. The response rates (percentages) for influences 3 and 6, 68% and 75% respectively, are amongst the highest recorded for any influence or sub-group studied so far among students.

Comment:

Although the difference in the response to 'experiment in an organised way' at Matriculation level is of interest, in general, boys' and girls' perceptions of the influences of practical work are almost identical.

5.3 THE ASSOCIATION OF STUDENTS' PERCEPTION OF THE INFLUENCES OF PRACTICAL WORK WITH ACADEMIC PERFORMANCE IN SCIENCE

Students were divided into three groups (low, medium and higher performers) based on their end of year marks in physical science in the case of High School students, and on their achieved Matriculation grades in Physics and/or Chemistry in the case of Matriculation students.

Table 5.4 shows the responses of low, medium and high

Table 5.4

THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF INFLUENCES OF PRACTICAL WORK WITH ACADEMIC PERFORMANCE IN SCIENCE

	High School Students (% response) by Academic Group a			Matriculation level students (% response) by Academic Group a		
Possible Influences	Low	Med	High	Low	Med	High
1. Careful observation	61	58	52	43	33	40
2. Interpret observations logically	41	42	48	50	45	47
3. Made theory clearer	39	52	51	36	56	68 *
4. Made theory more real and interesting	31	43	43	57	62	56
5. Finding out for myself	44	41	52	21	32	18
6. Training in skills and techniques	39	37	38	64	62	69
7. Experiment in an organised way	54	49	40 *	64	34	43 *
8. Prepared me for final examinations	15	16	17	0	12	12 *
9. Personal interest in practical work	42	45	37	57	39	35 *
10. Has encouraged me to study science further	7	6	11	7	14	13
N	59	173	214	68	89	14

* differences between groups are statistically significant $p \leq 0.01$.

a at High school level, awards are Credit, Higher Pass, Pass, Lower Pass, Fail. For our purposes HIGH = C or HP; MEDIUM = P; LOW = LP or F.
At Matriculation level, awards are Credit, Pass, Lower Pass, Fail, in Physics and Chemistry.
For our purposes HIGH = C+P or greater; MEDIUM = P+P; LOW = LP/F.

performers for High School and Matriculation students for each influence.

Results:

At High School level, one influence is significantly different amongst the three academic groups, that is 'experiment in an organised way'. Low performers reponded more positively on this influence followed by medium performers and last by high performers.

At Matriculation level, four influences are significantly different amongst the three academic groups. These influences are 'made theory clearer', 'experiment in an organised way'. 'prepared me for final examinations' and 'personal interest in practical work'.

High and medium performers are much more positive than low performers about 'made theory clearer'. Low performers are more positive than the other two groups about 'experiment in an organised way'. Low performers are much less positive than medium and high performers about 'prepared me for final examinations'. Low performers are more positive than medium and high performers about 'personal interest in practical work'.

Comment:

The responses for the three academic groups at High School level are very similar, in other words perceptions of of the influence of practical work are not associated with academic performance at this level. At Matriculation level there are differences, almost entirely associated with the low academic performer, and some of the differences are quite substantial.

5.4 THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF THE INFLUENCES OF PRACTICAL WORK WITH TYPE OF SCHOOL

Since differences exist between type of school (i.e. State, Independent and Catholic) in regard to the students' performance, it was thought necessary to investigate the association of students' perception of influences of practical with type of school. The results are shown in Table 5.5.

Results:

The three major divisions of school type in this survey are State schools, Catholic and Independent schools. At High School level, five influences are significantly different, they are, 'made theory clearer'; 'made theory more real and interesting'; 'finding out for myself'; 'training in skills and techniques'; 'experiment in an organised way';

State school students are much more positive than Independent students, while Catholic school students are less positive on 'made theory clearer'. Independent and Catholic school students are much more positive while State school students are less positive about 'made theory more real and interesting'. Independent and State school students are positive while Catholic school students are less positive about 'finding out for myself'. Independent school students are positive while Catholic and State school students are less positive on 'training in skills and techniques'. State and Catholic school students are positive while Independent school students are less positive about 'experiment in an organised way'.

At Matriculation level only one influence 'has encouraged me to study science further' is significantly different between the two groups, and this is a relatively unimportant influence

Table 5.5

THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF THE INFLUENCES OF PRACTICAL WORK WITH TYPE OF SCHOOL

	High School Students (% response)			S D	Matriculation level Students (% response)		S D
Possible Influences	Type of School				Type of School		
	State	Cath.	Indep.		State	Indep. & Cath.	
1. Careful observation	56	62	53		35	36	
2. Interpret observations logically	44	43	46		47	41	
3. Made theory clearer	55	38	43	*	60	55	
4. Made theory more real and interesting	36	50	51	*	57	60	
5. Finding out for myself	48	33	52	*	31	41	
6. Training in skills and techniques	34	38	49	*	65	60	
7. Experiment in an organised way	49	42	34	*	42	29	
8. Prepared me for final examinations	17	13	19		11	12	
9. Personal interest in practical work	38	49	43		38	43	
10. Has encouraged me to study science further	8	9	10		9	26	*
N	291	82	83		223	42	

* differences between groups are statistically significant at $p \leq 0.01$.

as far as students are concerned. Independent and Catholic school students at Matriculation level were taken as one group because of the small sample size. The only influence that is significantly different is 'has encouraged me to study science further'. State school students are much less positive than Catholic and Independent school students about this influence.

Comment:

Students' perceptions of the influence of practical work are associated to some considerable extent with school type at High School level. There is no equivalent association at Matriculation level.

5.5 THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF THE INFLUENCES OF PRACTICAL WORK WITH SPECIFIC DISCIPLINES

In this section it was thought important to investigate if there are any differences between students studying science but doing different subjects, i.e. physics only or chemistry only.

At high school level all students in the sample were involved with general science. However, at matriculation level, students were involved with physics and/or chemistry. A small number of students in the sample were involved with physics only or chemistry only. This is the group that has been considered in this section, and consequently, their responses are purely for the individual discipline. Although the sample size is small it represents more than 10 schools involved in almost identical programmes in the two disciplines. The results are shown in Table 5.6.

Table 5.6

THE ASSOCIATION OF STUDENTS' PERCEPTIONS OF THE INFLUENCES OF PRACTICAL WORK WITH SPECIFIC DISCIPLINES [a]

	Matriculation level Students (% response)	
Possible Influences	Chemistry Only[a]	Physics Only[a]
1. Careful observation	44	36
2. Interpret observations logically	44	46
3. Made theory clearer	56	73
4. Made theory more real and interesting	50	46
5. Finding out for myself	31	55
6. Training in skills and techniques	74	36
7. Experiment in an organised way	31	36
8. Prepared me for final examinations	6	36
9. Personal interest in practical work	50	27
10. Has encouraged me to study science further	13	9
N	16	11

[a] A small number of students studied Matriculation Chemistry but not Physics or vice-versa. This is the data for these students.

At $P \leq 0.01$ level, there are no significant differences associated with any influence in the list, but at $P \leq 0.05$, there are some significant differences associated with influences 6 and 8, 'training in skills and techniques' and 'prepared me for final examinations'.

The chemistry students are more positive than the physics students about 'training in skills and techniques' (74% vs. 36%). The physics students are more positive than the chemistry students about 'prepared me for final examinations' (36% vs. 6%).

Comment:

The sample size is too small to allow great weight to be places on the differences. The data does however represent more than 10 schools and a study of a large sample would seem to be worthwhile.

5.6 DETAILED EXAMINATION OF ASSOCIATION OF THE INFLUENCES OF PRACTICAL WORK AS PERCEIVED BY STUDENTS FOR INDIVIDUAL SCHOOLS

As a consequence of the findings for school type in this section it was considered important to investigate in detail the association of the influences of practical work for individual schools at both High school and Matriculation College level. At High school level 20 schools, and at Matriculation level, 11 schools, were involved in the survey. Tests of difference between school responses were carried out to find out if there were any major differences in the students' responses for each item from the list of ten influences. A χ^2 test was applied across all schools and a Z-test was conducted on the differences between the *maximum* and *minimum* responses.

Tables 5.8 and 5.8 show the results of χ^2 and Z tests for High Schools and Matriculation Colleges, respectively. At Matriculation level, only 7 schools were considered when conducting the Z-tests for the maximum and minimum percentage divergences. Four schools were not considered (those with a sample size less than 15). Almost all sample sizes at High School were ~25-30.

It should be noted that there are methodological considerations involved in this treatment which need to be approached with caution. A χ^2 test, although not a very strong test, can be validly carried out on bivariant data, but how valid is it to take the extreme cases for the school samples and argue about differences?

In one sense we are emphasizing the aggregate response and its variation, while in the other we appear to abandon the notion of aggregates altogether. This is a most interesting problem and very relevant to many situations in this type of research. The 'school' is a very important natural unit in its own right and should not be lost in aggregate data. There are no statistical ambiguities involved, it is simply a break with traditional practice but for important and valid reasons.

5.7 THE TEST OF DIFFERENCE BETWEEN 21 HIGH SCHOOLS

Table 5.7

THE TEST OF DIFFERENCE BETWEEN HIGH SCHOOLS   N = 459 (Students), (21 High Schools)

Possible Influence	Average response (%)	χ^2 for all High Schools	Significant at $P \leq 0.01$	Maximum observed response (%)	Minimum observed response (%)	Probability (P)	Significant at $P \leq 0.01$
1. Careful observation	57	18.7		73	33	0.0021	*
2. Interpret observations carefully	44	22.3		67	30	0.0047	*
3. Makes theory clearer	50	27.2		75	27	0.0001	*
4. Makes theory more real and interesting	41	32.3	*	59	17	0.0021	*
5. Enables students to find out for themselves	46	20.6		77	19	0.0001	*
6. Gives training in skills and techniques	38	21.8		57	23	0.0036	*
7. Teaches to experiment in an organised way	45	24.0		62	20	0.0002	*
8. Prepares students for final examination	17	17.9		38	3	0.001	*
9. Gives personal interest in practical work	40	28.5		67	20	0.0000003	*
10. Encourages to study science further	9	14.6		17	0	0.0091	*

5.8 THE TEST OF DIFFERENCES BETWEEN 11 MATRICULATION COLLEGES

Table 5.8

THE TEST OF DIFFERENCE BETWEEN MATRICULATION COLLEGES N = 265 (students); (11 schools)

Possible Influence	Average response (%)	χ^2 for all Matric. Colleges	Significant at $P \leq 0.01$	Maximum observed response (%)	Minimum observed response (%)	Probability	Significant at $P \leq 0.01$
1. Careful observation	35	10.3		42	14	0.0120	*
2. Interpret observations carefully	46	7.3		57	33	0.0594	
3. Makes theory clearer	59	5.0		67	50	0.1423	
4. Makes theory more real and interesting	57	7.4		67	50	0.1060	
5. Enables students to find out for themselves	32	11.5		37	14	0.0329	
6. Gives training in skills and techniques	64	9.2		68	57	0.1492	
7. Teaches to experiment in an organised way	40	10.8		56	29	0.0446	
8. Prepares students for final examinations	11	13.0		21	0	0.0019	*
9. Gives personal interest in practical work	39	20.6		56	26	0.0179	
10. Encourages to study science further	12	16.1		33	5	0.0040	*

Results:

At High School (Grade 9 and 10) only one influence is associated with a χ^2 value corresponding to $p \leq 0.01$ that is 'makes theory more real and interesting'. There is no detectable difference in χ^2 for the student samples from the 20 different schools involved for any of the remaining items.

However, when extreme cases are considered (the maximum and minimum responses observed for individual schools) then a Z test reveals that *all* 10 influences are significantly different at $p \leq 0.01$.

At Matriculation level, there were no statistical differences in χ^2 for all seven schools with student groups greater than 15. (In the majority of cases the numbers involved were greater than 30.) However, when extreme cases are considered, then a Z test shows that three influences are significantly different at $p \leq 0.01$; i.e. 'careful observation', 'prepares students for final examinations' and 'encourages to study science further'.

Comment:

In an overall sense, students in High Schools perceive practical work in a similar way, but when extreme cases are considered, the responses between some schools are considerably different. In other words, some schools *are* 'doing differently' - as reported by their students.

Overall, matriculation students perceive practical work in a similar way but when extremes cases of schools are considered, it seems practical work at those schools concerned is associated with three differences - and items which are not without interest.

5.9 GENERAL DISCUSSION

Students' perceptions of the relative importance of the influences of practical work at both the end of High School and at Matriculation level show evidence of ordering. This ordering is clearer at Matriculation level though the range of responses for individual influences is only slightly greater than that observed for High School students (64%-11% cf. 57%-9%). An absence of ordering would occur if each influence received a response percentage of 40%. Such a situation could be due to either a random selection of influences or to a very substantial variation between individual respondents.

What emerges from the overall responses at High School level is that 'careful observation' and 'made theory clearer' are relatively important influences according to students and 'had encouraged me to study science further' and 'prepared me for final examinations' are clearly relatively unimportant influences. The remaining six influences are closely grouped and are almost tied in terms of rank order.

At Matriculation level, the separation between the responses is much more well defined. It is observed that three influences 'made theory clearer', 'made theory more real and interesting', 'training in skills and techniques' are relatively important according to students at this level, while three influences 'finding out for myself', prepared me for final examination', and 'has encouraged me to study science further' are considered to be relatively unimportant.

A comparison between the two student groups show that the greatest changes in perceived influence are associated with 'careful observation'; 'made theory more real and interesting';

'finding out for myself' and 'training in skills and techniques'. The direction of these changes are of considerable interest in that the matriculation students perceive their practical work to be much more technique oriented and much less associated with careful observation than the high school students. Matriculation level students also place 'finding out for myself' in 8th place with a response rate of 32% - considerably lower than that recorded for High School students.

These responses from High School students are of interest in view of the science curricula operating at present in Tasmanian schools, which have been affected by ASEP, and to a lesser extent by Nuffield, ISCS and JSSP. A considerable amount of student-directed practical work takes place but from the writer's experience it is very simple, instant and visual with a minimum of genuine experimentation. Not surprisingly the students' perception is perhaps more of visual aid than an experimental enterprise at High School.

By comparison, the Matriculation syllabus in Chemistry is a modified form of Chem Study which is divided into two distinct parts each of one year's duration. A similar approach is adopted for Matriculation Physics though the affects of established overseas curricula are less well-defined. Although the intention of both syllabuses is to encourage discovery learning, students' perceptions at present, are of a highly technique oriented practical component at Matriculation level. 'Training in skills and techniques' emerges as the most important influence with a response rate of 64%, while 'finding out for myself' is ranked 8th with a response of 32%.

It is interesting to note that the same group of students rank 'careful observation' 7th with a response of 35%. The 'training in skills and techniques' emphasis is particularly strong as far as Chemistry students are concerned. A small number of students (N = 16) were involved with Matriculation Chemistry only (i.e. not both Physics and Chemistry) and the response percentage for this influence was 74% for this group - 18% higher than the next most important influence. This represents quite a disturbing emphasis since it would appear that the practical components of both Physics and Chemistry and particularly the latter have metamorphosed into quite the opposite of what was intended. One should add that the teachers involved are mainly honours graduates and subject specialists whose professional competence is unquestionable.

Tables 5.3 - 5.5 deal with the possible association of perceived influences of practical work with three variables: sex difference, overall academic performance in science, and type of school.

There are one or two differences in the perceptions of boys and girls mainly at Matriculation level where all teaching and instruction in science is co-educational. However where differences exist they are a matter of degree and the rank order of influences for boys and girls is virtually identical as can be seen by inspection of Table 5.3. Consequently, we suggest that students' perceptions of practical work are not associated to any extent with sex difference of students.

Overall academic performance is not associated with perception of the influence of practical work for medium and high performers but there are some interesting differences in the responses of the low performers - i.e. the unsuccessful academic group. These differences are most noticeable at Matriculation level. Low academic performers are particularly conscious of 'training in skills and techniques' and 'experiment in an organised way' while ' made theory clearer' is perceived to be much less important as an influence. It may be that the practical work employed is unsuitable for the lower groups in that it involves them in psycho-motor/organisational activity with little reinforcement. Certainly, this group and their responses need to be looked at most carefully by science teachers and educators particularly if Matriculation studies in Physics and Chemistry are considered to be part of a general education and not simply as a filter for tertiary studies.

Students' perceptions of the influences of practical work are associated with type of school, particularly at High School level as can be seen from Table 5.5.

This suggests that practical work in schools can be and is perceived substantially differently within school groupings. This is not a trivial point, and answers the doubts that teachers and educators might have as to whether curricula and/or individual teachers effect major differences in orientations towards an enterprise such as practical work.

Clearly, they can and do. Pursuing this point we have made careful study of the responses of individual schools. The findings in Tables 5.7 and 5.8 fully support the observations made above concerning association with type of school.

*	Chapters 4 and 5 deal specifically with *teachers'* perception of aims, and *students'* perception of course influences. After the completion of the bulk of this thesis a comparison of these two orientations was written for publication elsewhere. It is included in the collection of papers at the end of this thesis.	*

CHAPTER SIX

STUDENTS' ATTITUDES TOWARDS PRACTICAL WORK

This chapter is mainly concerned with response of students in regard to their *attitude* towards practical work.

The word attitude tends to have different meanings depending on how and when it is being used. Some of the lexical definitions found in educational and psychological writings are as follows:

> "a tendency to act toward or against some environmental factor which becomes thereby a positive or negative value"
> Bogadus (1931)

> "... the effect for or against a psychological object"
> Thurstone (1932)

> "... a mental and neutral state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situation with which it is related"
> Allport (1935)

Definitions such as these imply that attitudes are learned, that they are hypothetical, latent mental states which may *influence* behaviour, but are not synonymous with behaviour; and that they involve positive or negative emotional feelings and evaluative reactions towards people, things, events or propositions. These definitions though very useful, are regarded by theorists to have failed to capture the richness of a complex concept and hence they have attempted to describe attitudes in other ways. Rosenberg and Hovland (1960), for example, have presented their conception of attitudes schematically, which treats 'attitudes' as a hypothetical mental state which mediates between environmental or personal stimuli and the observable responses made by the individual.

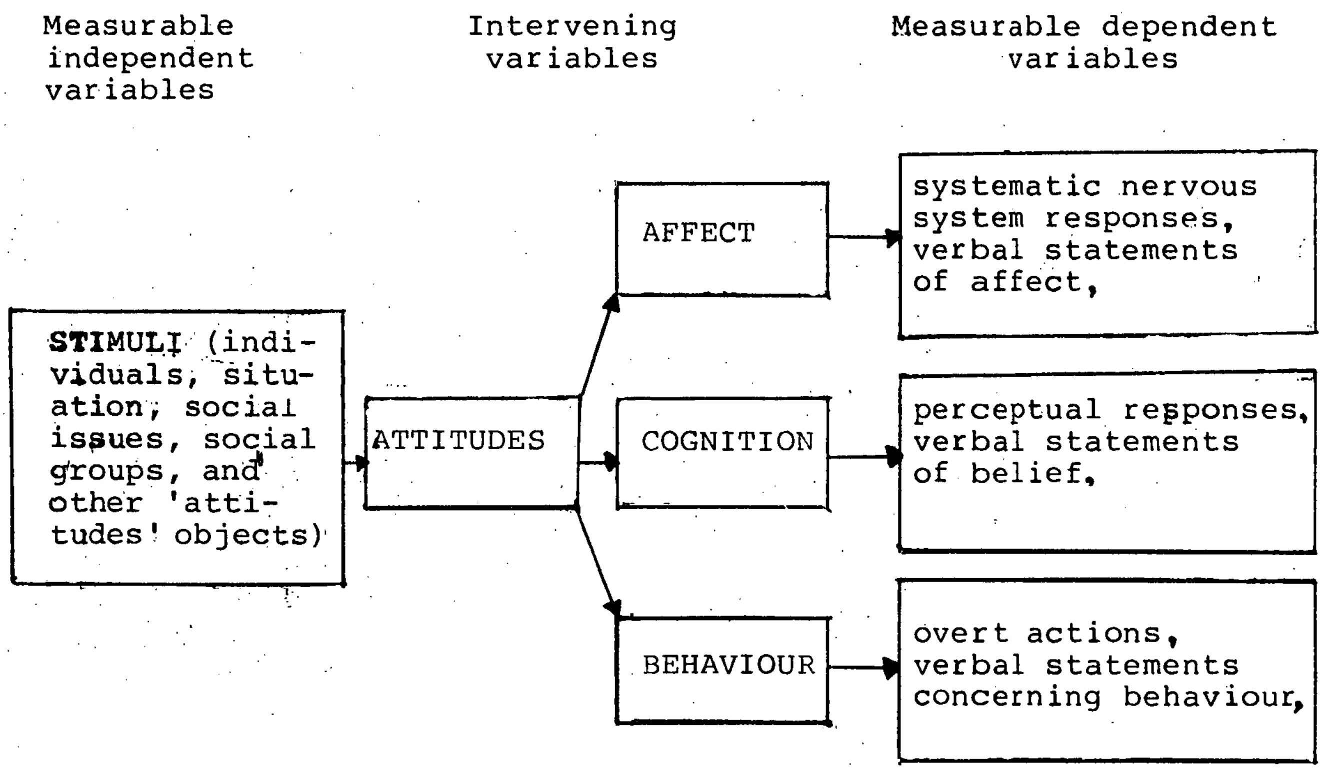


Figure 6.1 A schematic conception of attitudes (after Rosenberg and Hovland, 1960)

In the schematic conception shown in Fig. 6.1, attitudes are described in terms of three components:

(i) A cognitive component, consisting of concepts and propositions; a student's attitude towards practical work in science, for example, would be linked to sets of ideas that the student has about aspects of science.

(ii) An affective component, comprising the emotional reactions which the person has towards the attitude object; a student's attitude to school practical work would include feelings of pleasure or pain, liking or disliking.

(iii) A behavioural component, a predisposition to action (doing), e.g. a willingness to perform an experiment in a laboratory etc.

In this study High School and Matriculation level students were asked "Consider for a few minutes your attitude to practical work at school and then write in your own words how you feel it has influenced you".

The students' responses were then grouped into the three categories: Behaviour (doing or psychomotor)
Affective (feeling)
Cognitive (thinking)

and responses in each category were classified as either positive or negative responses. In all 98% of students, replied to this open question with responses that varied from a simple phrase or sentence such as "I like practical work" to quite detailed comments such as "It helped me to understand the theoretical work covered in our course. It also enabled me to use important apparatus which I may use in my career (engineering), so I think I will adjust easily to working with new methods and equipment as it has improved my skills. It has improved my interest in science".

The following are some categorised examples of students' responses concerning their attitude towards practical work.

Positive Responses (Category type is shown in italics)

(Affective) 1. Practical work *has affected my outlook on science* as it *has influenced my career decision.*

(Affective) 2. Practical work *interests me*, it's a break from studying non-interesting subjects and this has helped me *build a good attitude towards science.*

(Affective) 3. Practical work *is wonderful because you see things happen* and some of us who are not so bright are helped by practical work *to like science more* and in our exams our marks go up. We should do a lot more of practical work.

(Cognitive) 4. It *helped me to understand science*. I found that in the units where we didn't have much practical work, I didn't do well in the tests and did not understand the unit.

(Cognitive) 5. Practical work has *helped me to understand the scientific analysis of results and it provides a link between theory and reality.*

(Cognitive) 6. I have learnt a lot through practical work and *it helps me to think why things happen the way they happen* and in this way my reasoning has been improved.

(Behavioural) 7. Practical work *gave me some experimental techniques* and gave me *confidence in handling laboratory equipment*. I like experiments and I like to see things happen.

(Behavioural) 8. I *always look forward* to a practical lesson in the laboratory because it's where *you have a chance to do things by yourself*, and you see all sorts of reactions.

(Behavioural) 9. I *like to assemble laboratory apparatus and mix chemicals by myself*. I feel relaxed when I get the results required. I like verifying scientific laws by experiments.

Negative Responses (Category type is shown in italics)

(Affective) 1. Practical work *doesn't interest me at all.* As a matter of fact *I hate it because it is boring.* Some teachers are alright but others bore you to death and without an interesting teacher the whole lesson is very tiring and boring.

(Affective) 2. I have *lost interest because the teacher likes the brainy kids only* and they are the ones who are always asked questions instead of us. It's *quite unfair* to us.

(Affective) 3. My attitude towards practical work *is only a bludge.* I think *we are wasting time* to do practical work and it makes the theory look confused. My results are always wrong.

(Cognitive) 4. Practical work *hasn't helped me understand the theories of science. The experiments we perform never help me to understand the topic better.*

(Cognitive) 5. Practical work *presents things in a difficult way.* I cannot see the significance of doing it and I think it's a waste of time - and money.

(Cognitive) 6. We *don't learn much through practical work.* I think practical work and science in general are *absolutely incredibly confusing to all.* I don't understand a thing.

(Behavioural) 7. I get *confused when I see things happen.* I can't tell why they happen. *It's always better if the teacher does it for us.*

(Behavioural) 8. It's *difficult for me to connect the apparatus by myself. I have lost interst* hence I take advantage of the time to play around with chemicals and laboratory equipment.

(Behavioural) 9. I *hate the chemicals* because they smell and I don't like doing things like dissection, *and I normally get dirty during practical work which puts me into trouble* with my parents.

Table 6.1 shows the percentage responses of High School students in each category. N.B. Some students responded in all three areas while others responded in one or two areas and all these responses were considered in this analysis. Only one response in a particular area was considered, i.e. if two positive statements in cognitive area were given, only one statement was tabled and included in the results.

Table 6.1

HIGH SCHOOL STUDENTS (N = 459) RESPONSE REGARDING ATTITUDE TOWARDS PRACTICAL WORK

ATTITUDINAL CATEGORY	POSITIVE RESPONSE (%)	NEGATIVE RESPONSE (%)	OVERALL RESPONSE (%) *	NO. OF RESPOND-ENTS
Cognitive Component	65%	7%	72%	325
Affective Component	63%	14%	77%	346
Behaviour Component	17%	4%	21%	94
		N =	450	

* percentages are calculated as:

$$\frac{\text{number of responses (in that category}}{\text{total number of responses (450) to the open question}}$$

Results:

From Table 6.1 the high school students' responses as regards their attitude toward practical work were mainly in the Cognitive (72%) and Affective (77%) categories and least in the Behaviour category. Students gave a much higher percentage of positive than negative responses in each category.

Table 6.2 shows the percentage responses of Matriculation students' responses in each category.

Table 6.2

MATRICULATION STUDENTS (N=265) RESPONSES REGARDING ATTITUDE TOWARDS PRACTICAL WORK

ATTITUDINAL CATEGORY	POSITIVE RESPONSE (%)	NEGATIVE RESPONSE (%)	OVERALL RESPONSE (%) *	NUMBER OF RESPONDENTS
Cognitive Component	76%	4%	80%	205
Affective Component	50%	8%	58%	146
Behaviour Component	19%	3%	22%	55
		N =	254	

* percentages are calculated as:

$$\frac{\text{number of responses (in that category}}{\text{total number of responses (254) to the open question}}$$

Results:

From Table 6.2 the Matriculation College students' responses as regards their attitude towards practical work were mainly in the Cognitive (80%) with more than half in the Affective (58%) categories, and least in the Behaviour category. Again, as for High School students, Matriculation students gave a much higher percentage of positive than negative responses in each category.

Comment:

Judging by these responses, the attitudes of high school students towards the practical work experience in high schools are as much concerned with 'feeling' as 'thinking' and considerably less concerned with 'doing'.

Judging by the responses, the general attitude of Matriculation students in regard to practical work seems to be similar to that of High School students except that they are relatively more concerned with 'thinking' than 'feeling' but equally less concerned with 'doing'.

Teachers and educators should be heartened by the very strong positive response in all three categories and by the very high percentage of student returns, many of which contained detailed and thought-provoking comments. It is interesting to note that positive responses usually referred to practical work as an activity, but many of the negative responses tended to attach blame to the teacher for what transpired.

It may well be that successful practical work programmes, once operating, are self-sustaining to the extent that students are largely unaware of intrusions by the teacher. This is not a trivial observation and if it is true, then teachers and educators might well use it as a major criterion for evaluation of such work.

CHAPTER SEVEN

TECHNIQUES FOR THE ASSESSMENT OF PRACTICAL WORK

For the majority of science teachers, assessment seems to be the single most important determining influence on the nature of school practical work. The extent to which practical work contributes to the overall assessment varies from one particular system of education to another depending on the type and range of objectives that practical work is intended to cover.

In the Australian context, the importance of close integration of theory and practical work has repeatedly been stressed, though it is not clear if this view is shared by all science teachers in Australia.

The Boards make recommendations to schools which normally refer to what should be done though there is much less guidance to how it should be assessed. In Tasmania, in the Higher School Certificate Manual, it is stated that "... A candidate will not be permitted to present himself for examination in the subjects of Biology, Chemistry, Geology or Physics unless he shall have received practical instructions in the year of examination for the minimum time prescribed in the syllabus at a school which he has complied with the following conditions:

(i) the laboratory and equipment must previously have been inspected by a person appointed by the Schools Board of Tasmania and approved by the Board after consideration of the inspector's report.

(ii) The laboratory and laboratory work in the subject may at anytime without notice be inspected by a person appointed by the Schools Board of Tasmania and must be approved by him. A candidate's work must be ready all the time for inspection ..."

The Schools Board makes further recommendations to schools such as:

"all candidates presenting themselves for examination must have completed a course of practical work in a laboratory which has been approved after inspection by inspectors appointed by the Schools Board of Tasmania, *the suggested minimum time for laboratory work is 50 hours per year.* A list of experiments and a section of the syllabus to which they are applicable is available from the Schools Board on request." It is through such recommendations that teachers tend to select what they have to teach.

The importance of developing psychomotor and cognitive skills in practical activities is recognised in all States in Australia. For instance in New South Wales, the importance of developing such skills is emphasized by both the Secondary Schools Board and the Board of Senior School Studies in their respective Aim Document Manuals. The Boards emphasize the fact that skill testing should be incorporated into the *school's assessment mark.*

7.0 SCHOOL BASED ASSESSMENT AND ITS IMPLICATIONS FOR PRACTICAL WORK

In recent years, throughout Australia there has been a greatly increased emphasis on school-based curriculum development, and a decline in the emphasis on external examinations. There has also been increasing responsibility placed on the classroom teacher to develop and apply evaluation and assessment procedures which provide a level of comparability of results across schools. The Australian classroom teacher is thus faced with considerable responsibility in selecting and organising content and also in carrying out any pupil assessment programme. *Testing* has always been part of a teacher's day to day activity in school, but never has such a high degree of responsibility rested on his shoulders to ensure high levels of reliability, validity and also comparability with testing in other schools. Teachers are required to devise techniques for evaluating interest, attitudes and performance, and then convert the results to a component of an overall assessment. Of course, this is not an easy task for the teachers especially when many have limited knowledge of the theory and technique of testing.

When a teacher assesses his pupil's practical work, his assessment is usually concerned with measuring those skills and abilities which have been established as being important and which the course intends to develop. Skills in *communication, observation* and *manipulation* are regarded as the most important ones, by various American writers, and it is claimed that the methods of assessment for each of these skills will be different as they focus on distinct aspects of psychomotor and cognitive development.

It is probably true to say that those science teachers who genuinely want their students to develop problem-solving and laboratory skills see to it that these kinds of learning find their way into tests and other evaluation procedures. Lunetta, Hofstein and Giddings (1981) claim that teachers understand that, grading systems reflect the true goals of teachers and schools, and that many students gear their best efforts to activities that will be rewarded at the test-time.

Although the curriculum system and the Examination Boards normally recommend *what* should be assessed, but precisely what is being assessed depends, of course, on the teacher's pedagogical objectives for laboratory work, and laboratory activities have been used to accomplish a wide variety of goals. To be able to assess the various outcomes of laboratory work, it is essential to identify the component skills associated with laboratory work.

Kempa and Ward (1975) in the United Kingdom describe the overall process of practical work in science education as involving four phases:

(i) Planning and design of investigation in which the students predict results, formulate hypothesis and design procedures,

(ii) Carrying out of experiments in which the students make decisions about investigative equipment,

(iii) Observation of a particular phenomenon, and

(iv) Analysis, application and explanation in which the student is processing data, discussing results, exploring relationships and formulating new questions.

It is interesting to note that this U.K. source emphasizes the 'investigation' aspect of practical work. Item (i) for instance, describes a comprehensive and mature investigational involvement. There is a strong disposition towards holistic 'experimenting' as a central requirement.

The continuous assessment of practical work in Nuffield Chemistry* qualifies the weightings for the major desired outcomes as follows:

1. Skills in observation 25%
2. Ability to interpret observations 15%
3. Ability to plan experiments 10%
4. Skills in manipulation 30%
5. Attitude to practical work 20%

The Nuffield criteria were formalized in the early 1960's and an examination of assessment profiles required by two major Examination Boards in the U.K., almost two decades later show them to be almost identical.

The Joint Matriculation Board (JMB, 1979) and the University of London Examination Board (1977) concentrated their assessment of practical work on five main areas:

1. Manipulative skills .... (25-30%)
2. Skills in observation and the accurate recording of such .... (25-30%)
3. Ability to interpret observations .... (20-25%)
4. Ability to devise and plan an experiment . (10-15%)
5. Attitudes .... (10-20%)

It would seem that the Nuffield schemes had a considerable influence on the assessment of practical work, generally.

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* Nuffield Chemistry, G.C.E. O-level (School Certificate level in the U.K.).

In the United States, Jeffrey (1967) suggested six areas are associated with laboratory work:

1. Communication: identification of laboratory equipment and operations.
2. Observation: recording of observations and detecting errors in techniques.
3. Investigation: accurate recording of measurable properties of an unknown substance.
4. Reporting: Maintenance of a suitable laboratory record.
5. Manipulation: skills in working with laboratory equipment.
6. Discipline: maintenance of an orderly laboratory and observation of safety procedures.

Jeffrey didn't provide any weighting for the six items associated with laboratory work. The inclusion of 'communication' as a major item and 'discipline' add dimensions that are missing from most recommendations stemming from the U.K. 'Communication', an exercise in practical work and dialogue seems part of the American tradition.

It should be noted that some of the above mentioned practical goals coincide with broad goals of science education that are not necessarily laboratory based and can be assessed with conventional paper-and-pencil tests. Other goals, specifically practical skills and goals in the affective domain are generally not assessed on conventional tests.

7.1 METHODS OF EVALUATING PRACTICAL WORK

Science writers have identified three broad categories for evaluating students' activity in the laboratory:

1. *Written reports* - either traditional reports or paper and pencil tests.
2. *Laboratory practical examinations and tests.*
3. *Observational assessment or continuous assessment* by the science teacher.

The three categories arise as a consequence of the difficulty of assessing an enterprise which has a wide range of desired outcomes, some of which do not lend themselves easily if at all to objective assessment.

It is suggested by Giddings and Hofstein (1980) that the forms of assessment utilized by the science teacher should take into account the following criteria:

(a) Reliability - seen as the degree to which the forms of assessment yield consistent results;

(b) Validity - seen as the degree to which the assessment procedure measures the aims of the laboratory course;

(c) Usability - seen as the criterion which must follow once we have chosen the procedures that are reliable and valid for our task. Namely that we choose those which offer the most convenience, economy and interpretability.

Giddings and Hofstein reflect these anxieties by defining criteria of 'reliability' and 'validity' which are not novel, but then add an interesting criterion which they define as 'usability'. There is a strong note of pragmatism in this third choice.

Therefore, before one gets into selecting which method of laboratory assessment is best in assessing particular skills, it is quite important to gather the information needed to prepare an evaluation plan. A broad curriculum strategy is provided in science education document from Western Australian Institute of Technology, 'Evaluation in Science Laboratory Work'. The document's emphasis is on procedure.

Table 7.1

INFORMATION NEEDED TO PREPARE AN EVALUATION PLAN

1. Evaluative Questions (what do we need to know to determine the value of effectiveness of 'x'?).

2. Project/Curriculum objectives (what objectives is 'x' attempting to achieve?).

3. Information Required (what information is needed to answer the evaluative questions or determine if objectives have been attained?

4. Source of Information (where and/or from whom can the needed information be obtained?).

5. Strategy for Collecting Information (what comparisons and generalizations do we want to make from the information? What implications do these have for sampling, comparison groups, etc.?).

6. Method of Collecting Information (what procedures or instruments are best for collecting the needed information?).

7. Information Collection Arrangements (who will collect the information, under what conditions, on what schedule?).

8. Analysis of Information (what analysis methods/techniques will be used to analyse the information?).

9. Reporting of Information (to whom, how, and when should information be reported?).

7.2 ASSESSMENT PROCEDURES

Written Reports

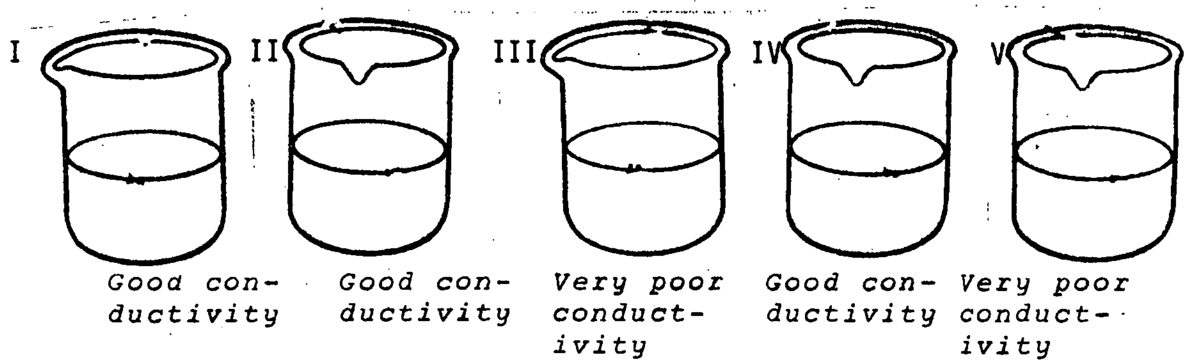
(a) Traditionally, student laboratory performance has always been assessed by a method of evaluating the student's laboratory reports, written during or subsequent to the laboratory experience. Assessment based solely on the written reports (according to some science writers) may be biased by various factors such as neatness, writing skills, and 'volume' which, if taken as an example may enhance the appearance of the report and may bias evaluation. Some science teachers and educators are concerned that grading reports is often subjective and often based on a narrow array of criteria.

From written reports, a teacher cannot be sure if a student has acquired skills in manipulating equipments, observing, or organising and performing an investigation efficiently. It is possible that the laboratory report or notebook may offer indirect evidence of certain skills but sole dependence on reports in evaluating laboratory activity may mislead a teacher and encourage cheating. On the other hand, used sensitively, laboratory reports can stimulate student dialogue and interaction as well as provide one source of evaluative information.

(b) One can also prepare aper-and-pencil test items designed to assess knowledge of the techniques and principles underlying laboratory procedures. The paper-and-pencil test can assess components of communication, reporting, application and interpretation of observation, planning and design, analysis of laboratory activity. But one cannot use written test items exclusively as the basis for evaluation to assess skill in the performance phase of laboratory activity.

The following are some examples of paper-and-pencil test items used in the American Chemical Society High School Paper, 1971, and the Chem. Study Achievement Tests, semester examinations:

1. *The following information is used in Questions 1 and 2. Five beakers each containing 20ml. of clear, colourless liquids are tested for electrical conductivity at room temperature.*



Of the contents so far described all of the following statements are true <u>except</u> one. Identify the statement that is <u>wrong</u>.

(a) III and V may contain pure water

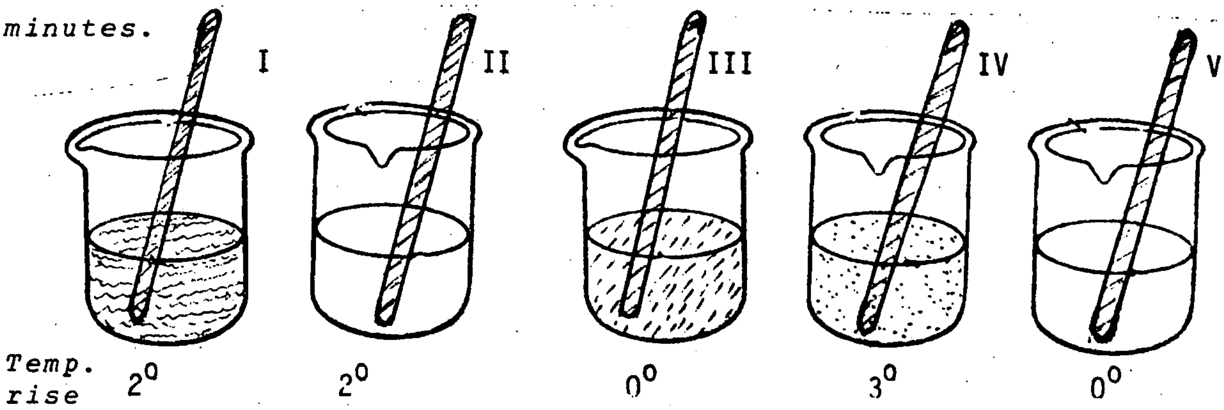
(b) I, II and IV clearly contain ions

(c) III and V may contain non-metallic ions

(d) III and V may contain solutions

(e) I and V may contain aqueous solutions.

The following additional information is used in Question 1 and 2. Ten ml. portions of clear, colourless liquid (X) at room temperature are added to the contents of each of the five beakers. The following observations are made after 2 minutes.



Beaker	*Temperature Change*	*Description*	*Conductivity*
I	2^{o}	*A white precipitate has formed*	*Good*
II	2^{o}	*No visible change*	*Good*
III	0^{o}	*Solution turn red*	*Good*
IV	3^{o}	*Bubbles of colourless gas form*	*Good*
V	0^{o}	*No visible change*	*Good*

2. *Which one of the following interpretations is LEAST likely to be true?*

(a) *No two of the beakers had the same contents before liquid X was added.*

(b) *All of the beakers now contain ionic solutions.*

(c) *None of the beakers now contain only one pure substance.*

(d) *Chemical reactions have occurred in beakers I, III and IV.*

(e) *Liquid X may have been identical to the liquid originally contained in beaker II.*

3. *It is experimentally determined that the liquid X is an aqueous solution of sodium carbonate, $NaCO_3$. All of the following conclusions may now be made EXCEPT one. Identify the wrong conclusion.*

   (a) the compound, Na_2CO_3, is soluble in water.

   (b) the original contents of beakers III and V could have been pure water.

   (c) the compound, Na_2CO_3, exists as ions in water solution.

   (d) in beaker I the solid precipitate probably contains CO_3^{-2} ions.

   (e) the gas produced in beaker IV could be carbon dioxide, CO_2.

7.3 PRACTICAL EXAMINATIONS/TESTS

Another method considered to be important by some educationists, in evaluating practical work is the use of Practical examinations and tests, which could be used to measure the extent to which a student can record and communicate his observations and/or manipulations performed during a defined period of testing. Some science teachers and those concerned with the examination of laboratory work, tend to ignore the practical examination as a means of collecting information on student performance due to problems of implementation and validity.

Today, very few countries set a practical examination as part of the final assessment. Where practical examinations still exist, the class teacher normally prepares the materials for the examination and this examination is supervised by him also with an external supervisor appointed by the Examining Board. Practical examinations of this format have been criticised on the grounds of poor *validity* and *reliability* (Vernon, 1972).

Some science writers and educationists believe that if practical work has any value at all in the study of science, then it should be evaluated for the final assessment too. Science teachers give students so-called "practical examinations" to assess acquisition of laboratory skills (manipulative skills, observations and abilities and more complete problem solving and science process skills). It is common to find students in introductory science classes measuring length, recording temperature, determining mass or weight, measuring volume and determining density. In Biology classes, it is common to find students moving from station to station, observing and identifying organs and tissues of prepared specimens, sometimes with the aid of a microscope.

The following is an example of practical work tests (Source: ASTEP, Monash University, 1976).

__A Practical Test__

1. *You are asked to find the temperature at which water boils in the laboratory today. Collect one each of - Bunsen burner, tripod, gauze, box of matches, celsius thermometer (black tape) Fahrenheight thermometer (yellow tape) and two 250ml. size beakers.*

   Rinse out beaker and ¼ fill it with hot water from the sink heater.

   Boil the water and measure the temperature with both thermometers.

   Write your results here:

   Temperature of boiling water is _____ ^{o}C or _______ ^{o}F.

Turn off the gas: carefully pour cold water into the beaker, taking care not to allow any on the outside of it, until it is nearly full. Wait a minute and it should cool enough to put away.

Pack up and clean up.

Be careful of hot apparatus.

2. *You are asked to filter a mixture.*

Collect one each of - filter paper, filter-ring, small retort stand, beaker mixture, filter-funnel, 150m. size beaker.

Set the apparatus up as to filter the mixture. Stir the mixture up with the stirring rod. Filter 1/3 of the mixture.

(i) Describe the substance collected in the funnel

____

____

(ii) Describe the substance collected below the funnel __________________________________

____

(iii) How many different substance do you now think were in the original mixture? __________

____

Now return what is left of the mixture to where you got it. Rinse out your apparatus, clean up and put it away as you found it.

3. *Name this piece of apparatus*

____________________________ *(volmeter was used)*

Name the gas in tube A ____________________________

Describe briefly what this experiment can show _______

____

____

These and many other examples are commonly used in schools by teachers as practical work tests. The major advantage of such tests is that they permit the assessment of a large number of students within a small period of time.

The assessment of laboratory outcome could also be assessed by external practical examinations set by Examining Boards. In this type of examination a student enters the laboratory, he finds the material and the examination paper. He is requested at several points during the examination to call the examiner who is always available in case of difficulty in understanding a particular question. The marking, grading, and standardization takes a form already described in the previous chapter.

An example of this type of examination is given in Fig. 7.2; set by the University of Tasmania for Chemistry candidates at matriculation level in 1964.

Fig. 7.1

"THE UNIVERSITY OF TASMANIA

MATRICULATION EXAMINATION

November 1964

CHEMISTRY

Advanced Level: Practical

Text books, Analytical Tables and Note books may be brought into the Examiation. Tables of logarithms and Slide Rules may be used.

Time allowed: 3 hours

Report at the top of each answer sheet your examination number, sample number, school and the date.

Use the answer sheets provided.

Report all tests and observations you make.

PART 1: Volumetric Analysis

1. The solution provided for volumetric analysis consists of sodium carbonate dissolved in distilled water.

(a) Titrate 20 or 25 ml. samples of this solution with the standard hydrochloric acid solution (approximately 0.1 N) provided, using methyl orange as indicator. Carry out duplicate determinations and report your results on the form provided.

(b) Titrate 20 or 25 ml. samples of solution with the standard hydrochloric acid solution (approximately 0.1 N) provided, using phenolphthalein as indicator.

(c) Boil the solution obtained in 1(b) and record your observation.

Report

(i) Calculate the normality of the sodium carbonate solution.

(ii) Write equations for 1(a), 1(b) and 1(c).

(iii) Calculate the weight of anhydrous sodium carbonate in 1 litre of solution.

(iv) Can you offer explanations for the difference in results with the two indicators in 1(a) and 1(b), and the observation in 1(c)?

PART II: Qualitative Analysis

The simple salt provided contains one cation and one anion.

Investigate it qualitatively by systematic methods and report your observations and conclusions on the forms provided.

Notes: Candidates are instructed.

1. to record on their answer papers the identification numbers of the samples provided for analysis.

2. to replace stoppers in sample tubes at the end of the examination and to leave the samples with the answer papers at their working places."

Such practical examinations were discontinued in Tasmania due to the fact that *teachers* were sceptical about the worth of practical examinations. The deficiencies of traditional practical examinations were appreciated and the assessment was left to individual schools though no guidance was supplied as to methods of assessment.

One of the values of formal practical examinations is considered to be the means of bringing the Examinations Boards and the schools into direct personal contact, and such examinations help schools to obtain apparatus and materials. It is generally accepted that practical examinations alone result in evaluating only limited effects of experimentation and limited aspects of the candidates' practical ability, hence it ought to be used in conjunction with other methods (i.e. continuous assessment). Although in many respects the teachers themselves are in the best position to assess the value of practical examinations, one assumes that they are sufficiently skilled and have the time to undertake such procedures.

7.4 CONTINUOUS (OBSERVATIONAL) ASSESSMENT

It can be argued that reports or laboratory practical examinations have serious limitations regarding the breadth of skills that they measure.

Continuous internal assessment represents an attempt to devise a superior alternative form of practical internal examinations. This is due to the fact that many science teachers believe that in any prolonged course of study much of the interesting and worthwhile work that is undertaken is not assessed in a final examination. This type of work of which the teacher has intimate knowledge can legitimately draw upon all available sources of information in order to arrive at descriptions which are so fair and accurate as human ingenuity can make them. One of these sources is undeniably the teacher's opinion. Teacher assessment is, of course, not new to the educational scene. Most science teachers have generally accepted that, if assessment is to reflect the originality of the work being carried out in the school, then there must be an element of internal assessment. This change is a response to a range of concerns expressed by classroom teachers and those responsible for external practical examinations. Certainly most teachers would see this task as a natural part of their role as teachers and simply an extension of the assessment that all teachers carry out in their day-to-day teaching. Continuous assessment is regarded as the best instrument for assessing practical work as it can cover adequately the variety of tasks and techniques which comprise a total program of practical work and it reduces the likelihood of chance, success or failure.

This method is regarded as the only satisfactory method for determining whether a student demonstrates the necessary manipulating activity or not, in which a teacher makes observations of a student while the experiment is in progress. By using continuous assessment, the teacher is in a position to identify those students who have developed the appropriate competencies in the manipulation, and execution of a practical activity.

In other words, with greater involvement in the continuous assessment of practical skills, the teacher is likely to develop a greater awareness of the scope and objectives of laboratory work, as well as identifying student strengths that otherwise may not have been reflected in more conventional assessments.

Although most teachers are in favour of this method of assessment, it does have its opponents whose objections are mainly association with the time-consuming nature of such procedures.

In observational assessment, the teacher unobtrusively observes and rates each student during normal laboratory activities. Observations can be recorded over an extended period of time, or they can be made after a single laboratory activity.

Some Examining Boards or Institutions are now aware of the problems that may arise if teachers are not guided in this matter. For example, in the case of a teacher making assessment of the skills over a period of time during which he can observe each student for a reasonable length of time, some problems arise because the more original and novel the course work, the more difficult it is to establish criteria for assessment that will ensure uniformity of standards between the very large numbers of schools involved. Thus the Schools Boards involved normally take care of such problems by offering guidelines to schools.

For instance, the SCISP (School Council Integrated Science Project) curriculum is associated with the following recommendations, in which a teacher is guided on how to conduct his assessment and what he has to assess, based on the aims of assessment.

Table 7.2

COURSE AIMS OF THE SCIS CURRICULUM

Skills:
Candidates should be able to demonstrate their degree of competence in:

1. (a) recalling and (b) understanding those concepts which would enable them to pursue science (course in Physics, Chemistry, Biology or Physical Science) to a higher level or as a hobby.

2. (a) recalling and (b) understanding those patterns which are of importance to the scientist.

3. making critical appraisal of available information (from whatever source) as an aid to the formulation or extraction of patterns.

4. using patterns and making critical appraisal of available information in order to
   (a) solve scientific problems and
   (b) make reasoned judgements.

5. Organising and formulating ideas in order to communicate them to others.

6. understanding the significance, including the limitations, of science in relation to technical, social and economic development.

7. being accurate in the reporting of scientific work.

8. (a) designing and performing simple experiments (in the laboratory and elsewhere) to solve scientific problems and (b) to show perseverence in these and other learning activities.

<u>Attitudes</u>:
Candidates should:

9. be able to work (a) individually and (b) as part of a group.

10. (a) be sceptical about suggested patterns yet
    (b) willing to search for and test for patterns.

11. be concerned for the application of scientific knowledge within the community.

Aims 5, 7, 8(a) and (b), 9(a) and (b), 10(a) and (b) and 11 in the above table are assessed by the teacher by using a five-point scale as shown in Table 7.3 which shows how a teacher awards marks and the criteria for award of marks (Aim 9 is used as an example).

<u>Aim 9</u>: <u>Being able to work individually and as part of a group</u>

Some experiments are designed for individual work; others are designed for group activity. Teachers are expected to assess each aspect of the aim separately. In working individually a student should be able to gather and erect apparatus, perform the experiment and reach his conclusion, without asking others for help.

Table 7.3 THE ASSESSMENT PROFILE FOR AIM 9 IN THE SCIS CURRICULUM

Aim Assessed	Mark Awarded	Criteria for Award of Mark
9(a)	5	Tends to be self confident and works with little supervision. Seeks information (from a variety of sources) by himself. A high standard of (individual) homework.
	4	Works well within the confines of the pupils' manual (or similar instructions).
	3	Sometimes distracted by other activities, showing lack of concentration. Homework reasonably attempted. Seeks help from others if the answers are readily available.
	2	Need for reassurance by the teacher. Needs help and regularly reminding of the task in hand.
	1	Work needs constant checking. Very easily distracted.
9(b)	5	Has the ability to act either as a team leader (e.g. planning the group task and participating in this) or as a team member (e.g. carefully carrying out his part of the whole task). Does not monopolise a discussion. Deals with peers with tolerance and respect their opinions.
	4	Takes part in class discussion. Anxious that the purpose of the whole group should come to fruition.
	3	Reliably carries out instructions which are given. Always has to be invited to participate in class discussion but does so when asked.
	2	Prefers to watch rather than to do but will carry out assigned tasks. Little contribution to class discussion.
	1	Does not contribute to group discussion. Allows other members of the group to do all of the work. Passive involvement in all group activity.

The following are some basic principles of continuous assessment as summarised by Gidding, Hofstein (1979) concerning practical work.

1. Teachers should inform their students at the beginning of the course that their practical work is being assessed in a continuous manner over the whole program. Details should be given regarding the abilities and skills that are to be assessed. Fears have been expressed that the position of the teacher as an assessor may affect adversely the close relationship between student and teacher. Experience suggests that no fear need exist. Teachers are normally invovled in the assessment aspect of a student's work as part of their everyday teaching.
2. As far as possible, the teacher should make assessments during a normal practical class and make their assessment procedure as unobtrusive as possible. It is not necessary to assess all students on the same day or on the same experiment. It may be that some students are absent or more likely there is insufficient time to assess all students. Also any one experiment is unlikely to assess all the areas at one time.
3. There are three main ways in which marks can be allocated to a particular objective and teachers will probably find that they will have to use all of them at some stage of the program:
   (i) <u>A mark scheme</u>. This will be most useful when marking written evidence of observation, interpretation, planning and accuracy.

(ii) Marking by impression on a single occasion. This will be useful for marking evidence that is less precise than in (i). For example, a teacher may wish to assess dexterity in handling unfamiliar apparatus - say in some simple paper chromatography. Teachers should try only assess one such quality during the session by impression using some kind of the rating scale.

(iii) Marking by impression over a period of time. This will apply mainly to altitudes to practical work, but some of the less precise aspects of manipulative skills may also be better assessed periodically rather than in single experiments. The period can be once a term, once a year, or for some objectives, once at the end of the course.

The following is a comparison of the three methods of Laboratory Assessment in the context of High School Science Instruction as presented by Giddings and Hofstein (1979).

Table 7.4

A COMPARISON OF THE THREE METHODS OF LABORATORY ASSESSMENT

Dimension	Written Report	Paper-and Pencil Test	Practical Examination	Continuous Assessment
Outcomes measured	Comprehension and Interpretation	Comprehension, Interpretation and Planning	Manipulation and Comprehension	Can cover all the objectives in the particular domain
Reliability	Very low	Low-medium	Very low	High
Validity	Low	Low	Low-medium	Medium-High
Usability:				
Convenience	High	High	Low	Medium
Economy	High	High	Low	Low
Interpretability	Low	Low	Low	High
Assessor	Teacher	Teacher	Teacher or External Assessor	Teacher
Degree of Involvement of Assessor	Low	Low	High	High
Level of Anxiety on Behalf of Student	Low-Medium	Medium	Very High	Low-Medium
Use in Redesigning and Planning of Future Program	Low	Low	Low	High

In this chapter we have argued the case for three different modes of assessment of practical work. Further to that, we concur with many educators and teachers that all three modes are essential for a comprehensive evaluation. The three modes are essentially interdependent, but on its own written evidence assessment method, assesses only a limited range of laboratory skills, hence the teacher cannot base his assessment solely on written evidence; neither should his assessment depend on practical examinations alone, in which students are assessed on the basis of certain previously identified criteria; nor should he base his assessment on just continuous assessment, in which during a particular course, the student is assessed by his own teacher over a number of different classroom experiments. If the continuous assessment method is used alone it could be highly subjective.

Therefore, in order to have a sound practical assessment in schools one is bound to use the three methods mentioned, which could be very taxing and time-consuming for the teacher.

CHAPTER EIGHT

TEACHERS' AND STUDENTS' PRACTICE AND PREFERENCES REGARDING THE ASSESSMENT OF PRACTICAL WORK IN TASMANIAN SCHOOLS

In a survey conducted in the U.K. by Buckley and Kempa (1972) it was found that teachers and students who participated in the enquiry showed considerable preferences for a system of teacher-based assessment of practical abilities in place of external examinations. Such findings and recommendations have led some educators to ponder on the adoption of an assessment procedure that would require teachers to accept the role of assessors/examiners. It is argued that teachers would find the enterprise to be too tedious and time consuming. Others have argued that a system of teacher-based assessment, if adopted, would reflect adversely on the student/teacher relationship in that strains would arise between teacher and student which do not normally exist where external examinations only are used.

Consequently, in this survey it was thought of interest to examine students' preferences in regard to assessment, and the teacher's practice in regard to assessment of practical work.

This information was obtained from teachers with regard to the following questions:

(a) Did you assess the practical work done by your students in 1980?

(b) If yes, how did you assess it in 1980?
Teachers were asked to tick any method they used to assess practical work from the list:
(i) Practical examinations (externally assessed)
(ii) Practical examinations (internally assessed)

(iii) Continuous assessment by the teacher

(iv) A combination of (i) and (ii)

(v) A combination of (i), (ii) and (iii)

In regard to whether they assessed practical work or not, the following results were obtained:

Table 8.1

TEACHERS' RESPONSES IN REGARD TO THE ASSESSMENT OF PRACTICAL WORK

	Percentage Response (teachers)		
Assessed Practical Work or Not?	At Grades 7 and 8	At Grades 9 and 10	At Grades 11 and 12
Yes	89	89	96
No	11	11	4
N =	168	181	55

Results:

The results show that the majority of teachers at both High School and Matriculation levels are actively engaged in the assessment of practical work done by their students.

The responses from High School and Matriculation teachers in regard to *practice* for type of assessment are provided in Table 8.2.

Table 8.2

TEACHERS' PRACTICE REGARDING THE METHOD OF ASSESSMENT OF PRACTICAL WORK

	Percentage Response (teachers)		
Type of Assessment	At Grades 7 and 8	At Grades 9 and 10	At Grades 11 and 12
Continuous assessment (by teachers)	84	78	78
Practical examinations (by teachers)	15	18	12
Practical examinations (external)	1	1	0
Both Practical examinations (external) and practical examinations (internal)	0	2	10
All above (Practical examination, external, practical examinations, internal, and continuous assessment)	0	1	0
N =	133	149	50

Results and Comments:

From Table 8.2, the order of practice indicates that the grades 7 and 8 teachers (99%) assess practical work, partly by some practical tests and partly by continuous assessment. Similarly at grades 9 and 10 (96%) and at grades 11 and 12 (100%) use that method. But in the main, most teachers at all levels (over 80%) use the continuous assessment method alone. The results indicate that teachers are strongly in favour of teacher-based assessment of practical abilities.

Similarly, information was obtained from students with regard to the following questions:

1a) *Do you think that your practical work should be assessed separately?*

1b) *What percentage should practical work contribute to your overall mark in Science?*

Students were asked to express their preference for one of the following methods of assessing practical abilities.

i) *Practical examinations (by outside examiner)*

ii) *Practical examinations (by your teacher)*

iii) *Continuous assessment (by your teacher)*

iv) *Both (i) and (ii)*

v) *All of (i), (ii) and (iii)*

'Practical work' was defined as including demonstrations by the teacher, as well as experiments performed by the student either in groups or individually.

In regard to whether they think practical work should be assessed separately, the following results were obtained.

Table 8.3

STUDENTS' RESPONSES IN REGARD TO WHETHER PRACTICAL WORK SHOULD BE ASSESSED SEPARATELY

Practical work to be assessed separately	Students' Responses at High School Level (%)	Students Responses at Matriculation	
		Physics (%)	Chemistry (%)
Yes	61	89	89
No	39	11	11
N =	459	230	231

From Table 8.3, it is clear that most of the students at both levels are in favour that their practical work should be assessed separately, and matriculation students are much more in favour of this method than High School students in this regard.

Concerning their preferences regarding the method of assessment of practical work, the results are indicated in Table 8.4.

Table 8.4

STUDENTS' PREFERENCES REGARDING THE METHOD OF ASSESSMENT OF PRACTICAL WORK

Preferred Type of Assessment	Percentage response (students)		
	At High School	At Matriculation Level	
		Physics	Chemistry
Continuous assessment (by teacher)	48	78	79
Practical examination (by teacher)	30	13	12
Practical examination (external)	6	4	4
Both Practical examinations (external) and Practical examinations (internal)	8	1	1
All above (Practical examinations, external, Practical examinations, internal, and continuous assessment	8	4	4
N =	300	207	210

Results and Comments:

The order of preference indicates that the High School students (78%) would like their practical work to be assessed by their own teachers, partly with practical tests and partly by continuous method. Matriculation (Physics and Chemistry) students (91%) responded in a similar manner. It is interesting to note that Matriculation students (≃78%) have a much higher preference for continuous assessment than High School students (48%). Generally it is found that students are strongly in favour of teacher-based assessment of practical abilities.

Teachers were asked to indicate what percentage of their students' overall mark they would prefer to be allocated to practical work. The responses are provided in Table 8.5.

Table 8.5

TEACHERS' PREFERENCES REGARDING THE WEIGHTING OF PRACTICAL WORK

	Percentage response (teachers)		
Suggested percentage contribution to the overall mark	At Grades 7 and 8	At Grades 9 and 10	At Grades 11 and 12
0%	2	1	2
About 10%	17	17	7
About 20%	30	27	42
About 30%	23	29	30
About 40%	10	10	8
About 50%	10	12	11
More than 50%	8	4	0
N =	168	181	46

Results and Comments:

From Table 8.5, the results indicates that about 51% of the teachers at grades 7 and 8; 55% at grades 9 and 10; and 49% at grades 11 and 12 prefer the weighting of 30% or more of the overall mark to be allocated to practical work.

Teachers obviously prefer a much more substantial contribution to the overall mark from practical work than exists at present. At Matriculation level, (Physics A and Chemistry A) and at High School level almost a half of teachers prefer a weighting of 30% or more.

It was thought important to explore any possible differences between male and female teachers' preferences in regard to assessment of practical work. The results are given in Table 8.6.

Table 8.6

THE ASSOCIATION OF TEACHERS' ASSESSMENT PREFERENCES OF PRACTICAL WORK WITH SEX DIFFERENCE OF TEACHER

	Percentage response (teachers)					
	At Grades 7 and 8		At Grades 9 and 10		At Grades 11 and 12	
Suggested percentage contribution to the overall mark	Males	Females	Males	Females	Males	Females
0%	2	3	1	0	2	1
About 10%	15	30	15	19	14	8
About 20%	31	14	31	17	37	42
About 30%	17	27	22	36	23	17
About 40%	9	11	10	6	9	17
About 50%	16	12	14	14	14	8
More than 50%	10	3	7	8	0	6
N =	131	37	145	36	43	12

Results and Comments:

The responses from male and female teachers are very similar at all grade levels except some minor fluctuations in distribution notable at grades 7 and 8. Teachers' orientation towards weighting of practical work is not associated with the sex difference of teachers involved.

It was also thought important to examine any possible association of preferences regarding assessment with years of teacher experience. The results are given in Table 8.7.

Table 8.7

THE ASSOCIATION OF TEACHERS' ASSESSMENT PREFERENCE OF PRACTICAL WORK WITH YEARS OF EXPERIENCE

	Percentage response (teachers)											
	At Grades 7 and 8				At Grades 9 and 10				At Grades 11 and 12			
Suggested contribution to the overall work	<1yr	1-3 yrs	4-10 yrs	>10 yrs	<1yr	1-3 yrs	4-10 yrs	>10 yrs	<1 yr	1-3 yrs	4-10 yrs	>10 yrs
0%	0	0	4	0	0	0	1	0	0	0	0	0
About 10%	27	20	15	19	20	16	16	14	0	14	18	8
About 20%	27	20	32	24	27	28	29	26	13	43	46	31
About 30%	18	11	20	24	7	31	25	26	38	29	11	39
About 40%	9	20	5	11	12	13	12	12	25	0	7	15
About 50%	0	19	17	14	27	9	14	17	25	14	17	8
More than 50%	18	9	7	8	7	3	3	5	0	0	0	0
N =	11	35	85	37	15	32	92	42	8	7	28	13

Results and Comments:

Preferences were not associated to any extent with years of teaching experience at either grades 7 and 8 or grades 9 and 10 but there were some anomalous results from teachers at grades 11 and 12. Briefly, the percentage of grade 11 and 12 teachers preferring a weighting of 30% or more with years of experience are as follows: 88%/exp<1 year; 43%/exp 1-3 years; 35%/exp 4-10 years; 62% exp>10 years.

Group sizes are small but there may be an orientation here well worth exploring in depth.

It was thought important to investigate the preference of teachers with regard to the assessment of practical work in respect to the type of school involved (i.e. State, Independent and Catholic). The results are shown in Table 8.8.

Table 8.8

THE ASSOCIATION OF TEACHERS' ASSESSMENT PREFERENCE OF PRACTICAL WORK WITH TYPE OF SCHOOL CONTROL

	Percentage response (teachers)								
	At Grades 7 and 8			At Grades 9 and 10			At Grades 11 and 12		
Suggested per-cent contrib-ution to the overall mark	State	Indep	Cath	State	Indep	Cath	State	Indep	Cath
0%	2	0	0	1	0	0	0	0	0
About 10%	17	10	40	17	12	13	15	7	11
About 20%	28	40	10	28	29	25	36	43	33
About 30%	25	10	10	26	29	13	21	29	22
About 40%	9	20	10	7	12	19	12	7	11
About 50%	10	20	20	13	12	25	9	14	22
More than 50%	9	0	10	8	6	5	7	0	1
	148	10	10	148	17	16	33	14	9

Results and Comments

Groups of Independent and Catholic schools results do need to be interpreted with caution. However, there are virtually no differences in preference for teachers in the different types of school (State v Independent v Catholic), other than a few minor fluctuations associated with Catholic High Schools.

Students were also asked to indicate the percentage they thought that practical work should contribute to their overall mark in science. The following results were obtained as given in Table 8.9.

Table 8.9

STUDENTS' PREFERENCES REGARDING THE WEIGHTING OF PRACTICAL WORK

Suggested percentage contribution to the overall mark	Percentage response (students)		
	At High School	At Matriculation level	
		Physics	Chemistry
0%	4	8	8
About 10%	11	18	18
About 20%	19	33	36
About 30%	22	16	21
About 40%	14	10	8
About 50%	30	14	10
More than 50%	0	1	0
N =	459	239	247

Results and Comments

From Table 8.9, the results indicate that about 66% of students at High School, 41% Physics students and 39% Chemistry students at Matriculation levels prefer a weighting of 30% or more of the overall mark to be allocated to practical work.

Students, like teachers, obviously prefer a much more substantial contribution to the overall mark than exists at present, though Matriculation students prefer a lower weighting than High School students, and their preferred weighting is somewhat lower than that preferred by their teachers (approx: students 40% c.f. teachers 50% prefer a weighting of 30% or more). The responses of High SChool students indicate a preference for a higher weighting than that of teachers (approx: students 60% c.f. teachers 50% prefer a weighting of 30% or more).

Less than 1% of High School students preferred a weighting of more than 50%. However, the High School group repond as two populations, one group preferring a weighting about 20-30% and second group preferring a weighting of about 50%.

At Matriculation level, the responses of students of Physics and Chemistry are virtually identical.

Teachers were required to indicate how often they assessed their students' performance in practical work in Science. Their responses are given in Table 8.10.

Table 8.10

FREQUENCY OF ASSESSMENT OF PRACTICAL WORK ACCORDING TO TEACHERS

	Percentage Response (teachers)		
Frequency of Assessment	At Grades 7 and 8	At Grades 9 and 10	At Grades 11 and 12
About once a week	29	31	61
About once a month	45	51	27
About once a term	18	11	7
About once a year	3	3	0
Never	5	4	5
N =	168	181	55

Results and Comments

At Grades 7 and 8, about 74% of the teachers indicated that they are assessing practical work at least once a month, while at Grades 9 and 10, about 82% of teachers indicated that frequency; and at Grades 11 and 12, about 88% are assessing practical work at least once a month. Matriculation teachers indicate a particularly high weekly frequency fo assessment (61%).

Students were asked to indicate how often their teachers gave them marks or awards for their practical work. High School students were asked to refer to the past two years at school, while Matriculation students were asked to refer to their matriculation subjects. Their responses are indicated in Table 8.11.

Table 8.11

FREQUENCY OF ASSESSMENT OF PRACTICAL WORK (ACCORDING TO STUDENTS)

	Percentage Response (students)		
	High School	Matriculation Level	
Frequency of Assessment		Physics	Chemistry
About once a week	11	34	54
About once a month	12	38	26
About once a term	30	18	11
About once a year	11	3	3
Never	36	7	6
N =	459	239	247

Results and Comments

From Table 8.11, the results indicate that 23% of High School students were given marks or awards for their practical work contrary to what their teachers said (74% at Grades 7 and 8, and 82% at Grades 9 and 10).

At Matriculation level, 72% of Physics students and 80% of Chemistry students indicated this frequency, which is almost in agreement with their teachers' responses (88% at Grades 11 and 12).

At both levels, teachers indicated a much higher response for that frequency than their students.

Generally it seems there is some kind of practical evaluation taking place at both High School and Matriculation levels with greater frequency at Matriculation level than at High School level.

Again students were asked if they have had any practical tests set by their teachers.

(i) At High School level students were asked "During the past two years at school have you ever had any *practical tests* set by your teacher?"

(ii) At Matriculation level, students were asked "Apart from any practical examination set by the Schools Board or Examinations Board have you ever had any *practical tests* set by your teacher?"

Their responses are as indicated in Table 8.12.

Table 8.12

STUDENTS' RESPONSES IN REGARD TO WHETHER THEY HAD ANY PRACTICAL TESTS SET BY TEACHERS

	Percentage Response (students)		
Any practical test by the teacher	High School	Matriculation level	
		Physics	Chemistry
Yes	38	26	21
No	62	74	79
N =	459	226	131

Results and Comments

From Table 8.12, the results indicate that it is not a common practice for teachers to give practical tests to their students as part of their practical assessments.

Those students who indicated that they have had practical tests set by their teachers, were asked to indicate how often those tests were given. Their responses are given in Table 8.13.

Table 8.13

FREQUENCY OF DOING PRACTICAL TESTS (ACCORDING TO STUDENTS)

	Percentage Response (students)		
	High School	Matriculationlevel	
		Physics	Chemistry
About once a week	4	4	5
About once a month	15	4	5
About once a term	30	34	22
About once a year	30	14	11
Never	21	45	57
N =	218	104	109

Results and Comments

The results from Table 8.13 indicate that the assessment by using practical tests is not at all a common practice in Tasmanian schools at both High School and Matriculation levels. It seems, where it takes place, it would be at most once a term.

Although the major part of practical experience is likely to be relatively 'immediate' laboratory based experience, it was decided to examine to what extent extended practical work (projects), and outside activities (field work and excursions) are used in Tasmanian Schools. Results are provided in Table 8.14.

Table 8.14

FREQUENCY USE OF OTHER FORMS OF PRACTICAL WORK AS REPORTED BY TEACHERS

	Percentage Response (teachers					
Type of Practical Work	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions (visits) conducted by the teacher	0	0	12	20	50	18
Field work done by the student (field work is practical work done outdoors)	2	1	12	40	25	20
Project work done by the student individually or in groups	12	7	17	48	8	8

Results and Comments

A sizeable percentage of teachers (28-30%) indicate that they never use *excursions* or field work but a surprising percentage 12% of High School and Matriculation teachers indicate that they conduct an excursion once a month.

Field work is rather more common than project work with the majority of teachers indicating at least once a term.

Project work is generally conducted once a term but a substantial number of teachers (36%) indicate a frequency greater than this.

Table 8.15

FREQUENCY USE OF OTHER FORMS OF PRACTICAL WORK (AS REPORTED BY HIGH SCHOOL STUDENTS)

Type of Practical Work	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions (visits) conducted by the teacher	2	1	2	4	26	65
Field work done by the student (field work is practical work outdoors)	2	1	5	25	28	39
Project work done by the student individually or in groups	16	4	15	35	15	15

Results and Comments: High School Students

Excursions: About one third (35%) of High School students indicate that they had excursions as part of practical work at least once a year, while the rest indicate that they had not taken part in any excursion (65%) which is at variance with the teachers' responses.

Field work: About 39% of the students indicate that they never had any field work, but it seems field work is rather more common with a substantial group (53%) indicating between once a term and once a year.

Project work: Project work is generally conducted once a term (35%) but an equal percentage indicate a frequency greater than this.

Table 8.16

FREQUENCY USE OF OTHER FORMS OF PRACTICAL WORK (AS REPORTED BY CHEMISTRY MATRICULATION STUDENTS

Type of Practical Work	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions (visits) conducted by the teacher	1	0	0	0	4	95
Field work done by the student (field work is practical work done outdoors)	0	0	0	5	7	88
Project work done by the student individually or in groups	1	2	1	80	16	0

Table 8.17

FREQUENCY USE OF OTHER FORMS OF PRACTICAL WORK (AS REPORTED BY PHYSICS MATRICULATION STUDENTS)

Type of Practical Work	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions (visits) conducted by the teacher	0	0	0	1	6	93
Field work done by the student	0	0	3	19	25	53
Project work done by the student individually or in groups	1	0	3	78	10	8

Results and Comment: Matriculation level

Excursions: More than two thirds of Matriculation Chemistry students (95%) and Physics students (93%) indicate that they never had excursions, contrary to their teachers' responses. It seems excursions are taking place more often at High School than at Matriculation level.

Field work: Again a sizeable percentage of Chemistry students (88%) and Physics students (53%) indicate that they never had field work. The evidence is that field work is more common at High Schools than at Matriculation level.

Project work: The majority of Matriculation students indicate that they did project work as part of practical work once a term (80% Chemistry students and 78% Physics students). This indicates project work is rather more common than excursions or field work. This is also in agreement with teachers' responses.

8.0 OBSTACLES TO PRACTICAL WORK

It was considered important to investigate if teachers felt there were any obstacles to their conducting practical work in their schools. Teachers were presented with five statements to represent a possible source of difficulty in arranging student experimental work. They were asked to place a tick in the appropriate column to indicate the degree to which each has been a source of difficulty at their schools in 1980.

Table 8.18 represents teachers' responses to each statement, at both High School and Matriculation levels.

Table 8.18

OBSTACLES TO PRACTICAL WORK AT GRADES 7 AND 8

OBSTACLES TO PRACTICAL WORK	Percentage response (teachers)			
	Not a problem	Rarely a problem	Sometimes a problem	A significant problem
An insufficient supply of basic apparatus	45	28	23	4
Inappropriate laboratory facilities	27	27	28	18
Too much preparation time involved	33	21	36	10
Too few laboratory assistants	46	17	16	21
Difficult to store apparatus	28	26	33	13

Table 8.19

OBSTACLES TO PRACTICAL WORK AT GRADES 9 AND 10 ACCORDING TO TEACHERS

	Percentage Response (teachers)			
OBSTACLES TO PRACTICAL WORK	Not a problem (%)	Rarely a problem (%)	Sometimes a problem (%)	A significant problem (%)
An insufficient supply of basic apparatus	44	29	24	3
Inappropriate laboratory facilities	27	29	24	20
Too much preparation time involved	31	24	32	13
Difficult to store apparatus	34	23	30	13
Too few laboratory assistants	45	20	15	20

Table 8.10

OBSTACLES TO PRACTICAL WORK AT GRADES 11 and 12 ACCORDING TO TEACHERS.

	Percentage Response (teachers)			
OBSTACLES TO PRACTICAL WORK	Not a problem (%)	Rarely a problem (%)	Sometimes a problem (%)	A significant problem (%)
An insufficient supply of basic apparatus	43	31	21	5
Inappropriate laboratory facilities	63	30	5	2
Too much preparation time involved	43	25	30	2
Difficult to store apparatus	59	20	16	5
Too few laboratory assistants	40	28	16	16

Results and Comments: On Obstacles to Practical Work

At Grades 7 and 8:

A sizeable percentage of teachers indicate that they have a sufficient supply of basic apparatus (73%), appropriate laboratory facilities (54%), but also indicated that there are some obstacles to practical work such as too much preparation time involved (54%), too few laboratory assistants (37%), difficulty to store apparatus (46%). Responses suggest that more than half of the teachers at Grades 7 and 8 are satisfied with the laboratory facilities in their schools.

At Grades 9 and 10:

Again at Grades 9 and 10, teachers seem to be satisfied with practical work facilities in schools. 73% feel they have a sufficient supply of basic apparatus, 56% have appropriate laboratory facilities; though 45% feel that too much preparation time is involved; 35% indicate they have too few laboratory assistants; and 43% feel there is a difficulty in storing apparatus.

At Grades 11 and 12:

At Matriculation level, teachers' responses were similar to those from the High Schools in some areas: 74% feel they have a sufficient supply of basic apparatus; 32% feel too much preparation time is involved; 32% feel they have too few laboratory assistants. The difference in responses were observed in two areas: 93% are satisfied with their laboratory facilities (56% at High School level indicated satisfaction); 21% feel they have difficulty to store apparatus (43% at High School level indicated this difficulty).

8.1 GENERAL COMMENTS

The results in this survey show that there is clearly a big gap between current practice in regard to the use of practical work for overall assessment and the preferences of both teachers and students.

Tasmanian schools are generally well equipped in terms of basic equipment, laboratory facilities, laboratory assistance and storage. Functional problems are thus relatively minimal and this was indicated in the survey responses.

A considerable proportion of time would appear to be spent on a range of practical experiences, more so at High School than Matriculation level. Students would indicate that, in some situations, this involvement is considerably less than claimed by teachers.

What remains then is an educational justification for the shift in emphasis preferred by teachers and judgement as to whether or not it is administratively feasible. The educational justification is easily made. Practical skills and laboratory work is a badly neglected area and yet it represents a component of school science which if used imaginatively, could make the latter much more appropriate to the needs of the average student and the non-scientist. Scientific literacy is a major consideration for teachers and educators.

CHAPTER NINE

THE HISTORICAL DEVELOPMENT OF THE SCIENCE SYLLABUS AND ASSESSMENT PROCEDURES FOR PRACTICAL WORK IN TASMANIA IN THE PAST THREE DECADES

This chapter deals mainly with the historical development of the science syllabus and describes in detail the assessment procedures for practical work that have been employed by teachers in Tasmanian schools as from 1950.

At the same time it was considered desirable to examine the role of the Schools Board of Tasmania and the perceptions of the Supervisors of Science in the past three decades. The Supervisor of Science is in a unique situation in that he is in a position to generalise from direct contact and observation of all aspects of science teaching for every individual school in Tasmania. Perceptions regarding such matters were obtained from individual supervisors using a structured interview.

9.0 THE ROLE OF THE SCHOOLS BOARD OF TASMANIA

Since it is the Schools Board that is responsible for appointing a Science Syllabus Committee and to set external examinations it is important to analyse its role since 1945.

In 1946 the school leaving age in Tasmania was raised to sixteen years and the Schools Board (constituted in 1944), instituted a four year course of academic secondary education leading to the Schools Board Certificate. The Intermediate Examination, which had been conducted by the University at third year secondary school up to 1938, had been replaced by similar examinations conducted by the State Education Department and the Associated Public Schools.

These examinations now ceased, and the Schools Board Certificate at fourth year level replaced them from 1946. Secondary Schools were allowed to choose between an accrediting system or an external examination. In 1959, in order to accommodate the changing system of secondary education in Tasmania, the by-laws were amended (to take effect in 1960) to provide a wide range of certification at the fourth year secondary level. In 1969 the Schools Board became the sole examining and certifying body at the secondary level.

Under the influence of the Schools Board the Science Syllabuses were continually modified, and one feature that emerges from examination of written recommendations over this period is an increasing emphasis on practical work.

In the past three decades, science educators and teachers in Tasmania have been involved in the production of new science curricula which have a reduced emphasis on content. This approach has developed as a consequence of two main orientations. Firstly the questioning of the autonomy of the scientific disciplines and the growing conviction that the *scientific process* considered common to all the scientific disciplines is more important than the content. Secondly the notion of integration of the disciplines so that a multi-scientific disciplinary approach can be brought to bear on major themes. While this general approach was evolving various minor changes were made to the documented science syllabuses, and many educators and teachers were involved in the production of these syllabuses. What is most important to observe is the steady and growing involvement of practising teachers in curriculum decisions.

In this context, the science syllabus has become a consensus statement of the aims and objectives of education in science, and today a curriculum handbook is produced to assist teachers in the task of selecting suitable learning experiences or activities to achieve these aims. In recent years, there has been a move from a syllabus of stated general aims towards a more flexible and detailed curriculum description intended to act as a guide for science teachers.

A brief description of the present High School and Matriculation level syllabuses in Tasmania would seem to be in order.

9.1 THE PRESENT HIGH SCHOOL SCIENCE SYLLABUSES

Science Syllabuses for High School (grades 7 to 10) in Tasmania are outlines of endpoints to be reached rather than subject topics prescribed in detail. Since there is no external examination in Tasmania at this level, it is claimed that there does not need to be the complete uniformity of subject matter that was previously demanded. Consequently, schools have a school based general science syllabus from grades 7 to 10. Some Independent and Catholic schools, on the other hand, continue to teach the individual disciplines.

The syllabus indicates the areas of study that could be covered by students. Teachers base their courses of study on the aims of education in science, i.e. knowledge, skills, attitudes and interests, and normally take into account the locality and the school facilities available when determining the emphasis to be placed on the course of study or unit. Teachers are advised by the Schools Board to make a *practical approach* to the principles outlined in the syllabus. Most of the units are oriented about *laboratory experiences* and *investigations* largely stemming form the students themselves.

9.2 THE PRESENT MATRICULATION LEVEL SCIENCE SYLLABUSES

For a long time, at Matriculation level, courses have been rigidly defined in the four science areas with teachers being tied to courses established by the Higher School Certificate Committee of the Schools Board of Tasmania.

In grades 11 and 12, prescribed syllabuses are given in a much greater detail by comparison with the High School Syllabuses and are examined externally. The prescribing bodies are the Schools Board of Tasmania's Subject Syllabus Committees which are made up of representatives of the University of Tasmania, the Department of Education and Independent schools with the addition of occasional co-opted members for limited terms.

Matriculation level syllabuses are examined externally by teams of examiners appointed by the Schools Board of Tasmania. In the main, the examiners are members of subject departments of the University and are also members of the appropriate syllabus committees.

The Chemistry and Biology Subject Committees have adopted modified forms of CHEM-STUDY and Biological Science (BSCS) respectively. The Physics Subject Committee proposed its own Trial Syllabus rather than adopt an overseas course.

The following are Board recommendations in regard to the Chemistry and Physics Syllabuses at Matriculation level which indicate the emphasis to be placed on practical work.

The latter are shown in italics.

*<u>Nature of the Chemistry Syllabus at Matriculation Level (Years 11 & 12)</u>

The syllabus consists of a main core with a prescribed list of options. Only the core material is examined externally. *A total of four weeks should be devoted to the options which comprise 15% of the total marks for the subject and which are assessed <u>internally</u>.* The internal assessment for the members of each class is standardized against the score the member of the class on the external examination. Only the core material is examined. *The syllabus is based on the principles and concepts of the Chem. Study course.*

*<u>Notes on Options</u>

In general the proposed options provide the opportunity for comprehensive *practical work* involving the application of skills already acquired. Internal assessment of the options will therefore allow assessment of some objectives which would otherwise be ignored. It is expected that most students would study two options for two weeks. However the possibility of devoting the four weeks to a single option has not yet been examined.

*<u>Nature of the Physics Syllabus</u>

The syllabus consists of a core plus options. Only the core material is examined externally. Assessment of the option is included in the internal component.

*<u>Regarding Options</u>

In general *the options should be covered as far as possibly to experimental investigation,* formal mathematical derivations being of secondary consideration.

* Abstract from the Higher School Certificate Manual for 1980.

Students *should learn to use appropriate apparatus and base their opinions on the results of carefully selected experiments*. This in no way precludes teachers from fully developing mathematical equations etc., but it is felt that the time available for the options does not allow as much in-depth study of the materials as would be required for the core component of the syllabus.

Thus one of the main purposes of dealing with this part of the syllabus is to broaden the student's experience in physics, and to link it with *the practical applications of physics* in certain areas.

Self-learning techniques and self-pacing programmes, would be ideal methods of dealing with some, if not all, of the options, there being good opportunities for students to deal with areas which they consider to be of real interest to them.

9.3 INTERVIEWS WITH PREVIOUS SCIENCE SUPERVISORS

In order to gain insight into developments which led up to the present situation, where available all of past and present Science Supervisors were interviewed using a structured interview technique. Table 9.1 shows the interviewed supervisors.

Table 9.1

INTERVIEWED PREVIOUS AND PRESENT SCIENCE SUPERVISORS

Name	Period as Supervisor	Current Occupation
Hector Boyd *	1950-1954	Now retired, and former Senior Lecturer, University of Tasmania
Jim Scott	1964-1971	Acting Director General of Education
Brian Hortle	1971-1973	Matriculation College Principal, seconded to the Education Department (Further Education area)
Graham Fish	1974-1978	Regional Superintendent of Schools
Ian Winter Roy Pallelt	1979-1982 1978-1982	Acting Science Supervisor in place of Roy Pallelt who is the current supervisor

The detailed structured 'prompt' sheet is given in the Appendix. Essentially, supervisors were asked to explain:

> The role of a Science Supervisor in Tasmania in regard to the Science Syllabus and assessment; the major changes or developments that took place in the syllabus in science; the major changes that took place in regard to practical work during their times; and finally the major changes that took place in regard to assessment of practical work. For each question, Supervisors were required to comment regarding their attitudes towards those changes at that time and their attitudes now, with hindsight.

* The gap between 1954-1964 is due to two reasons, that:
  (a) after Hector Boyd the position of science supervisor was left vacant for some time;
  (b) the next supervisor who took over in the late 50's is deceased.

Hector Boyd: Science Supervisor (1950-1954)

On the Role of Science Supervisor

Hector Boyd was the first Science Supervisor to be appointed in Tasmania and his role was to ensure that the syllabus was suitable for all schools, and *to assess teachers and schools* in regard to science teaching. The High School Science Syllabus, at that time, was general science and there was little opportunity to teach the separate disciplines. Boyd reintroduced separate Physics, Chemistry and Biology, as well as a range of general science options so that in principle there was a range of possible studies in science.

At Matriculation level, Physics and Chemistry remained unaltered until the mid sixties.

According to Boyd

> *'the standard of science teaching was very low, and that was for two reasons; first, there were very few well qualified science teachers. For instance, only three teachers in the State Schools had a degree in Physics and not many more in Chemistry. The second reason was the lack of adequate equipments and laboratories.'*

On Practical Work

Boyd set up a Science Centre in Hobart where a considerable range of equipment was constructed and made available to schools in Tasmania.

In the early 50's there were approximately 15 High Schools in Tasmania which simplified this distribution of equipment. Seminars were conducted in Burnie, Launceston and Hobart on the various science subjects using the best local teachers to demonstrate experiments suitable for the new syllabuses and the equipment one would use for them. These sessions became very popular. During Boyd's time laboratories were built in most new Tasmanian Schools, and improvements started in the existing schools. A laboratory technician (or laboratory assistant) was appointed to every High School in Tasmania during Boyd's time, something that had not existed previously and was clearly intended to improve and foster laboratory work.

Boyd convinced the authorities of the need for central places in the new schools where all tools could be kept. 'Workshop' back-up of the sort envisaged had not previously existed in Tasmanian High Schools. There were more than 100 different tools itemised for carpentry, metal work, etc.

On assessment of practical work

As regards assessment of practical work, there was practically no assessment, except by individual teachers but it didn't count in any way towards final examination results. Boyd tried to introduce examinations into a few schools where teachers were willing but

> *'most of the teachers in Tasmania were very much against it. They weren't used to it, didn't understand it, didn't think it would work.'*

However, as Boyd reflects, in the U.K. at that time, practical examinations were part of a well-established tradition.

Jim Scott: Science Superintendent (1964-1971)

The role of a Science Supervisor

According to Scott, during the early 60's, the role of the Science Superintendent was one of ensuring that the facilities were adequate for the teaching of science; that the syllabus was appropriate for the students; and to assess teachers and schools with regard to the teaching of science (this was because most of science teachers were not trained). This was the only period that the superintendent had also a role of supervisor.

Much of Scott's energy in the mid-60's went into designing new laboratories and supplying new equipments, at a time when such things were becoming readily available. Discontent was expressed by teachers concerning the existing syllabus and it was felt that there was a need to redesign it in the late 60's. As Chairman of the various science committees of Schools Board, it was Scott's duty to bring about change in the syllabus which reflected teachers and schools' needs at that time. The Science teachers came to realise that the assessment of practical work was as important as the assessment of theory. However, the assessment of practical work taking place in schools was still the responsibility of the individual teacher, but schools now had to satisfy the Schools Board's prescribed requirements. As Superintendent Scott also assessed all Science teachers and examined their teaching programs.

The sixties according to Scott represented a period of disenchantment with aspects of formal science, particularly at High School level. There was the feeling that children were being forced to take in a great mass of scientific knowledge and simply regurgitate it. This reaction to Science Curricula was almost universal. In Tasmania, as in many other parts of the world teachers and educators could not agree on what should be kept in and what left out of the syllabus. Scott comments that the ideas of Benjamin Bloom found almost immediate acceptance by many, but not all educators in Tasmania.

In the Trial Syllabus, which was developed in line with Bloom's ideas, the following statements were made about Science:

> Science is a search for truth, leading by induction, deduction and verification to an organised body of knowledge which stimulates further research. Science requires careful observation and logical argument from well-established factual and theoretical bases leading to predictions which must be objectively tested. Application of knowledge so obtained allows man increased use and control of material environment.
>
> Personal involvement in science should lead the student to application of scientific method in his own search for truth and in decision-making, to an understanding of the forces operative in the material universe and their interplay and of the way in which such forces may be harnessed

> to the benefit of mankind. Such involvement should stimulate curiosity leading to continued professional knowledge of natural phenomena.

As Scott observes it was felt necessary to make a strong statement about the fundamental nature of scientific method. The Schools Board statement of 1971 then following by a consideration of *'effective learning'* and the familiar Bloom-type categorisation of desired outcomes in terms of knowledge, skills, attitude, interests, as follows:

> Knowledge: The student should acquire that scientific knowledge which enables him to gain the most fruitful understanding of his environment including himself as part of it.
>
> Skills: The student should develop skills necessary in a scientific search for truth. These skills are concerned with careful observation and accurate recording with correlation, with the recognition and clear definition of problems, with prediction, with design and conduct of experiments.
>
> Attitudes: Science studies should influence the students' approach to the problem solving by encouraging persistence, the practice of seeking evidence and of withholding judgment until evidence is available, imaginative thinking and the critical appraisal of theories and explanations. They should also lead to an appreciation of the impact of science on our society and to the formation of soundly based attitudes to the conservation of our total environment.
>
> Interest: The natural curiosity of the student should be guided and encouraged so that life long interests, beneficial to the individual and to society may be developed.

The Trial Syllabus according to Scott, proved to be unsatisfactory because *'teachers felt that it was too short, too neat, and didn't give them the real guidance that they wanted. It was viewed as a great failure.'*

Meanwhile at Matriculation level, there were also major changes taking place. Chem-Study was introduced in 1965 and the BSCS Syllabus, about at the same time. These curriculum packages were adapted for Australia. As Scott observes

'It was a complete change of what had gone on before from a knowledge oriented syllabus to methods of enquiry in science which students studied, and as they did so, they accumulated knowledge and skills.'

On practical work

There was a sharp shift in the type of practical work used at all levels.

'In the late 50's and early 60's there were still shortages of facilities in schools, the laboratories were not the laboratories of today and practical work was more demonstrational.'

Scott in his role as Supervisor made considerable efforts

'to change this and practical work was now done as group or individual work, and was less demonstrational.'

He notes that

'this was considered desirable by most science teachers at that time.'

The equipment in most school laboratories was updated in the mid to late 60's, and

> *'they turned themselves over to having real practical work with groups of children. This was a major change with regard to High Schools.'*

At Matriculation level, the change was considerable too. Schools adopted syllabuses which were mainly oriented to practical work; students were doing practical work all the time. Initially, Chem-Study in Tasmania

> *'was viewed as continuous practical work, where pupils had practical activities and a discussion with a teacher - and so on.'*

<u>On assessment of practical work</u>

Assessment of practical work during this period of considerable curriculum change still remained the responsibility of the individual teacher. Some High School teachers began to assess skills and techniques such as weighing and measuring or used tests for observational, communication or predictive skills. Although individual activities were encouraged there was no clear overall policy on such matters and no formalized assessment was considered necessary.

At Matriculation level strong recommendations were made for both Physics and Chemistry. The suggested minimum time for laboratory work was specified as 50 hours per year. The Chemistry Syllabus group appointed inspectors whost duties were limited to the inspection of laboratory facilities. However, specific assessment procedures for practical work internally or externally controlled, formal or informal were not considered. In view of the quite extensive work that went into assessment procedures for practical work in the U.K. during the same period of curriculum change, the Tasmanian (Australian) approach requires some explanation. Scott, partly explains this orientation as follows ...

> *'Since practical work was so much a part of the whole syllabus ... it was more than a requirement ... it was really part of a whole assessment.'*

One can't help feeling uneasy about this rationalisation in view of Boyd's observations that in the previous period teachers were simply reluctant to do so. It seems much more likely that decisions were a consequence of 'laissez faire' attitudes rather than a purposeful integration of practical work and theory.

Brian Hortle: Science Supervisor (1971-1973)

The role of a science supervisor

Hortle replaced Scott as Supervisor but did not have the role of Superintendent. The role of a Supervisor was now restricted to the guidance of teachers in regard to the matters related to the curriculum. Hortle spent much of his time in smaller schools (the District Schools) where there were no Senior Science Masters, or where there was only one teacher of science and very often someone with little experience. Hortle was also heavily involved in the implementation of the Australian Science Education Project (ASEP) in the State. According to Hortle

> *'the standard of Science in Tasmania during this time became very high. When ASEP units were first introduced, teachers accepted them, and there was genuine enthusiasm that they were so practically oriented. The students were given a package of practical exercises, as it were, they had to do for themselves and draw their own conclusions.'*

Hortle comments:

> *'I think, during that time there was a move to more practically based science work and investigational work in schools ... One thing I was pleased about was the fact that the changes in the High School Science Syllabus, and the introduction of the ASEP type units*

> *allowed teachers to introduce far more practical work into the classroom situation.*

<u>On practical work</u>

Hortle observed that

> *'practical work became the core of the work in the Science laboratory or science area',*

and that

> *'a few years before I became a science supervisor you could have gone to any school in Tasmania and you would have found if they had seven periods a week for science, five periods would have been in the classroom and two, a double period, was in the science laboratory ... even when I was a Supervisor of Science, there were schools that were still running their timetables on that basis ... one thing that ASEP did is that it allowed the teachers to make the whole thing develop around practically based activities. The units made very simple requirements (on the teacher) as far as practical work was concerned ...'*

However, at Matriculation level he felt the end point of the examination

> *'... was so much based on the academic level III examination paper, that the practical work was pushed aside. It didn't count for anything very much ... though there was some internal component in both Physics and Chemistry ... but the greatest emphasis was made, in the classroom, on the theoretical work.'*

<u>On assessment of practical work</u>

The assessment of practical work during this period was similar to that described by Scott. Hortle reports that

> *'the increased use of internal assessment allowed the teachers to be able to give some component (of laboratory work) to the examination mark ... that was a*

good point ... but I still ask myself this question: How much of that assessment, really was based on practical work done by the student? ... I know it varied from school to school ... but there was a lot of covering up of the internal mark ... and this is the situation even now ... let's face it, the internal assessment component of practical work is still very small at this stage.'

A general comment on present science teaching

Since Hortle has been a Principal for almost nine years and is the only science supervisor who returned to the School System his perceptions regarding science teaching at present in Tasmanian Schools would seem to be of particular interest. Hortle comments:

'Over the last nine years, I feel there has been a tendency to move away from the physics and chemistry based sciences in High Schools, to a more environmentally based biological, geological type. This could be due to our society being more environment conscious ... It's something that has caught the imagination of teachers and students, too. Another reason is that at that period of time many of the teachers that were coming out of training were in fact teachers with a very strong biological, geological science base, not necessarily a strong chemistry, physics, science base, and naturally they were more at home teaching biological science. And over the years there was a tendency to forget about the Physics and Chemistry.'

In regard to Matriculation level science he comments:

'I'm still worried about the amount of practical work in some of the modern courses at Matriculation level. I'm concerned about the Chemistry course, particularly which is based on the old Chem-Study ... There is much more

> *discussion of theoretical concepts ...*
> *no doubt the students are better prepared to cope with ideas in Chemistry, but I wonder how good they are at handling the practical side of the subject. My main concern is that there isn't as much practical work done in the schools (now) as there was in the (old) Matriculation Colleges, particularly in Chemistry.'*

Graham Fish: Science Supervisor (1974-1978)

On the role of Science Supervisor

During Fish's time as Science Supervisor there was, again, a change of role emphasis. Facilities and equipment were now readily available. As Science Supervisor, Fish was not required to formally assess teaching or school programmes. This became specifically the job of a Regional Superintendent during Hortle's period. The Supervisor was much more concerned with the curriculum aspects of science.

According to Fish

> *'this was a good change ... and was due to the fact that teachers were better trained compared to many teachers in the 60's ... that is ... the academic and professional training received by teachers today is much more comprehensive.'*

In an attempt to clarify problems that had arisen concerning the Trial Syllabus, Fish wrote and distributed guidelines in the form of a 141 page document entitled 'The Science Curriculum in the Secondary School (1975)'. The document contains discussion sections centred on key questions.

These key questions can be seen as corresponding to an *'aim/content, learning experience/evaluation'* model. The document is *not prescriptive* but attempts to outline a *process* by which individual teachers or schools might contrast a curriculum. Fish explains his rational as follows:

> *'there was no one correct or even one preferable science content for School Science Courses for all teachers and all children.'*

Teachers were free to choose.

Almost two years later a second document was produced concerned mainly with evaluating the achievements of students. This was favourably reviewed and was produced and distributed to schools in Western Australia. It is clear that Fish during his time as Supervisor placed a great emphasis on written guidelines with a particular emphasis on the purpose and means of assessment.

Major changes in the syllabus

There were no major changes in syllabus at either High School or Matriculation level. High School was given freedom of choice but Matriculation Colleges had highly prescriptive syllabuses. Chem-Study was now the required programme for all Schools, rather than an alternative, and after some revision a similarly framed Physics syllabus was the prescribed mode.

Some High School teachers were critical of the new Curriculum according to Fish

> *'because it didn't normalise the content.'*

Fish records that

> *'the committee did a good job ... but couldn't come up with a content (description) which could be covered in four years.'*

As far as High School Science is concerned, the major changes in the 1970's were associated with a greater emphasis on 'skill-based activities rather than content-based activities'. By 'skill' Fish would seem to be referring to aspects of scientific processes or methods rather than laboratory techniques.

<u>On practical work</u>

As regards practical work, specifically, there was an organisational move towards having *all* science lessons in the laboratory where previously the use of

> *'three single theory lessons and a double practical period was the most common arrangement. Rather than being seen as an isolated activity, practical work is (how) much more related to the theory.'*

Though Fish notes that

> *'some people felt that the practical work that is done in schools by students is a bit trivial ... but this is difficult to judge.'*

During the 70's a number of schools introduced the ISCS programme which can be described as a wholely practical self-paced scheme. One should note that this programme was introduced initially into schools in which the social class of pupils is heavily skewed towards the bottom end of the relevant schools.

At Matriculation level, according to Fish, students spend more time on practical work than High School students, which Fish attributed to 'specialization' while High School Students, by comparison

> *'move from one subject (discipline) to another on a very regular basis.'*

<u>On assessment of practical work</u>

Fish's observations on assessment at the period indicate an acceptance of internal assessment at both High School and Matriculation level by both teachers and supervisors. He comments:

> *'The major change in regard to the assessment of practical work is one from external practical assessment to a series of practical tests which are prepared in a school. Practical work nowadays at both High School and Matriculation level is assessed internally by the School and is part of*

the internal component. This is considered to be a good change ... In the past we used to do so many field excursions and write reports on them ... we used to make the students do practical examinations on say rocks, fossils, etc. ...'

The situation in regard to assessment of practical work, thus remained substantially unchanged from that used during Scott's period of office.

Ian Winter: Acting Science Supervisor (1979-1982)

On the Role of Science Supervisor

According to Winter, the present role of a Science Supervisor is to formulate curriculum policies, to determine the curriculum content and to assist individual schools with constructing an appropriate syllabus which is aimed at meeting the goals that the curriculum suggests. Recently, according to Winter

'a core-syllabus document has been produced and currently the assessment procedures are being produced to suit that particular core. This core is based on skills and skill development. A set of items, questions and activities are being compiled that will assist teachers in determining greater attitudinal levels of school development.'

Winter notes that, this particular area of curriculum and assessment within it will occupy roughly 30-40% of school assessment procedures and the remainder, 60-70%, will be determined by the school itself. This core-syllabus has been distributed to all schools and is being trialled at the moment (1982) and it is likely to operate as soon as the trials are over, if accepted by teachers.

Winter comments

> *'the major change in the late 70's and the early 80's at High School Science, is that there has been a greater emphasis on skill-based activities rather than content-based activities. Now all schools have something specific to focus on, and this has been a major breakthrough in terms of giving schools some specific guidance while allowing them to maintain a high degree of flexibility in their approach.'*

<u>On practical work</u>

Winter states that there are no major changes at Matriculation level at this stage. He notes that

> *'most science subjects at this level have always had a high content of practical work. A greater deal of the time is spent on practical work.'*

At High School he points out that there are two recognisable approaches:

1. The 'old method' which involves a theory base followed by practical work.

2. A 'newer method' exemplified by newer programmers such as ISCS.

According to Winter

> *'this particular programme is now slowly gaining popularity ... there are about 7 or 8 schools in Tasmania employing this approach at the moment.'*

<u>On assessment of practical work</u> In the late 70's and early 80's, at Matriculation level, practical work has been and is assessed internally by the School and is part of the internal component as well as of the total work. According to Winter, this corresponds to a

> *'... series of tests and assignments which are set by the teacher in the school.'*

He also believes that in recent years there has been an increase in school based assessment of practical work at High School and presumes that at Matriculation level (the work) would be strongly geared to the practical work completed by the student.

9.4 COMMENTS AND CONCLUSION

The present syllabus descriptions for Science Courses in Tasmanian Schools demonstrates some orientations that are specifically local and some that are in line with universal movements. Tasmania has a two stage certification, i.e. at High School and Matriculation level. Whereas the High School Science Curriculum is school-based, school-moderated and non-prescriptive, the Matriculation Curriculum in Physics and Chemistry, by comparison, is largely externally moderated and is highly prescriptive.

It is true that the Matriculation level curriculum has always been subject to external moderation and control but only in recent years has it been associated with highly prescribed syllabuses such as Chem-Study and Web of Life.

Curriculum changes at High School reflect the general influence that in the U.K. and the U.S. are associated with the so-called 'progessive movement'. This latter movement has not been characterised by any defined credo but in general it is associated with the notion of:

1) freedom of choice of student (and teacher) in relation to the curriculum
2) student-centred education
3) an emphasis on what interests the student.

Allied to these notions is an hostility of progressives towards any sort of curriculum prescription. Inevitably, this makes assessment a most complicated affair with the almost impossible task of establishing parity between schools. Without any clear direction regarding expected performance by pupils the standards of individual schools can be very low indeed. This is the situation in the High School (12-16 year group) in Tasmania although this situation is by no means unique to Tasmania. Curriculum orientations which have their roots in the writings of Rousseau, Froebel and Pestalozzi, and may well be appropriate for kindergarten pupils, have been applied to the secondary area. This is one of the explanations offered for the extremely different science curriculum descriptions being recommended at High School compared to Matriculation level. The emergence of the present orientations and their relation to practical work can be traced through the comments and observations of the Science Supervisors.

Consider the Science Supervisor's description of the curriculum:

Boyd's attempt in the 1950's to reinstate Physics, Chemistry and Biology, rather than general science in High Schools, failed and by the end of the decade general science was the established teaching mode.

During Scott's period of office, the child-centred activities of the recommended syllabus for the time were replaced by a *content* description only. This was based on taxonomical descriptions of *processes* of science, but without prescription. It is not clear what effect these curriculum changes had on the quality of practical work.

Hortle's response to these changes indicates some concern about the real outcomes. While indicating sympathy with the policies being recommended: the provision of laboratories and encouragement of school based assessment at High School, he expressed doubts to Chemistry at Matriculation level, his own forte, when a science teacher. His comments reflect the anxiety of all educators when required to review a situation in the absence of evaluative evidence. It should be noted that he is much closer to the teaching situation than any of the others.

By comparison, Fish was clearly more attracted (than any of his predecessors) to behaviourist modelling of the High School curriculum and placed much faith in Klopfer's taxonomical descriptions of curriculum - which owe much to Bloom. School based general science is thus provided with a theoretical rationale designed to promote laboratory based teaching. Fish's comments regarding the possible 'trivial nature' of the practical experiences '... but who can judge' would suggest that in the final analysis he too had doubts about the true outcomes in regard to practical work.

Pallett and Winter indicate more concern for an established core of general science based on process skills, and which interestingly enough single out essential practical techniques as an important part of this core. However, for them, general science is still the favoured teaching mode, but school-based assessment may now have a moderating component built into it which is a compromise between internal and external controls.

Assessment, as might be expected, has an important influence on the curriculum. Apart from its use in distinguishing between pupils, it is also a measure of the effectiveness and quality of the teaching being provided. Unfortunately, in regard to practical work, this evaluative dimension is not available. As far as specific assessment of practical work is concerned Boyd in the 1950's clearly wished to establish an external examination system but was not able to do so. Supervisors since that time have paid little attention to assessment of this particular component, perferring to treat it as an integral part of the whole. Hortle's observations are the most questioning on this point.

His reservations are borne out by the findings in Chapter Eight. True assessment of practical work counts for very little in the final analysis in the Tasmanian Examination System. Neither can one say what is actually taking place in school laboratories. However, Tamir* and Glassman's

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* Tamir's extended study of almost all aspects of the implementation and effectiveness of BSCS in Israel represents one of the few comprehensive accounts of a curriculum transplant.

study of a practical examination for BSCS students should be read closely in this regard. To quote their concluding paragraph

> 'since performance in the practical examinations has very low correlations with performance in paper and pencil tests, even when these written papers are enquiry oriented, the practical mode should be regarded as a distinct mode of performance. Hence, practical examinations should become a regular component of any assessment dealing with laboratory oriented curricula.
>
> The relatively high reliability of the practical examination reported here should encourage teachers and schools to incorporate such examinations in their assessment procedure.'

This would support the view that practical examinations should become a regular component of any assessment dealing with laboratory oriented curricula. The relatively high reliability of the practical examination reported by Tamir should encourage teachers and schools to incorporate such examinations into their assessment procedure.

CHAPTER TEN

DISCUSSION OF FINDINGS AND A COMPARATIVE OVERVIEW

10.0 INTRODUCTION

This chapter is presented as a summary of the survey findings. However, a comparative overview would also seem to be in order taking into account a number of similar investigations. Such studies have been undertaken in the U.K. and South Africa and the most direct comparisons are provided by the survey data of Kerr (1963), West (1972), Thompson (1975) in the U.K. and Lynch (1976) in South Africa.

A period of intensive science curriculum innovation began in all three countries in the early 1960's, and was implemented in the subsequent decade. National and cultural differences are likely to have had some influence on final outcomes and this may provide further insight into the process of curriculum change. For instance, it is recognised that science teaching is associated with some quite well-defined traditions and beliefs which are culturally and ideologically based. We do not escape these influences in our teaching or in the development of science curricula. One deep rooted notion which can be traced back to the beginning of science teaching in the U.K. is 'heurism', 'the investigational approach', or 'the method of finding out' (see Chapter One). Because of its special fascination for gifted teachers it tends to crop up again and again in U.K. curriculum innovations, pre-service and in-service courses. Whether it is a suitable method for the average teacher or a new teacher has never been established and many would have reservations about its general appropriateness.

The scope of the five surveys in question is presented in Table 10.1. As can be seen there is not a one to one relationship between the different sets of data, consequently comparisons need to be made with some caution.

Table 10.1

AIMS/INFLUENCES OF PRACTICAL WORK ACCORDING TO THE KINDS OF SCIENCE SURVEY IN U.K., SOUTH AFRICA AND TASMANIAN STUDIES.

Survey Study		Data from TEACHERS			Data from STUDENTS		
		Grades 7/8	Grades 9/10	Matric Level	Grades 7/8	Grades 9/10	Matric Level
Kerr, (U.K.)	1963	Physics Chemistry Biology	Physics Chemistry Biology	Physics Chemistry Biology	Physics Chemistry Biology	Physics Chemistry Biology	Physics Chemistry Biology
West (U.K.)	1972	Chemistry	Chemistry				
Thompson (U.K.)	1975			Physics Chemistry Biology			
Lynch	1976	Physical Science	Physical Science		Physical Science		Physical Science
Ndyetabura	1980	General Science	General Science	Physics Chemistry		General Science	Physics Chemistry

From Table 10.1, four comparisons strike us as being particularly interesting and valid. They are as follows:

1. Comparative Longitudinal* changes in *teachers'* perceptions

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* Strictly speaking any changes are pseudo-longitudinal since the data for say grade 7 and grade 10 are for different students. However, the surveys quoted involved large national or state samples and it is assumed that age-cohorts are comparable in terms of ability and other background and performance variables.

of practical work for science in general as provided by Kerr (U.K., 1963), Lynch (South Africa, 1976), Ndyetabura (Tasmania, 1980), West (U.K., 1972 - Chemistry only).

2. Comparative perceptions of *teachers* at School Certificate level of science in general, as provided by Kerr (U.K., 1963), Lynch (South Africa, 1976), Ndyetabura (Tasmania, 1980).

3. Comparative perceptions of *teachers* at Higher School Certificate level for Physics and Chemistry as provided by Kerr (U.K., 1963), Lynch (South Africa, 1976), Ndyetabura (Tasmania, 1980), Thompson (U.K., 1975).

4. Comparative perceptions of *students* of 'physical science' at Higher School Certificate level as provided by Kerr (Physics and Chemistry), Lynch (Physical Science), Ndyetabura (Physics and Chemistry).

10.1 THE AIMS OF PRACTICAL WORK AS PERCEIVED BY SCIENCE TEACHERS IN THE U.K., SOUTH AFRICA AND TASMANIA

It should be noted that the comparisons in these surveys have to be treated with caution, since different research methodologies were employed, different sample sizes were involved, and there is a variation in kinds of science being taught in these three countries (i.e., separate disciplines, physical science or general science).

Kerr's survey (1963) was a national survey involving 701 science teachers from 151 schools who were teaching physics, chemistry and biology in three groups (year 1 & 2; year 3-5;

and 6th Forms)* Kerr's survey was restricted to secondary schools following a grammar-school-type curriculum with provision of GCE courses being the main criterion for inclusion in the sample.

West's survey involved only 31 Chemistry teachers in 17 schools, 16 of which belong to one Local Education Authority. All the schools were involved in teaching Nuffield O-level Chemistry. West's survey included both grammar and comprehensive schools teaching both GCE and CSE syllabuses. In West's survey, replies were required only from chemistry teachers teaching year 5 (U.K.). West's survey, which was a reinvestigation of Kerr's findings in the light of recent curriculum development, comprised the ten aims used by Kerr.

In Thompson's survey (1975), the sample of 655 sixth-form teachers used was representative of the sixth form situation in England and Wales. The sixth form teachers taught separate physics, chemistry and biology. Thompson's list of aims comprised twenty aims which included Kerr's list of ten aims. Consequently, the lists are comparable.

Lynch's survey data in South Africa (1976) was obtained from teachers of physical and biological science in 632 schools from standard 6 to standard 10.** His list of aims comprised ten aims based on Kerr's list with modifications.

The present survey, Ndyetabura (1980), as indicated in

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* For comparison with *this* survey, year 1 and 2 is equivalent to grades 7 and 8, year 3-5 is equivalent to grades 9 and 10; and 6th form is equivalent to grades 11 and 12.

** For comparative purposes with *this* survey, standard 6 and 7 is equivalent to grades 7 and 8, standard 8 and 9 is equivalent to grades 9 and 10; standard 10 is equivalent to grades 11 and 12.

previous chapters involved 259 science teachers (in 82 Tasmanian schools) of which 168 are teaching general science at grades 7 and 8, while 181 are teaching general science at grades 9 and 10; and 55 teachers are engaged in the teaching of separate disciplines at Higher School Certificate (Physics and Chemistry). The list of aims comprised ten aims as used in Lynch's survey, except aim 10 which is not the same but is catered for in both the tables and the discussion.

10.2 COMPARATIVE LONGITUDINAL CHANGES IN TEACHERS' PERCEPTIONS OF PRACTICAL WORK FOR SCIENCE IN GENERAL AS PROVIDED BY KERR, LYNCH, NDYETABURA AND WEST

The data for comparisons are given in Tables 10.2 and 10.3. The South African and Tasmanian data are presented conjointly as the list of aims (except for aim 10) are identical for both surveys. Kerr's U.K. data is given in full for the separate disciplines and where aims correspond to those in the South African and Tasmanian surveys they are listed in the equivalent order and marked thus (*).

We have commented earlier (see Chapter 2) on the risks of making interpretations from relative rank orders, particularly since neither Kerr's U.K. or Lynch's South African surveys deal convincingly with the problem of interpreting tied ranks. However, as an academic exercise the Tasmanian data is presented in rank order and what is immediately striking is that where longitudinal changes exist they are generally very consistent. In order to clarify these longitudinal changes in teachers' perceptions we have marked them so that the direction of higher ranking order of the item is given thus → or ←, and those changes marked

Table 10.2

THE AIMS OF PRACTICAL WORK ACCORDING TO TEACHERS OF PHYSICS, CHEMISTRY AND BIOLOGY IN THE U.K.: RANK ORDER (KERR, 1963)

Suggested Aim	Physics Teachers			Chemistry Teachers			Biology Teachers		
	Year 1&2	Year 3-5	6th Form	Year 1&2	Year 3-5	6th Form	Year 1&2	Year 3-5	6th Form
1. Careful observation *	5	4	1	2	1	1	2	1	1
2. Interpret observations logically *	4	3	4	4	2	4	4	3	4
3. Make theory clearer *	6	2	2	6	4	2	6	4	2
4. Make theory more real and interesting *	2	6	7	3	6	9	3	2	6
5. Enables students to find out for themselves *	3	1	3	5	3	3	5	6	3
6. Gives training in skills and techniques *	7	8	6	7	8	5	8	9	5
7. To verify facts and principles already taught	8	7	5	8	7	6	7	7	7
8. To fit the requirements of practical examination regulations	10	10	10	10	10	8	10	10	8
9. Gives personal interest in practical work *	1	5	9	1	5	10	1	5	10
10. To give training in problem solving	9	9	8	9	9	7	9	8	9

N.B. The direction of higher marking order of the item is represented as → or ← (associated with at least three positions in mean rank).

Table 10.3

THE AIMS OF PRACTICAL WORK ACCORDING TO SCIENCE TEACHERS IN TASMANIA (1980) AND SOUTH AFRICA (LYNCH, 1976): RANK ORDER

Suggested Aim	TASMANIAN TEACHERS			SOUTH AFRICAN TEACHERS		
	At Grades 7&8	At Grades 9&10	At Grades 11&12	Overall Teachers' aims for Practical Work	Teachers' aim for standard 6 & 7	Teachers aim for standard 8, 9 & 10
1. Careful observation	2 ←	6	6	2	2	2
2. Interpret observations logically	3	1	1	4	3	4
3. Make theory clearer	6	4	4	3	4	3
4. Make theory more real and interesting	4	3	2	1	1	1
5. Enables students to find out for themselves	5	2	3 →	5	5	5
6. Gives training in skills and techniques	1 ←	5	5	8	7	7
7. Teaches to experiment in an organized way	7	7	9	9	9	9
8. Prepares students for final examinations	10	10	10	10	10	10
9. Gives personal interest in practical work	8	8	8	6	6	6
10. Encourages to study science further (Tasmania)	9	9	7	-	-	-
10. Makes the teaching more interesting and stimulating (Sth.Africa)	-	-	-	7	8	8

N.B. The direction of higher marking order of the item is represented as → or ← (associated with at least 3 positions in mean rank).

are associated with at least 3 positions in mean rank (e.g., see Kerr, Aim 1 for Physics).

The intention is to examine possible longitudinal changes in perception on the part of the teacher and not to compare rank order of individual items at this stage and with this in mind a number of trends are evident.

Overall, teachers in the U.K. (in 1963) indicated a greater number of longitudinal changes and a greater degree of longitudinal change than in the other two surveys. In fact the South African teachers provide almost identical responses for all 3 teaching situations. Lynch has interpreted this consistency as being due to the tendency for South African teachers to see practical work as a visual aid rather than a scientific activity in its own right. Consequently, South African teachers' orientations to practical work might be expected to be unaffected by the age or ability of their students. The responses of Tasmanian teachers are somewhere between these extremes with 3 items indicating changes. It seems a pity that a direct comparison with U.K. teachers for the 1970's is not available since it would presumably reflect the influence of the various Nuffield science projects that were implemented in the decade or so after Kerr's survey.

However, West's more limited survey for chemistry teachers and Thompson's specific data for sixth form chemistry are provided conjointly in Table 10.4 and they would suggest that U.K. teachers' perceptions still change longitudinally though U.K. teachers' perceptions of High School practical work are now substantially the same overall whether the teachers are working with beginners or at the end of the programme. Where

Table 10.4

THE AIMS OF PRACTICAL WORK ACCORDING TO CHEMISTRY TEACHERS IN THE U.K.: RANK ORDER (WEST, 1972 & THOMPSON, 1975)

Suggested Aim	Chemistry Teachers in West's survey		Chemistry Teachers in Thompson's survey
	Year 1-2	Year 3-5	6th Form
1. Careful observation	5	5	1/20
2. Interpret observations logically	3	2	3/20
3. Make theory clearer	8	6	18/20
4. Make theory more real and interesting	4	3	2/20
5. Enables students to find out for themselves	2	1	14/20
6. Gives training in skills and techniques	6	8	4/20
7. To verify facts and principles already taught	9	10	19/20
8. To fit the requirements of practical examination regulations	10	9	16/20
9. Gives personal interest in practical work	1	4	6/20
10. To give training in problem solving	7	7	12/20

N.B. The direction of higher marking order of the item is represented as → or ← (associated with at least three positions in mean rank).

longitudinal changes take place they are generally associated with the introduction of students to Higher School Certificate (VI-form) Courses.

Specific Longitudinal Changes

One of the most marked changes is associated with 'interest' (aim 9) in both presentations of U.K. data but there is no equivalent change in responses of Tasmanian or South African teachers. Teachers in the U.K. consider this to be the most important aim of practical work for beginners at High School level and decreasingly less important as the student progresses. By comparison teachers in Tasmanian and South African schools consider this to be a relatively unimportant aim at all teaching levels.

Aim 6, 'Training in skills and techniques' is associated with a completely opposite change in orientation for Tasmanian teachers when compared with the responses of U.K. teachers. Tasmanian teachers would indicate this to be the most important aim for *beginners* at High School quite the opposite to the perceptions of teachers in the U.K. surveys.

'Careful observation', (aim 1) is also an aim associated with diametrically opposite changes in orientation for Tasmanian compared with U.K. teachers. The combined West and Thompson data for Chemistry indicates a distinct difference from Kerr's findings for Chemistry and it would be in line with Kerr's findings in 1963 for Physics. i.e., 'Careful observation' is a middle ranked aim to begin with which becomes the most important aim for more advanced students. Quite the reverse responses are provided by Tasmanian teachers.

'Finding out for themselves' (Aim 5) is particularly interesting aim in the list since it was one of the main orientations of Nuffield O-level schemes and appears in only slightly more muted tones in Chem Study. We find that there is now a very marked change in teachers' perception of the importance of this aim according to the West/Thompson data. It is now ranked either one or two by teachers at both ends of the High School period in the U.K. However, at Higher School Certificate (VI form) level it drops to $^{14}/20$. In Tasmania, however, the changes in teachers' perceptions with respect to this aim, are once again in the reverse direction.

10.3 COMPARATIVE PERCEPTIONS OF TEACHERS AT SCHOOL CERTIFICATE LEVEL FOR SCIENCE IN GENERAL AS PROVIDED BY KERR, LYNCH AND NDYETABURA

Direct comparisons of teachers' perceptions of practical work provided in Table 10.5 are somewhat questionable in view of differences in the academic orientation of the samples. Kerr's sample was drawn from grammar schools only, while West's sample deals with a mixture of grammar and comprehensive schools. Consequently, these two groups reflect the perceptions of teachers dealing with academically select groups. The Tasmanian and South African teachers are more comparable in that their students groups are totally comprehensive at this stage. However, there are aims which are associated with considerable variation in mean rank, namely 'careful observation, aim 1; 'make theory more real and interesting', aim 4; and 'finding out', aim 5. These would seem to merit some special comment. The responses to 'careful observation' may well have arisen as a consequence of the fact/theory dichotomy that seems to exist in many teachers' minds.

Table 10.5 COMPARATIVE PERCEPTIONS OF TEACHERS AT SCHOOL CERTIFICATE LEVEL FOR SCIENCE IN GENERAL: AS PROVIDED BY KERR, LYNCH AND NDYETABURA

Suggested Aims	General Science	Physical & Biological Science Teachers	Chemistry Teachers	Physics Teachers	Chemistry Teachers	Biology Teachers
				KERR IN U.K.		
	Ndyetabura in Tasmania	Lynch in S. Africa	West in U.K.	year 3-5	year 3-5	year 3-5
1. Careful observation	6	2	5	4	1	1
2. Interpret observations logically	1	3	2	3	2	3
3. Make theory clearer	4	4	6	2	4	4
4. Make theory more real and interesting	3	1	3	6	6	2
5. Enables students to find out for them-selves	2	5	8	1	3	6
6. Gives training in skills and techniques	5	7	-	8	8	9
7. Teaches to experi-ment in an organised way	7	9	-	-	-	-
8. Prepares students for final examinations	10	10	-	-	-	-
9. Gives personal inter-est in practical work	8	6	4	5	5	5
10. Encourages to study science further/makes the teaching more inter-esting and stimulating	9	8	-	-	-	-

We have commented elsewhere on the function of careful observation in science (Lynch and Ndyetabura, Journal of Research in Science Teaching, 1982):

> "... students at school certificate level rate 'careful observation' as a significantly more important influence than 'interpret observations logically'. We are inclined to think that these particular differences in perception are tied to the relative importance of 'fact' and 'theory' as perceived by teachers and learner. Theories are built on factual evidence. In that sense they are generalizations built on particular observations. Anyone involved with the fundamental research will testify to the anxieties associated with identifying clear unequivocal observations - and verbalizing the same. Students are almost certainly in the same situation with regard to phenomena examined in the school laboratory. 'Careful observation' is never subordinate to 'interpretation' in the world of research. Why should it be any different at the school laboratory level? ... Presumably, teachers' aims are 'finding out' about theories and it is likely that observation in the laboratory will be given this emphasis by teachers. Students (even the highly selected matriculation students) do not rate this as a major influence. In fact there is considerable discordance about this item ..."

This issue certainly strikes us as being fundamentally related to what science is all about and clearly teachers' perceptions vary considerably, which may also be a discipline related phenomenon. 'Make theory more real and interesting', aim 4, is also associated with considerable variation in response, and to be strongly discipline related where science is taught as separate disciplines.

'Finding out', aim 5, is given first place for two of the samples but is ranked only fifth in South African schools at this level. Of course there is enormous peer group pressure to rank this aim highly in both the U.K. and Tasmania. It tends to be associated with imaginative, gifted teaching as we observed in the review part of this chapter (see Introduction), but may be less suitable for the average teacher.

10.4 COMPARATIVE PERCEPTIONS OF TEACHERS AT HIGHER SCHOOL CERTIFICATE LEVEL FOR PHYSICS AND CHEMISTRY AS PROVIDED BY KERR, LYNCH, NDYETABURA AND THOMPSON

The Higher School Certificate data in Table 10.6 would seem to merit a comparative overview. In all four surveys the responses are from samples of teachers who are teaching the more academically able, at a comparable age.

The South African data are available for both physical and biological science; that being the subject division at this level. Lynch comments elsewhere (Lynch, 1976) that 'teachers views on the purpose of practical work (in South Africa) show few differences, whatever level or type of secondary school pupil is considered, nor do they depend on language medium, sex, type of school or on experience and qualifications (professional or academic) of the teachers. Consequently the order presented in Table 10.6 applies to general science teaching, physical science or biological science teaching at this level. The Tasmanian students are very similar in age, ability and state of preparation to their South African counterparts whereas the U.K. (six former) is probably a year more advanced in his academic studies and on average a year older.

Six of the ten aims listed are now associated with considerable variation, though it should be noted that the majority of the variation is attributable to the responses of the U.K. teachers. Except for differences in teachers' responses to 'observation' and 'interpretation of observation', the South African and Tasmanian data are strikingly similar. Since we have commented several times on the observation/interpretation dilemma in this thesis further comments seem unnecessary.

By comparison U.K. teachers strongly subscribe to the prime

Table 10.6

COMPARATIVE PERCEPTIONS OF TEACHERS AT HIGHER SCHOOL CERTIFICATE LEVEL FOR PHYSICS AND CHEMISTRY: AS PROVIDED BY KERR, LYNCH, NDYETABURA AND THOMPSON

Suggested aim	Physics & Chemistry	Physical Science	Physics	Physics
	Ndyetabura in Tasmania	Lynch in S.Africa	Kerr in U.K.	Thompson in U.K.
1. Careful observation	6	2	1	1/20
2. Interpret observations logically	1	4	4	3/20
3. Make theory clearer	4	3	2	4/20
4. Make theory more real and interesting	2	1	7	12/20
5. Enables students to find out for themselves	3	5	3	16/20
6. Gives training in skills and technique	5	7	5	18/20
7. Teaches to experiment in an organised way	9	9	-	19/20
8. Prepares students for final examinations	10	10	-	14/20
9. Gives personal interest in practical work	8	6	10	6/20
10. Encourages to study science further/makes the teaching more interesting and stimulating	7	8	-	2/20

importance of observation unlike their Tasmanian counterparts. They place much less emphasis on 'making theory more real and interesting' than either Tasmanian or South African teachers. Curiously, after a decade or more of intense curriculum development and proselytization, U.K. teachers now rank 'finding out' very low indeed ($^{16}/20$) which caused Thompson to comment:

> 'Of particular interest is the reduced emphasis on discovery methods Aim 8 (Thompson's List), 'for finding' facts and arriving at new principles', is now ranked lower by teachers of all three sciences than in 1962. Also, apart from Nuffield physics teachers, other sciences teachers place much less emphasis on discovery experiments than they do on standard exercises. It seems that, in general science teachers are less than enthusiastic about this aspect of recent curriculum developments. The use of projects, which might be thought to foster some of the same aims, is far from widespread at present although there is evidence of a growing awareness of their value.'

This represents a major change from Kerr's observations.

Teahcers' perception of the importance of 'skill and techniques' is also associated with considerable variation in responses. It now ranks very low indeed for U.K. Chemistry teachers and this would suggest a major change in orientation from Kerr's time. Whereas in Tasmania it is a middle-ranked aim, and rather lower than that for South African science teachers.

10.5 COMPARATIVE PERCEPTIONS OF STUDENTS OF 'PHYSICAL SCIENCE' AT HIGHER SCHOOL CERTIFICATE LEVEL AS PROVIDED BY KERR, LYNCH AND NDYETABURA

The *student* comparisons are really limited to the studies of Kerr (1963, U.K.), Lynch (1976, South Africa) and Ndyetabura (1980, Tasmania), and are shown in Table 10.7. Unfortunately none of the more recent U.K. studies provide data concerning *students'* perceptions.

Kerr's questionnaire to students contained only six of

Table 10.7

COMPARATIVE PERCEPTIONS OF STUDENTS AT HIGHER SCHOOL CERTIFICATE FOR PHYSICS AND CHEMISTRY: AS PROVIDED BY KERR, LYNCH AND NDYETABURA.

Teachers' responses are shown in parenthesis

POSSIBLE INFLUENCE	Physics & Chemistry Students Tasmania (Matriculation) 1980		Physical Science Students S.Africa (Matriculation) 1976		Physics & Chemistry Students U.K.(a) (Sixth Form) 1963		(b)
1. Careful observation	7	(6)	3	(2)	4	(1)	*
2. Interpret observations logically	4	(1)	4	(4)	2	(4)	
3. Theory made clearer	2	(4)	2	(3)	5	(2)	*
4. Theory made more real and interesting	3	(2)	1	(1)	1	(7)	
5. Finding out for myself	8	(3)	8	(5)	6	(3)	
6. Training in skills and techniques	1	(5)	7	(7)	3	(5)	*
7. Experiment in an organised way	5	(9)	6	(9)			
8. Prepared me for final examination	10	(10)	9	(10)			
9. Personal interest in practical work	6	(8)	5	(6)			
10. Has encouraged me to study science further	9	(7)	10	(8)			

(a) based on the *mean* scores for physics and chemistry. See Table 35, p. 120 in 'Practical Work in School Science', J.F. Kerr.

(b) items between students which involve a difference of at least 3 positions of mean rank order.

the ten items used on the related teachers' questionnaires. Consequently, all the surveys are associated with six common aims, while the Tasmanian and South African surveys of students' perceptions each contain a further four aims.

The student samples represent an academic elite in all three countries. In all three surveys considerable attention was devoted to obtaining controlled, motivated, thoughtful responses from the students. The samples are large and representative. Consequently there seems no reason why we cannot take these responses as a genuine consumer guide for matriculation practical work at National levels. The equivalent teachers' responses to the corresponding aims are given in parenthesis so that it is also possible to comment on the extent of teacher/student concordance for all three groups.

Table 10.7 shows the students' 'rank ordering of their perceptions of the influences of practical work in surveys conducted in the U.K., South Africa and Tasmania.

One immediately striking observation is that whereas there is a considerable measure of concordance for South African students and teachers this is not so in Tasmania, and was not so in the U.K. in Kerr's time.

If we use a difference of 3 positions of rank order as a marker for a significant difference (-in line with criteria used in parts 2 and 3 of this chapter), then we find the total differences per student/teacher sub-group are:
Tasmania (4), South Africa (1), U.K. (4). Some of the discordances are quite considerable, notably responses to 'theory made more real and interesting' for U.K. students; 'training in

skills and techniques' for Tasmanian students.

The major differences to practical work between *student group-responses* are associated with 'careful observation', aim/influence 1; 'theory made clearer', aim/influence 3; 'training in skills and techniques', aim/influence 6.

In a nutshell, Tasmanian students consider that their practical work is mainly about acquiring 'skills and techniques' and as a supplement to theory ('clear' and 'more interesting').

By comparison South African students consider that their practical work is mainly about making 'theory clearer' and 'more interesting' and that it supplements aspects of the process of 'observation'.

Neither Tasmanian nor South African students perceive 'has encouraged me to study science further' to be a major influence (or that 'it prepreared me for final examinations'). In other words, career choice is not influenced to any extent by experimentation in Tasmanian or South African schools. It is most interesting that both student groups consider that it was a supplement to theory (aim 3) and yet did not prepare them for final examinations to any extent (aim 8). As far as the latter observation is concerned they are quite correct. Lynch (1978) observed that there was no correlation between students' experience of practical work in high schools (though wide in range and very variable) and their subsequent matriculation level. Even though as Lynch points out, 'examinations used were designed to test a wide range of cognitive skills'. How then does it still supplement the theory in the students' (and teachers') minds? There is a contadiction here which is well worth looking into. It may well be more palatable a mode of supplementing the theory and this is what is misleading the student. There is some evidence to support this view from studies of the effectiveness of media on student learning. It would seem to be the case the provided the media is instructionally sound, that choice of medium does not matter a great deal. Students seem able to adapt to or abstract from tape vs. television etc. equally well. The 'visual aid' aspect of practical work is perhaps equally effectively achieved by demonstration and blackboard diagrams as by hands-on experience.

The Tasmanian matriculation students are on average a year younger than their U.K. counterparts and at about the same stage as the equivalent South African students. Physics and Chemistry in Tasmanian schools are taught separately and the courses are highly prescriptive at matriculation level. For instance, Chemistry is taught as a modified Chem.Study programme throughout the State. Practical work tends to be fairly well defined;as a consequence this makes the Tasmanian data particularly interesting since students' perceptions relate to a much more homogeneous approach to curriculum than exists in either the U.K. or South Africa. The programmes used were originally chosen and designed with much the same intention as the Nuffield Programmes - integrated and varied practical work and an emphasis on discovery learning. In spite of this the students perceptions are striking in that they do not reflect these desired outcomes. 'Finding out' in term of rank order and absolute score is not considered to be an important influence, neither is 'careful observation'. 'Training in skills and techniques' is the dominant influence closely followed by 'theory made more real and interesting'. Curiously, the 'training in skills and techniques' influence is much more dominant than in U.K. or South African schools. Yet, the programmes were originally intended to de-emphasize this training aspect!

Experimentation which encourages a 'hands-on' approach would seem to have a natural tendency to revert to an experience in skills and technique training. Investigational or discovery orientations are obviously difficult to maintain even with well defined programmes designed with those specific intentions. Consistent with this observation is the finding that students perception of influence 10 'has encouraged me to study science further' is so low in terms of absolute scores and rank order in both Tasmanian and South African studies. One might have expected that such a select group of science students would have responded more positively to this item. But clearly the 'spirit of experimentation ' is not, in general, inculcated in either group. South African students would seem to perceive practical work as something of a visual aid while in Tasmania students see it as a training in a range of relatively interesting techniques.

One is forced in view of this evidence and historical precedents to conclude that a simple monolithic approach to curriculum is not the means *per se* of engendering discovery-related outcomes.

10.5 SUMMARY AND CONCLUSION

On the Relationship Between Purpose and Assessment of Practical Work in Tasmanian Schools

The first part of this thesis deals essentially with an examination of the *purpose* of practical work based on the orientation of teachers and pupils towards a list of possible aims. The second part of the thesis is concerned mainly with providing a description of the present situation regarding the *assessment* of practical work based on evidence from written syllabuses, structured interviews with State Science Co-ordinators, and a survey of present and preferred practice according to teachers and students.

Purpose and assessment are not mutually separate issues. A great deal of educational literature has evolved which addresses itself to interaction of these notions both explicitly and implicitly. The majority of behaviourists would no doubt agree with Bloom that:

> '... our experience suggest that unless the school has translated the objectives into specific and operational definitions, little is likely to be done about the objectives.'

Certainly, some aspects of practical work can be formulated into quite precise objectives, and in Tasmania one can detect a very recent swing towards behaviourist modelling in this area though it is early days yet to comment on implementation and effectiveness.

The evidence from this thesis with regard to practical work is that, for the most part, teachers use aims or objectives more as a memory aid than as criteria for assessment purposes. In that respect, current practice is more in line with the situation in the U.K. than the U.S. Most of the curriculum materials used do have a structure related to stated aims or objectives but there are few instances where these objectives are so precisely stated that they define assessment. Practical work in Tasmanian schools is treated as an important but integral part of all science teaching programmes. It is strongly recommended by science supervisors and Examining Boards but it is not dealt with as a separate activity with its own specific problems. Consequently, most teachers would be familiar with the possible orientations that can be given to *science as a whole* but unaccustomed to viewing practical work in isolation.

Herein, almost certainly, lies the nexus of the problem as far as the relationship between purpose and assessment of practical work is concerned. Practical work is an experience which does *not* lend itself to assessment by written tests. To ignore its assessment is equivalent to making a statement about its importance, i.e. 'Practical Work is not important in the final analysis'. Inevitably, with such an overview the *quality* of the enterprise must suffer. Individual teachers will of course persevere with imaginative and extensive practical courses but it is all too easy to neglect this aspect of science teaching. On the other hand, the consensus opinion of science teachers in Tasmania is that practical work is important, should be assessed and should count substantially towards a final grading of the student. This is an important finding since it indicates a strong positive commitment to practically-based teaching, which in its own turn reflects on the validity of the teachers' responses to the purpose of practical work. For instance, we know from Thompson's Survey (1975) of time spent on practical work in European countries, during the last two years of secondary schooling, that this ranged from 0% in Austria and Italy to 50% for *physics* in the U.K. and 0% in Austria and Italy to 40% in the U.K. and France for *chemistry*. Consequently, teachers responses to the purpose of school practical work in Austria and Italy would be of questionable validity!

In terms of time allocated to practical work, Tasmanian teachers would be equivalent to their U.K. counterparts, though there is a suggestion from Supervisors' comments that at matriculation level there is not as much practical work done (now) as there was in the (old) matriculation colleges, particularly in chemistry.

Teachers' perceptions of the aims would appear, in some respects, to be misguided or misjudged, and when viewed against student perceptions indicate some major mis-matches. Proponents of neo-heurism may be dismayed by some of the students' perceptions but it is important that we establish the *real* nature and orientation of the learning experience and proceed from there rather than cling to idealised notions which may be very far removed from the reality of the situation. If reorientations are to be made then those involved should be aware of the true starting point in regard to both teacher and pupil perception of events.

In conclusion we would argue that much more consideration should be given to the perception of students as a starting point for curriculum evaluation.

R E F E R E N C E S

A N D

A P P E N D I C E S

REFERENCES

Ainley, J.G. The Australian Science Facilities Program: A Study of Its Influence on Science Education in Australian Schools. The Australian Council for Educational Research Limited. Hawthorn, Victoria, 1978.

Anderson, N.H. Scales and Statistics: Parametric and non-parametric. Psychological Bulletin. 1961, 58, 305-316.

Anderson, H.O. and Koutnik, P.G. Towards More Effective Science Instruction in Secondary Education. Macmillan, N.Y., 1972.

A.S.E.P. Position Document - A Summary. A.S.E.P. Melbourne, 1971.

A.S.E.P. Handbook. A guidance to A.S.E.P. Victorian Government Printer, Melbourne, 1974.

A.S.T.E.P., Monash: Monash University, 1979.

Atkin, J.M. Behavioural Objectives in Curriculum: A Cautionary note. The Science Teacher, 1968, 35, 5.

Ausubel, D.P. Some Psychological Considerations in the Objectives and Design of an Elementary School Science Programme. Science Education, 1963, Vol. 47, 3.

Ausubel, D.P. Education Psychology, A Cognitive View. Holt, Rinehart and Winston, N.Y., 1968.

Ausubel, D.P. An Evaluation of the Conceptual Schemes Approach to Science Curriculum. In Romey, William D, Inquiry: Technique for Teaching Science. Prentice Hall, 1968, 291.

Banner, R.J. and Richardson, E. How New is Discovery Learning? The Contribution of H.E. Armstrong. Australian Science Teachers Journal, 1969, 15, 1.

Ben-Zvi, R.; Hofstein, A.; Samuel, D. and Kempa, R.F. Modes of Instruction in High School Chemistry. Journal of Research in Science Teaching, 1977, 14, 433-439.

Bibergall, J.A. Learning by Discovery: Its Relation to Science Teaching. Educational Review, 1966, 18, 3.

Bloom, Benjamin S. Taxonomy of Educational Objectives. Chicago, 1957.

Boylan, C.R. The Role and Value of Practical Lessons in Science. Unpublished Thesis. University of Sydney, 1977.

Bradley, R.L. Is the Science Laboratory Necessary for General Education Science Courses? Science Education, 1968, 52, 58-66.

Browning, D.R. Project Work in Chemistry. Educ. Chem., 1967, Vol. 4, 2, 68.

Bruner, J.S. The Learning by Discovery Hypothesis in L. Shulman and E. Leislar (Ed.). Learning By Discovery: A Critical Appraisal. Rand, McNally, Chicago, 1966.

Buckely, J.G. and Kempa, R.T. Practical Work in Sixth Form Chemistry Courses. School Science Review, 1971, Vol. 53, p.24.

Buckely, J.G. and Kempa, R.F. Students Preference for Different Methods of Assessing Practical Work in Chemistry. Science Research Review and Chemical Education Sector, University of Anglia, 1972.

C.D.C. Planning Your Science Course. Curriculum Development Centre, Canberra, 1980.

Chambers, R.G. Laboratory Teaching in the U.K. New Trends in Physics Teaching, Unesco, Parris, 1972, Vol. 2.

Collete, A.T. Science Teaching in the Secondary School. Allyn and Bacon, Inc., Boston, 1973.

Colussi, M. Practical Work in School Science Teaching. Spectrum, 1976, 3, 13, pp.55-62.

Connell, L. Demonstration and Individual Practical Work in Science Teaching. School Science Review, 1971, Vol. 52, 180.

Court, G.R.; Donald, R.A. and Fry, J.R. Teaching Practical Physics: Part 1. Physics Education, 1976, 397-400.

Cunningham, Harry A. Lecture Demonstration Versus Individual Laboratory Method in Science Teaching - A Summary. Science Education, 1946, 30, 2, 70-82.

Cohen, David. The Development of an Australian Science Curriculum Model. Unpublished Ph.D. Thesis. Michigan State University, 1964, pp.300.

Cohen, David. The Products of Education. The Australian Science Teacher Journal, 1967, 13:3, 51-54.

Fox, David J. The Research Process in Education. New York: Holt, Rinehart and Winston, Inc., 1969.

Deale, R.N. Assessment and Testing in the Secondary School. Schools Council Examination Bulletin 32 Evans/Methuen Education, London, 1975.

Dear, A.D. The Place of the Laboratory in the Teaching of Science. Unpublished M.Ed. Essay. University of Sydney, 1969.

Dowdeswell, W.H. Teaching Science Through Projects. School Science Review, 1969, Vol. 51, 169.

Eggleston, J.F. and Kerr, J.F. Studies in Assessment. English University Pres, London, 1969.

Eisner, E.W. Educational Objectives: Help or Hindrance? The School Review, 1967, Vol. 75.

Esler, W.K . Creative Laboratory in a Traditional Programme. The Science Teacher, 1967, Vol. 34.

Fish, G. The Science Curriculum in the Secondary School. Mathematics-Science Resource Centre, 1975.

Fish, G. Evaluation of Achievement in Secondary School Science. Mathematics-Science Resource Centre, 1977.

Bobbitt, Franklin. The Curriculum, 1918.

Fraser, B.J. Are A.S.E.P.'s Aims Worth Achieving? Australian Science Teachers Journal, 1976, Vol. 22, 3.

Garito, J. Non-parametric Methods in Psychological Research. Psychological Report, 1959, 5, 115-125.

Garito, J. Scale Classification and Statistics. Psychological Review, 1960, 67, 277-278.

Gardner, P.L. Scales and Statistics. Review of Educational Research, 1975. 45, pp.43-57.

Giddings, G. and Hofstein, A. Trends in the Assessment of Laboratory Performance in High School Science Instruction. The Australian Science Teacher Journal, 1980, Vol. 26(3), pp.57-64.

Glaser, R. Variables in Discovery Learning in L. Shulman and E. Keisler (Ed.). Learning by Discovery: A Critical Appraisal. Rand, McNally, Chicago, 1966.

Green, E. Towards Independent Learning in Science. Granada, London, 1976.

Grobman, H. Developmental Curriculum Projects: Decision Points and Press. Itasca III. Peacock Publisher, 1970.

Harrow, A.J. A Taxonomy of the Psychomotor Domain. D. McKay, N.Y., 1972.

Hermann, G. Learning by Discovery: A Critical Review of Studies. Journal of Experimental Education, 1969, Vol. 38.

Hofstein, A. and Lunetta, V.N. The Role of the Laboratory in Science Teaching. Research Implications. Position Paper: For a Symposium of the National Association of Research in Science Teaching. Boston, 1980.

Hubler, H.C. Science for Children. Rnadom House, New York, 1974.

Hudson, B. Assessment Techniques. Methuen, London, 1973.

Hurd, P. de H. and Rowe, M.B. Science in the Secondary School. Review of Educational Research, 1964, June, Vol. 34, 2.

Jensen, J.V. The X Club: Fraternity of Victorian Scientists. Bn't. J. History Sci., 1970, Vol. 5, pp.63-72.

Boblick, John M. Applying the Systems Approach to Curriculum Development in the Science Classroom. Science Education, 1971, 55:2, 103-113.

Johnstone, A.H. and Wood, C.A. Practical Work in its Own Right! Education in Chemistry, 1977, 14, 11-12.

Keisler, L. and Shulman, E. Learning By Discovery: A Critical Appraisal. Rand, McNally, Chicago, 1966.

Kelly, P.J. and Lister, R.E. Assessing Practical Ability in Nuffield A-level Biology in J.F.E. Eggleston and J.F. Kerr (Eds.) Studies in Assessment. London, English University Press, 1969.

Hopkins, Kenneth and Glass, Gene, V. Basic Statistics for Behavioural Science. University of Colorado, 1978.

Kempa, R.F. and Ward, J.F. The Effect of Different Modes of Task Orientation on Observations Attained in Practical Chemistry. Journal of Research in Science Teaching, 1975, 12: 69-76.

Kerr, J.F. Practical Work in School Science. Leicester University Press, England, 1964.

Klopfer, L.E. Evaluation of Learning in Science in Bloom, B.S., Hastings, J.T. and Madaus, G.F. (Eds.). Handbook on Summative and Formative of Student Learning. McGraw-Hill, N.Y., 1971.

Knox, W.W. The Demonstration Method Versus the Laboratory Method of Teaching High School Chemistry. The School Review, 1927, 25, 376-386.

Kreitler, H. and Kreitler, S. The Role of the Experiment in Science Education. Instructional Science, 1974, 3, 75-85.

Kruglak, H. Experimental Outcomes of Laboratory Instruction in Elementary College Physics. American Journal of Physics, 1952, Vol. 20.

Kruglak, H. Achievement in Physics Students with and without Laboratory Work. American Journal of Physics, 1953, Vol. 21.

Kruglak, H. The Measurement of Laboratory Achievements. American Journal of Physics, 1954a, Vol. 22.

Kruglak, H. The Measurement of Laboratory Achievement: Paper-Pencil Laboratory Achievement Tests. American Journal of Physics, 1954(b) Vol. 22.

Lunetta, V.N. and Tamir, P. An Analysis of Laboratory Activities in Two Modern Science Curricula. Project Physics, and PSSC. National Association for Research in Science, Toronto, 1978.

Lunetta, V.N. and Tamir, P. Matching Lab. Activities with Teaching Goals. The Science Teacher, 1979, 46, 22-24.

Lunetta, V.N., Hofstein, A., Giddings, G. Evaluating Science Laboratory Skills. The Science Teacher, 1981, 47, 22-25.

Lugg, D. Getting Science Across. Cheshire, Melbourne, 1968.

Lynch, P.P. The Nature, Purpose and Organisation of Practical Work in High Schools and Universities in South Africa. Pretoria: Human Science Research Council of S. Africa, 1976.

Lynch, P.P. High School Students' Experience of Experimental Work in Physical Science and Its Relation to Pupil Attainment. Journal of Research in Science Teaching, 1976, 15, 543-549.

Lynch, P.P. An Examination of Gender Differences in Respect to Pupils' Recognition of Science Concept Definitions. Journal of Research in Science Teaching, 1980, Vol. 17, 4, pp.307-314.

Lynch, P.P. and Ndyetabura, V.L. Students' Perceptions of the Influences of Practical Work in Science at High School and Matriculation Levels, in Tasmanian Schools. Journal of the Science Teacher Association of Tas. July, 1981, and Austr.Sc.Ed.Research Ass. Journal, (1982)

Lynch, P.P. and Ndyetabura, V.L. Practical Work in Schools: An Examination of Teachers' Stated Aims and the Influences of Practical Work According to Students. Journal of Research in Science Teaching, 1982. (in press)

Lynch, P.P. and Ndyetabura, V.L. The Purpose of Practical Work: An Examination of the Aims of Teachers and the Perceived Influence of Practical Work according to Students in Tasmanian High Schools and Matric. Colleges. Austr.Sci. Teacher Journal, 1982

Maccoby, E.E. and Jacklin, C.N. The Psychology of Sex Difference. Stanford, Ca.: Stanford University Press, 1974.

Maclay, R.W. de M. A Taxonomy of Educational Objectives in the Psychomotor Domain in Educational Measurement and Assessment. Australian College of Education, Melbourne, 1969.

Mayer, R.E. and Greeno, J.G. Structural Difference Between Learning Outcomes Produced by Different Instructional Methods. Journal of Educational Psychology, 1972, 63, 165-173.

Miles, V.W. and Van Decenter, W.C. The Teaching of Science at the College and University Level. Review of Educational Research, 1961, 31 (3) p.305.

Ndyetabura, V.L. and Lynch, P.P. The Preferences of Tasmanian Science Teachers in Regard to the Assessment of Practical Work in Schools. Journal of the Sci. Teachers Assoc. of Tas., February 1982.

Ndyetabura, V.L. and Lynch, P.P. An Examination of Preferences of Teachers and pupils in Tasmanian Schools. Australian Science Teachers Journal, (in press) 1982.

Oppenheim, A.N. Questionnaire Design and Attitude Measurement. London, Heinemann, 1966.

Oxenhorn, J.M. Teaching Science to Under-Achievers in Secondary Schools. Globe Book Co. Inc., New York, Chicago, 1972.

Piaget, J. and Inhelder, R. The Psychology of the Child. Basic Books, N.Y., 1969.

Points, W.M. The Teaching of Science in Secondary Schools. J. Murry Ltd., London, 1970.

Popham, J.W. and Husek, T.R. Criterion Reference Testing. Journal of Educational Measurement, 1969, 6, 1-3.

Rainey, R.G. The Effects of Directed Versus Non-Directed Laboratory Work on High School Chemistry Achievement. Journal of Research in Science Teaching, 1965, Vol. 3.

Roberts, N.A. Unpublished Seminar Paper: Philosophy of Science Education Teaching Strategies. Macquarie University, 1972.

Robinson, J. Evaluating Laboratory Work in School Biology. American Biology Teacher, 1969, 31, 236-240.

Rousseau, J.J. Emile. Everyman Edition, Dent, 1950.

Rowlands, E. Fact and Fiction in Learning by Discovery. Australian Science Teachers' Journal, 1969, Vol. 15, 1.

Siegel, S. Non-parametric Statistics for the Behavioural Science. New York: McGraw-Hill, 1956.

Shepherd, R. Discovery in Secondary School Science Classrooms. Australian Science Teachers' Journal, 1969, Vol. 15, 1.

Stevens, S.S. On the Theory of Scales of Measurement. Science, 1946, 103, 677-680.

Stevens, S.S. Mathematics, Measurement and Psychophysics. In S.S. Stevens (Ed.). Handbook of Experimental Psychology. New York: Wiley, 1951.

Stevens, S.S. Measurement, Statistics and the Schemapiric View. Science, 1968, 161, 849-856.

Sund, R.B. and Trowbridge, L.W. Teaching Science by Inquiry in the Secondary School. Merrill Publishing Co., Columbia, Ohio, 1967, 49-61.

Sutcliffe, A. Students' Laboratories in England: A Historical Sketch. Sch. Science Review, 1929, Vol. 11, pp.81-90.

Swain, J.R.L. Practical Objectives. Educ. Chem., 1974, 12, No. 5, p.152.

Taba, H. Curriculum Development: Theory and Practice. New York: Harcourt, Brace and Javonovich, 1962.

Tamir, P. An Inquiry-oriented Laboratory Work in High School Biology. Journal of Educational Measurement, 1974, 11, 25-33.

Tamir, P. and Glazman, F. A Practical Examination for B.Sc.'s Students: A Progress Report. Journal of Research Science Teaching, 1970, 8, 307-315.

The Schools Board of Tasmania. The Science Curriculum in the Secondary School. Mathematics/Science Resource Centre, 1975.

The Schools Board of Tasmania. Higher School Certificate Manual. Schools Board of Tasmania, 1980.

Thompson, D. Queenwood College, Hampshire. A mid-19th Century Experiment in Science Teaching. Annals of Science, Vol. 11, pp.246-254.

Thompson, D. Science Teaching in Schools During the Second Half of the 19th Century. School Science Review, 1956, 33, 133, pp.298-305.

Thompson, J.J. European Curriculum Studies No. 4. Chemistry Council of Europe, Strasbourg, 1975.

Thompson, J.J. (Ed.). Practical Work in Sixth Form Science. Oxford: Oxford Department of Educational Studies, 1976.

Tisher, R.P. The Teacher's Role is Discovery Learning. Australian Science Teachers' Journal, 1969, Vol. 15, 1.

University of London, (G.C.E.). Notes of Guidance and Report Form for the Optional International Assessment of Specific Studies. University of London, 1977.

Vernon, P.F. The Measurement of Ability. University of London Press, London, 1972.

Walberg, H.J. Physics, Femininity and Creativity. Developmental Psychology, 1961, 1, 47-54.

Ward, J.N. Group Study Versus Lecture-demonstration Method in Physical Science Instruction for General Education College Students. Journal of Experimental Education, 1956, 24, 197-210.

Washton, N.S. Teaching Science Creatively. W.B. Sanders, Philadelphia, 1967.

West, R.W. Objectives for Practical Work in School Chemistry. School Science Review, 1972, 54, 148-157.

Whittaker, R.J. The Assessment of Practical Work in Techniques and Problems of Assessment. Macintosh, H.G. (Ed.). Edward Arnold, London, 1974.

Yager, R.E. Enger, H.B. and Snider, B.C.F. Effects of Laboratory and Demonstration Method upon the Outcomes of Instruction in Secondary Biology. Journal of Research Science Teaching, 1969, 6, 76-86.

Zingaro, J.S. and Colette, A.T. A Statistical Comparison Between Inductive and Traditional Laboratories in College Physical Science. Journal of Research in Science Teaching, 1968, Vol. 5, No. 3.

APPENDIX ONE

QUESTIONNAIRE TO HIGH SCHOOL

AND MATRICULATION TEACHERS

CONCERNING

PRACTICAL WORK

IN

SCIENCE

The University of Tasmania

CENTRE FOR EDUCATION
Department of Teacher Education

Box 252C, G.P.O., Hobart.
Tasmania, Australia 7001

1	2	3	4

5

QUESTIONNAIRE TO HIGH SCHOOL AND MATRICULATION TEACHERS CONCERNING PRACTICAL WORK IN SCIENCE

1. You are not required to put your name on this questionnaire. As far as possible complete the form independently of your colleagues. Some of the information requested is needed to classify the replies. Your co-operation is highly appreciated.

2. Except where otherwise indicated, the completion of the items requires only the insertion of a tick "✓" in the appropriate space provided.

IMPORTANT

For any worthwhile results to come from this study it is essential that every teacher completing a questionnaire should answer the questions frankly and honestly.

PLEASE REFER TO YOUR OWN EXPERIENCE WITH PRACTICAL WORK IN THE SCHOOL SITUATION, NOT WHAT YOU THINK OUGHT TO BE DONE.

GENERAL INFORMATION

Background Information:

1. Sex — male ☐ 6
   female ☐

2. Nature of appointment — Full-time member of the school teaching staff ☐ 7
   Part-time member of the school teaching staff ☐

3. Years of full-time teaching experience ☐ years 8 & 9

Questions 4, 5, 6, 7 and 8 refer to your highest academic qualifications in various science subjects. *Fill in the appropriate spaces using the following key:*

A = University course: 3 years or more

B = University course: 2 years

C = University course: 1 year

D = Specialization course during full time teacher training at a college of education

E = Subject passed at matriculation level

F = Subject not studied at matriculation level.

4. Highest academic qualifications in physics ☐ 10

5. Highest academic qualifications in chemistry ☐ 11

6. Highest academic qualifications in botany ☐ 12

7. Highest academic qualifications in zoology ☐ 13

8. Highest academic qualifications in geology ☐ 14

9. Professional training

   Have you done a formal teacher training course?

   Yes ☐ 15

   No ☐

10. Did your professional training include guidance in the organisation of demonstrations and student experimental work?

   Yes ☐ 16

   No ☐

11. Do you regularly read any science teachers journals (e.g. Australian Science Teachers Journal)?

   Yes ☐ 17

   No ☐

12. Under whose control does your school fall? 18

- State School ☐
- Independent School ☐
- Catholic School ☐

13. Does your school include boys only, girls only or is it co-educational? 19

- Boys only ☐
- Girls only ☐
- Co-educational ☐

14. What was the average size of your science classes *at the grade 7 level in 1980?* 20

- less than 20 ☐
- 20 - 29 ☐
- 30 - 40 ☐
- more than 40 ☐
- not applicable ☐

15. What was the average size of your science classes *at the grade 10 level in 1980?* 21

- less than 20 ☐
- 20 - 29 ☐
- 30 - 40 ☐
- more than 40 ☐
- not applicable ☐

16. What was the average size of your science classes *at the grade 12 level in 1980?* 22

- less than 20 ☐
- 20 - 29 ☐
- 30 - 40 ☐
- more than 40 ☐
- not applicable ☐

17. Which of the following teaching areas occupied most of your science teaching time *in 1980? Please mark only one of the spaces provided.* 23

- (i) mainly grade 7 & 8 ☐
- (ii) mainly grade 9 & 10 ☐
- (iii) your teaching is about equally distributed over the two areas above ☐
- (iv) mainly grade 11 & 12 ☐
- (v) about equally distributed over the full range grade 7 - 12 ☐
- (vi) if none of the above please specify .... ☐
  ....

Teaching Preferences

18. Indicate *which science area you prefer to teach* in your science teaching (place a '1' in the box for first choice '2' for second choice etc., or indicate no particular preference).

At Grade 8 – 10

24

- Chemistry ☐
- Physics ☐
- Biology ☐
- Geology ☐
- No particular preference ☐

What is the reason for your first choice? ....

....

....

18. (Continued)

At Grade 11 & 12

25

- Chemistry ☐
- Physics ☐
- Biology ☐
- Geology ☐
- No particular preference ☐

What is the reason for your first choice? ....

....

....

19. How did <u>you</u> assess your student's *OVERALL PERFORMANCE* in science *in 1980?* By

26

(i) exercises, tests and examinations based on *theoretical work only* ☐

(ii) exercises, tests and examinations based on both *theoretical and practical work* ☐

(iii) only final theoretical examinations ☐

(iv) if none of the above please specify.......... ☐

....

CURRENT PRACTICE REGARDING SCHOOL PRACTICAL WORK

For the purpose of this inquiry, the term "practical work" means experiments performed by the teacher as demonstrations as well as experiments and observational exercises carried out by students.

20. Did you assess the *PRACTICAL WORK DONE* by your students *in 1980?*

At grade 7 & 8

		27
Yes	☐	
No	☐	
not applicable to me	☐	

At grade 9 & 10

		28
Yes	☐	
No	☐	
not applicable to me	☐	

At grade 11 & 12

		29
Yes	☐	
No	☐	
not applicable to me	☐	

21. If you answered 'yes' to Question 20, how did you assess it *in 1980?* By

	at Grade 7 & 8 (30)	at Grade 9 & 10 (31)	at Grade 11 & 12 (32)
(i) Practical examinations (externally assessed)	☐	☐	☐
(ii) Practical examinations (internally assessed)	☐	☐	☐
(iii) Continuous assessment by the teacher	☐	☐	☐
(iv) A combination of (i) and (ii)	☐	☐	☐
(v) A combination of (i), (ii) and (iii)	☐	☐	☐

(vi) If none of the above please specify ....

....

22. How often did you assess your student's performance IN PRACTICAL WORK in science *in 1980?*

	at Grade 7 & 8 (33)	at Grade 9 & 10 (34)	at Grade 11 & 12 (35)
about once a week	☐	☐	☐
about once a month	☐	☐	☐
about once a term	☐	☐	☐
about once a year	☐	☐	☐
never	☐	☐	☐

23. What type of practical work did you yourself use with your class *in 1980?*

	Grade 7 & 8 (36)	Grade 9 & 10 (37)	Grade 11 & 12 (38)
(i) mainly demonstration	☐	☐	☐
(ii) mainly group work (greater than 2 students)	☐	☐	☐
(iii) mainly individual work (1 or 2 students for the purpose of this inquiry)	☐	☐	☐
(iv) combination of (i) & (ii)	☐	☐	☐
(v) combination of (i), (ii) & (iii)	☐	☐	☐
(vi) none	☐	☐	☐

24. What percentage of your students overall mark came from practical work *in 1980?*

	Grade 7 & 8 (39)	Grade 9 & 10 (40)	Grade 10 & 11 (41)
0 percent	☐	☐	☐
about 15 percent	☐	☐	☐
about 20 percent	☐	☐	☐
about 30 percent	☐	☐	☐
about 40 percent	☐	☐	☐
about 50 percent	☐	☐	☐
more than 50 percent	☐	☐	☐

25. What percentage of your students overall mark would you prefer to be allocated to practical work?

	Grade 7 & 8 (42)	Grade 9 & 10 (43)	Grade 11 & 12 (44)
0 percent	☐	☐	☐
about 15 percent	☐	☐	☐
about 20 percent	☐	☐	☐
about 30 percent	☐	☐	☐
about 40 percent	☐	☐	☐
about 50 percent	☐	☐	☐
more than 50 percent	☐	☐	☐

AMOUNTS AND KINDS OF PRACTICAL WORK

Please note that the term "practical work" is taken to include demonstrations, excursions, fieldwork, practical projects and experiments performed by students either in groups or individually. Consider your experience in 1980.

26. How often did your students see or do practical work of any kind in your science teaching in 1980 (i.e. in the Grade which occupied most of your science teaching time) 45

- About once every science lesson ☐
- About once in two science lessons ☐
- About once in four science lessons ☐
- Rarely ☐
- Never ☐

27. Please indicate how often the practical work done by your students was performed in the ways mentioned below (i.e. in the Grade which occupied most of your science teaching time).

	About every science lesson	About once in two	About once in four	Rarely	Never	
Demonstrations performed by the teacher						46
Laboratory work done by students individually or in groups Note: Lab work is practical work done in a laboratory or science room						47

28. What size groups do your students normally work in when doing experiments in the science laboratory?

	At grade 7 & 8 (48)	At grade 9 & 10 (49)	At grade 11 & 12 (50)
Individually	☐	☐	☐
In pairs	☐	☐	☐
In groups of three	☐	☐	☐
In groups of four	☐	☐	☐
In groups of more than four	☐	☐	☐

29. Indicate how often the practical work done by your students was performed in the ways mentioned below in your science teaching in 1980 (i.e. in the grade which occupied most of your science teaching time)

	About once a week	About once a fortnight	About once a month	About once a term	About once a year	Never	
Excursions conducted by the teacher							51
Field work done by the students (Note: field work is practical work done outdoors)							52
Project work done by the students individually or in groups							53

30. What size groups do your students normally work in when doing Field work? (Note: Field work is practical work done outdoors).

	At Grade 7 & 8 (54)	At Grade 9 & 10 (55)	At Grade 11 & 12 (56)
Individually	☐	☐	☐
In pairs	☐	☐	☐
In groups of three	☐	☐	☐
In groups of four	☐	☐	☐
In groups of more than four	☐	☐	☐

31. In 1980, to what extent did you use the results of students' practical work as a starting point for the introduction of a new topic?

	At Grade 7 & 8 (57)	At Grade 9 & 10 (58)	At Grade 11 & 12 (59)
Always	☐	☐	☐
Frequently	☐	☐	☐
Occasionally	☐	☐	☐
Rarely	☐	☐	☐
Never	☐	☐	☐

SCIENCE APPARATUS

32. In your school do you have a sufficient supply of "expendable" equipment (e.g. test tubes, beakers, stock reagents, etc.)?

	At Grade 7 & 8 (60)	At Grade 9 & 10 (61)	At Grade 11 & 12 (62)
Yes	☐	☐	☐
Yes, but minor deficiencies at certain times	☐	☐	☐
No, generally deficient in some items at some times	☐	☐	☐
No, generally deficiencies in many items occur frequently	☐	☐	☐
No, deficiences occur most of the time	☐	☐	☐
I don't know	☐	☐	☐

33. In your school do you have a sufficient supply of minor science apparatus (e.g. bunsen burners, stands, magnets, etc.)?

	At Grade 7 & 8 (63)	At Grade 9 & 10 (64)	At Grade 11 & 12 (65)
Yes	☐	☐	☐
Yes, but minor deficiencies at certain times	☐	☐	☐
No, generally deficient in some item at some time	☐	☐	☐
No, generally deficiencies in many items occur frequently	☐	☐	☐
No, deficiencies occur most of the time	☐	☐	☐
I don't know	☐	☐	☐

34. In your school do you have a sufficient supply of essential major items of equipment (e.g. balances, electric meters, microscopes, etc.)?

	At Grade 7 & 8 (66)	At Grade 9 & 10 (67)	At Grade 11 & 12 (68)
Yes	☐	☐	☐
Yes, but minor deficiencies at certain times	☐	☐	☐
No, generally deficient in some item at some time	☐	☐	☐
No, generally deficiencies in many items occur frequently	☐	☐	☐
No, deficiencies occur most of the time	☐	☐	☐
I don't know	☐	☐	☐

35. Each of the following statements represent a possible source of difficulty in arranging student experimental work. Place a tick in the appropriate column to indicate the degree to which each has been a source of difficulty at your school in 1980.

At Grade 7 & 8

	Not a problem 1	Rarely a problem 2	Sometimes a problem 3	A significant problem 4	
An insufficient supply of basic apparatus					69
Inappropriate laboratory facilities					70
Too much preparation time involved					71
Too few laboratory assistants					72
Difficulty to store apparatus					73

Not applicable to my teaching ☐

35. (Continued)

At Grade 9 & 10

	Not a problem 1	Rarely a problem 2	Sometimes a problem 3	A significant problem 4	
An insufficient supply of basic apparatus					74
Inappropriate laboratory facilities					75
Too much preparation time involved					76
Too few laboratory assistants					77
Difficult to store apparatus					78

Not applicable to my teaching ☐

At Grade 11 & 12

	Not a problem 1	Rarely a problem 2	Sometimes a problem 3	A significant problem 4	
An insufficient supply of basic apparatus					79
Inappropriate laboratory facilities					80
Too much preparation time involved					81
Too few laboratory assistants					82
Difficult to store apparatus					83

Not applicable to my teaching ☐

36. For each of the following items of equipment indicate:

(i) the approximate number possessed by the school

(ii) the frequency of use of the item (if any are possessed)

	Number	FREQUENCY OF USE (tick the appropriate column)				
		Never	Rarely	Occasionally	Often	
Astronomical telescope						84
Chemical semi-micro analysis kits						85
Power operated vacuum pump						86
Cathode-Ray Oscilloscope						87
Linear air track apparatus						88
Top loading balances						89
Anatomical model and skeletons						90
Aquarium tanks (with aerator and heater)						91
Micro-projector						92

THE AIMS OF PRACTICAL WORK

Please note that the term 'practical work' includes demonstrations done by you as well as experiments performed by your students either on their own or as part of a group.

37. In your own opinion what are the aims of your practical work?

Choose what you think are your Four most important aims from the list of possible aims.

TICK FOUR BOXES ONLY IN ANY ONE COLUMN

POSSIBLE AIMS OF PRACTICAL WORK	At Grades 7 & 8	9 & 10	11 & 12	
				93
1. To make observations more carefully				94
2. To interpret observations in a logical way (eg. to ask questions and not to make decisions unless there is suitable evidence for doing so.				95
3. To make the theoretical parts of science clearer.				96
4. To make the theoretical parts of science more real and interesting.				97
5. To enable students to find out facts and principles themselves (ie. new ideas and information are acquired through experiments first rather than from explanations from text books and teachers).				98
6. Give training in the skills and techniques of laboratory work.				99
7. To teach how to conduct laboratory experiments in an organized way.				100
8. To prepare students directly for final examinations.				101
9. To give a personal interest in practical work and experimentation.				102
10. To encourage the study of science or related subjects further after leaving school.				

APPENDIX TWO

QUESTIONNAIRE TO HIGHER

SCHOOL CERTIFICATE STUDENTS

CONCERNING

PRACTICAL WORK

IN

SCIENCE

The University of Tasmania

Postal Address: Box 252C, G.P.O., Hobart, Tasmania, Australia 7001

QUESTIONNAIRE

TO

HIGHER SCHOOL CERTIFICATE STUDENTS

CONCERNING

PRACTICAL WORK IN SCIENCE

1. You are not required to put your name on this questionnaire, and nobody at your school will see any of your answers to the questions. Your co-operation is highly appreciated.

2. Except where otherwise indicated, many questions will require you simply to place a tick "✓" in a box.

IMPORTANT

It will be a great help to future students doing science if you could answer the following questions frankly and honestly.

PLEASE REFER TO YOUR OWN EXPERIENCE, NOT WHAT YOU THINK IT OUGHT IDEALLY TO HAVE BEEN, and complete the questionnaire independently of your

GENERAL INFORMATION

Unless indicated otherwise, you are requested to fill in the questionnaire by placing a tick "√" in the appropriate box.

1. Please indicate your sex

- Boy ☐
- Girl ☐

6

2. What kind of school are you attending, a State School, Catholic or Private school?

- State ☐
- Catholic ☐
- Private ☐

7

3. Does your school cater for boys only, girls only or is it co-educational?

- boys only ☐
- girls only ☐
- co-educational ☐

8

4. Who is the main income earner in your home? (*Tick one box*)

- My father ☐
- My mother ☐
- A brother or sister ☐
- Another relative ☐ (please describe)

____

- Another person ☐ (please describe)

____

9

5. What is his or her job? If more than one job, write down the one in which most time is spent. If unemployed, put down last job
Be as clear as you can: tell us the kind of work and also the type of workplace. For instance

... uses a machine in a factory

... delivers mail for the post office

... teaches in a primary school

____

10 11

6. What was your level in the following subjects in Grade 11?
(*Put ticks in the boxes*)

	level II	level III	Do not have Levels	
Chemistry				12
Physics				13
Biology				14
Geology				15

Comments (if any) ______________________

____

7. What results did you get in Matriculation at Grade 11?
(*write in level, award, percentage mark*)

	level II	level III	Do not have Levels	
Chemistry **A**				16
Physics **A**				17
Biology **A**				18
Geology				19

Comments (if any) ______________________

____

8. Did you get any practical marks (awards) for your Science Courses in Grade 11?

Yes ☐ 20

No ☐

9. If you answered Yes to question 8, what results did you get for your practical mark associated with the Science Courses you had studied in Grade 11?
(*write in award and percentage mark*)

	Award	Percentage	
Chemistry A level II			21
Chemistry A level III			22
Chemistry B level III			23
Physics A level II			24
Physics A level III			25
Physics B level III			26
Biology A			27
Biology B			28
Science level II			29
Geology level II			30
Geology level III			31

Comments (if any) ______________________

____

10. Do you intend to study science in some form or other after you have left school (*e.g., for a science degree, medicine, dentistry, engineering, technical courses, etc.*)

(*Tick one box*)

I intend to study science further at University (e.g., science degree, medicine, dentistry, agricultural science, etc.)	32 ☐
I intend to study science further but not at university (e.g., Technical Course at College of Advanced Education, Technical College, etc.	☐
I do not intend to study science at all after I have left school.	☐
Undecided	☐

THE INFLUENCES OF PRACTICAL WORK IN PHYSICS AND CHEMISTRY

Please note that the term 'practical work' includes *demonstrations by the teacher* as well as *experiments performed by you* in your physics and chemistry classes.

11. HOW DID THE PRACTICAL WORK IN GRADE 11 INFLUENCE YOU?

Choose what you think were the *FOUR* most important influences from the list below.
Place a tick in the box to show you choice.

POSSIBLE INFLUENCES OF PRACTICAL WORK:	Please tick *four* boxes only
1. Helped me to make observations more carefully.	33
2. Helped me to interpret observations in a logical way (e.g., to ask questions and not to make decisions unless there is suitable evidence for doing so	34
3. Made the theoretical parts of science *clearer* to me	35
4. Made the theoretical parts of science *more real and interesting* to me	36
5. Led me to find out facts and principles for myself (i.e., new ideas and information were acquired through experiments *first* rather than from explanations from text books and teachers	37
6. Gave me training in the skills and techniques of laboratory work	38
7. Has taught me how to conduct laboratory experiments in an organised way	39
8. Has prepared me directly for final examinations (i.e., my overall mark will probably be higher because of the practical work I have seen or done at school)	40
9. Gave me a personal interest in practical work and experimentation	41
10. Has encouraged me to study science or related subjects further after leaving school	42

AMOUNTS AND KINDS OF PRACTICAL WORK

Please note that the term "practical work" is taken to include *demonstrations, excursions, fieldwork, practical projects and experiments performed by students either in groups or individually.*
Consider your experience at H.S.C. work.

12. How often did you see or do practical work of any kind in the science course or courses you have studied in Grade 11?
(Put a tick in the boxes)

	43 Physics	44 Chemistry
About every science lesson	☐	☐
About once in two science lessons	☐	☐
About once in four science lessons	☐	☐
Rarely	☐	☐
Never	☐	☐

13. Indicate how often the practical work done was performed in the ways mentioned below in the science course or courses you have studied in Grade 11.
(Put ticks in boxes)

IN PHYSICS

	About every science lesson	About once in two science lessons	About once in four science lessons	Rarely	Never
Demonstrations performed by the teacher					45
Laboratory work done by students individually or in groups.					46

(Note: Laboratory work is practical work done in a laboratory or science room)

14. IN CHEMISTRY

	About every science lesson	About once in two science lessons	About once in four science lessons	Rarely	Never
Demonstrations performed by the teacher					47
Laboratory work done by students individually or in groups					48

(Note: Laboratory work is practical work done in a laboratory or science room)

15. What was the most typical size of the group you have done laboratory work with in Grade 11?
(Put a tick in one of the boxes)

	49 Physics	50 Chemistry
Single student	☐	☐
2 students	☐	☐
3 students	☐	☐
4 students	☐	☐
more than 4 students	☐	☐

16. Indicate how often the practical work done was performed in the ways mentioned below in the science course or courses you have studied in **Grade 11**?
(Put ticks in the boxes)

IN PHYSICS	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions conducted by the teacher						51
Field work done by the student (Note: field work is practical work done outdoors.)						52
Project work (options) done by the students individually or groups						53

17.

IN CHEMISTRY	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never
Excursions conducted by the teacher						54
Field work done by the student (Note: field work is practical work done outdoors.)						55
Project work (options) done by the students individually or groups						56

18. What was the most typical size of the group you have done field work with in **Grade 11**?
(Put a tick in one of the boxes)

	57 Physics	58 Chemistry
Single student	☐	☐
2 students	☐	☐
3 students	☐	☐
4 students	☐	☐
more than 4 students	☐	☐

19. What was the most typical size of the group you have done project work with in **Grade 11**?
(Put a tick in one of the boxes)

	59 Physics	60 Chemistry
Single student	☐	☐
2 students	☐	☐
3 students	☐	☐
4 students	☐	☐
more than 4 students	☐	☐

20. During **Grade 11** to what extent were the results of practical work used as a starting point for the introduction of a new topic?
(Put a tick in one of the boxes)

	61 Physics	62 Chemistry
Always	☐	☐
Frequently	☐	☐
Occasionally	☐	☐
Rarely	☐	☐
Never	☐	☐

21. During **Grade 11** to what extent were the results of practical work used to verify or demonstrate what you had already been taught?
(Put a tick in one of the boxes)

	63 Physics	64 Chemistry
Always	☐	☐
Frequently	☐	☐
Occasionally	☐	☐
Rarely	☐	☐
Never	☐	☐

TECHNIQUES OF PRACTICAL WORK

22. Please tick in the appropriate column to show which of the following Techniques in Physics and Chemistry

in Column A : you know about
in Column B : you have seen done at school
in Column C : please indicate the *frequency* with which you carried out these techniques yourself, using the five point scale below.

Frequency Scale

5 = more frequently than once a month
4 = about once a month
3 = about once a term
2 = about once a year
1 = never.

** PLEASE CHECK EVERY ITEM **

PRACTICAL TECHNIQUE	A Know about	B Seen Done	C (frequency) Carried out yourself
Heating with a gas burner			65
Measuring with a ruler			66
Measuring with vernier calipers, micrometer or screw gauge			67
Using an Ammeter and/or Voltmeter			68
Reading a thermometer			69
Connecting up an electric circuit			70
Distilling a liquid			71
Crystallizing (growing crystals)			72
Measuring a volume of liquid with a measuring cylinder			73
Using a pipette			74
Weighing (on a rough balance)			75
Weighing (on an accurate balance to at least 2 decimal places)			76
Using magnets			77
Using a hand lens or a magnifying glass			78
Using a microscope			79

PRACTICAL WORK IN PHYSICS AT GRADE 11

23. Please tick in the appropriate column to show which of the following Experiments in Physics

in Column A : you know about
in Column B : you have seen done at school
in Column C : you have carried out yourself

** PLEASE CHECK EVERY ITEM **

PHYSICS EXPERIMENTS completed in Grade 11 & 12	A Know about	B Seen Done	C Carried out yourself
Investigated how acceleration depends on force			80
Determined a value for "g"			81
Investigated how a dynamo and/or an electric motor works			82
Investigated conservation of energy and/or linear momentum			83
Plotted electric and/or magnetic fields			84
Determined the characteristics of a "non-ohmic" resistor			85
Determined the total resistance of series and parallel combinations of resistors			86
Investigated the equations of motion in a straight line and/or a circular path			87

PRACTICAL WORK IN CHEMISTRY AT GRADE 11

24. Please place a tick in the appropriate column to show which of the following Experiments in Chemistry

in Column A : you know about
in Column B : you have seen being done at school
in Column C : you have carried out yourself

** PLEASE CHECK EVERY ITEM **

CHEMISTRY EXPERIMENTS completed in Grade 11 & 12	A Know About	B Seen Done	C Carried out yourself
Investigated the solubility or conductivity of a salt in water			88
Investigated the chemistry of an element or compound			89
Prepared an organic or inorganic compound (other than gases)			90
Investigated the Conditions that affect chemical equilibrium or the rate of a chemical reaction			91
Used or made molecular models			92
Determined the percentage composition, atomic or molecular weight of an element or compound			93
Examined the properties of some acids and bases			94
Investigated the stoichiometry of a reaction			95

25. Consider for a few minutes your attitude to practical work at school and then write in your own words how you feel, it has influenced you.

The following points may serve as guidelines.

(a) Changed or affected your attitude to science.

(b) Helped or supplemented the theoretical part of the course in any way.

(c) Influenced you in any other way.

____

____

____

____

____

PREFERENCES REGARDING THE ASSESSMENT OF PRACTICAL WORK

Please note that the term 'practical work' is taken to include demonstrations by the teacher as well as experiments performed by the student either in groups or individually. Consider your experience at H.S.C. work.

26. Do you think your practical work *should be* assessed?

	In Physics (96)		In Chemistry (97)
Yes	☐	Yes	☐
No	☐	No	☐

If yes, what type of assessment do *you* prefer?

	In Physics (99)	In Chemistry (99)
(i) Practical examination (by *outside* examiners)	☐	☐
(ii) Practical examination (by your teachers)	☐	☐
(iii) Continuous assessment by your teachers	☐	☐
(iv) Both (i) and (ii)	☐	☐
(v) All of (i), (ii) and (iii)	☐	☐

27. What percentage should *practical work* contribute to your *overall mark* in science?

	In Physics (100)	In Chemistry (101)
0 percent ..	☐	☐
about 10 percent ..	☐	☐
about 20 percent ..	☐	☐
about 30 percent ..	☐	☐
about 40 percent ..	☐	☐
about 50 percent ..	☐	☐
more than 50 percent ..	☐	☐

28. In your H.S.C. subjects how often did your teacher give you a mark or award for your practical work in science?

	In Physics (102)	In Chemistry (103)
about once a week	☐	☐
about once a month	☐	☐
about once a term	☐	☐
about once a year	☐	☐
never	☐	☐

29. Apart from any practical examination set by the Schools Board or Examinations Board have you ever had any *practical test* by your teacher?

	In Physics (104)	In Chemistry (105)
Yes	☐	☐
No	☐	☐

If yes, please indicate how often

	In Physics (106)	In Chemistry (107)
about once a week	☐	☐
about once a month	☐	☐
about once a term	☐	☐
about once a year	☐	☐
never	☐	☐

30. Do you feel satisfied with the present method of assessing your practical work?

	In Physics (108)	In Chemistry (109)
Yes	☐	☐
No	☐	☐

If no, please explain why

____

____

____

____

APPENDIX THREE

QUESTIONNAIRE TO
HIGH SCHOOL STUDENTS
CONCERNING
PRACTICAL WORK
IN
SCIENCE

The University of Tasmania

CENTRE FOR EDUCATION

Department of Teacher Education

Box 252C, G P O . Hobart.
Tasmania, Australia 7001

1	2	3	4

QUESTIONNAIRE

TO

HIGH SCHOOL STUDENTS

CONCERNING

PRACTICAL WORK IN SCIENCE

5

1. You are not required to put your name on this questionnaire, and nobody at your school will see any of your answers to the questions. Your co-operation is highly appreciated.

2. Except where otherwise indicated, many questions will require you simply to place a tick "✓" in a box.

<u>IMPORTANT</u>

It will be a great help to future students doing science if you could answer the following questions frankly and honestly.
PLEASE REFER TO YOUR OWN EXPERIENCE, NOT WHAT YOU THINK IT OUGHT IDEALLY TO HAVE BEEN, and complete the questionnaire independently of your fellow students.

GENERAL INFORMATION

Unless indicated otherwise, you are requested to fill in the questionnaire by placing a tick "√" in the appropriate box.

1. Please indicate your sex

   Boy ☐ 6
   Girl ☐

2. What kind of school are you attending, a State School, Catholic or Private school?

   State ☐ 7
   Catholic ☐
   Private ☐

3. Does your school cater for boys only, girls only or is it co-educational?

   boys only ☐ 8
   girls only ☐
   co-educational ☐

4. Who is the main income earner in your home?
   (Tick one box)

   My father ☐ 9
   My mother ☐
   A brother or sister ☐
   Another relative ☐
   (please describe)

   ____

   Another person ☐
   (please describe)

   ____

5. What is his or her job? If more than one job, write down the one in which most time is spent. If unemployed, put down last job 10 11
   Be as clear as you can: tell us the kind of work and also the type of workplace. For instance

   ... uses a machine in a factory
   ... delivers mail for the post office
   ... teaches in a primary school

   ____

6. What is your level in the following subjects in Grade 9?
(Put ticks in the boxes)

	Level I	Level II	Level III	Do not have levels	Comment (if any)
English					12
Mathematics					13
Science					14
Social Sciences (including geography history)					15

7. What results did you get on your last Grade 9 report?
(Write in award, percentage mark)

	Award	Percent-age	Comment (if any)
English			16
Mathematics			17
Science			18
Social Science			19

8. What results did you get in the Science course you had studied in Grade 9, on your last Grade 9 report?
(write in award and percentage mark)

		Award	Percentage	Comment (if any)
	Science mixed levels			20
	Science Level I			21
	Science Level II			22
	Science Level III			23
	Science A (advanced science)			24
	Biology Level III			25
	Chemistry Level III			26
	Physics Level III			27
Others				28
				29

9. Did you get any practical marks (awards) for your science courses in Grade 9?

Yes ☐ 30

No ☐

10. If you answered yes to question 9, what results did you get for your *practical mark* associated with the science courses you had studied in Grade 9?
(write in award and percentage mark.)

	Award	Percentage	Comment (if any)
Science mixed levels			31
Science Level I			32
Science Level II			33
Science Level III			34
Science A (advanced science)			35
Biology Level III			36
Chemistry Level III			37
Physics Level III			38
Others			39

11. Do you intend to study science in some form or other after you have left school (*e.g., for a science degree, medicine, dentistry, engineering, technical courses etc.*) *Tick one box.*

I intend to study science further at *University* (e.g., science degree, medicine, dentistry, agricultural science, etc.) ☐ 40

I intend to study science further but *not at University* (e.g. technical course at College of Advanced Education, Technical College, etc.) ☐

I do not intend to study science at all after I have left school. ☐

Undecided ☐

THE INFLUENCES OF PRACTICAL WORK

Please note that the term 'practical work' includes *demonstrations by the teacher* as well as *experiments performed by you, either on your own or as part of a group.*

12. HOW DID THE PRACTICAL WORK IN GRADE 11 INFLUENCE YOU?

Choose what you think were the *FOUR* most important influences from the list below.
Place a tick in the box to show your choice.

POSSIBLE INFLUENCES OF PRACTICAL WORK:	Please tick *four* boxes only
1. Helped me to make observations more carefully.	41
2. Helped me to interpret observations in a logical way (e.g. to ask questions and not to make decisions unless there is suitable evidence for doing so.	42
3. Made the theoretical parts of science *clearer* to me	43
4. Made the theoretical parts of science *more real and interesting* to me	44
5. Led me to find out facts and principles for myself (i.e., new ideas and information were acquired through experiments *first* rather than from explanations from text books and teachers	45
6. Gave me training in the skills and techniques of laboratory work	46
7. Has taught me how to conduct laboratory experiments in an organised way	47
8. Has prepared me directly for final examinations (i.e., my overall mark will probably be higher because of the practical work I have seen or done at school)	48
9. Gave me a personal interest in practical work and experimentation	49
10. Has encouraged me to study science or related subjects further after leaving school	50

AMOUNT AND KIND OF PRACTICAL WORK

Please note that the term 'practical work' includes *demonstrations by the teacher* as well as *experiments performed by you, either on your own or as part of a group*

14. How often did you see or do practical work of any kind in the science course or courses you have studied this year - i.e. in Grade 9?
(tick one box only)

- about every science lesson ☐ 51
- about once in two science lessons ☐
- about once in four science lessons ☐
- rarely ☐
- never ☐

15. Indicate how often the practical work done was perfomed in the ways mentioned below in the science course or courses you have studied this year - i.e. Grade 9
(Put ticks in the boxes)

	About every science lesson	About once in two science lessons	About once in four science lessons	Rarely	Never
Demonstrations performed by the teacher					52
Practical work done by students individually or in groups.					53

Note: Laboratory work is practical work done in a laboratory or science room.

16. What was the most typical size of the group you have done practical work with this year?

single student ☐ 54
2 students ☐
3 students ☐
4 students ☐
more than 4 students ☐

17. Indicate how often the practical work done was performed in the ways mentioned below in the science course or courses you have studied this year - i.e. Grade 9.

	About once a week	About once a fort-night	About once a month	About once a term	About once a year	Never	
Excursions (visits) conducted by the teacher							55
Field work done by the student (Note: Field work is practical work done outdoors.)							56
Project work done by the students individually or in groups							57

Details?: ____________________

18. What was the most typical size of the field work group that you worked with?

single student ☐ 58
2 students ☐
3 students ☐
4 students ☐
more than 4 students ☐

19. What was the most typical size of the Project work group that you worked with?

single student ☐ 59
2 students ☐
3 students ☐
4 students ☐
more than 4 students ☐

20. During this year, to what extent was the practical work used <u>as a starting point for the introduction of a new topic</u>?

Always ☐ 60
Frequently ☐
Occasionally ☐
Rarely ☐
Never ☐

21. During this year, to what extent was the practical work used <u>to illustrate what you had already been taught</u>?

Always ☐ 61
Frequently ☐
Occasionally ☐
Rarely ☐
Never ☐

TECHNIQUES OF PRACTICAL WORK

22. Please tick in the appropriate column to show which of the following Techniques in Science

in Column A : you know about

in Column B : you have seen done at school

in Column C : please indicate the *frequency* with which you carried out these techniques yourself, using the five point scale below.

Scale:

5 = more frequently than once a month
4 = about once a month
3 = about once a term
2 = about once a year
1 = never

** PLEASE CHECK EVERY ITEM **

PRACTICAL TECHNIQUE	A	B	C (How often)	
	Know About	Seen Done	Carried out yourself	
Heating with a gas burner				62
Measuring with a ruler				63
Measuring with vernier calipers or micrometer or screw gauge				64
Using an Ammeter and/or Voltmeter				65
Reading a thermometer				66
Connecting up an electric circuit				67
Distilling a liquid				68
Crystallizing (growing crystals)				69
Measuring a volume of liquid with a measuring cylinder				70
Using a pipette				71
Weighing (on a rough balance)				72
Weighing (on an accurate balance to at least 2 decimal places)				73
Using magnets				74
Using a hand lens or a magnifying glass				75
Using a microscope				76

23. Consider for a few minutes your attitude to practical work at school and then write in your own words how you feel it has influenced you.

The following points may serve as guidelines.

(a) Has changed my attitude to science.

(b) Helps me understand science work.

(c) Interests me.

ON PREFERENCES REGARDING THE ASSESSMENT OF PRACTICAL WORK

Please note that the term 'practical work' is taken to include demonstrations by the teacher, as well as experiments performed by the student either in groups or individually. Consider your experience over your last two years of school.

24. Do you think that your practical work should be assessed separately?

Yes ☐ 100

No ☐

If Yes, what type of assessment do you prefer?

(i) Practical examination (by outside examiner) ☐ 101
(ii) Practical examination (by your teachers) ☐
(iii) Continuous assessment (by your teachers) ☐
(iv) Both (i) and (ii) ☐
(v) All of (i), (ii) and (iii). ☐

25. What percentage should practical work contribute to your overall mark in science?

0 per cent ☐ 102
about 10 per cent ☐
about 20 per cent ☐
about 30 per cent ☐
about 40 per cent ☐
about 50 per cent ☐

26. During the past two years at school how often did your teacher give you a mark or award for your practical work in science?

about once a week ☐ 103
about once a month ☐
about once a term ☐
about once a year ☐
never ☐

27. During the past two years at school have you ever had any practical test set by your teacher?

Yes ☐ 104
No ☐

If Yes, please indicate how often

about once a week ☐ 105
about once a month ☐
about once a term ☐
about once a year ☐
never ☐

28. Do you feel satisfied with the present method of assessing your practical work?

Yes ☐ 106
No ☐

If no, please explain why

____
____
____
____
____

APPENDIX FOUR

LETTERS TO PRINCIPALS,
SENIOR MASTERS, TEACHERS AND
ADVISORY STEERING COMMITTEE

The University of Tasmania

CENTRE FOR EDUCATION
Department of Teacher Education

Box 252C, G.P.O., Hobart,
Tasmania, Australia 7001
Telephone: (002) 202101
Cables 'Tasuni'
Telex: 58150 UNTAS

LETTER TO SENIOR SCIENCE TEACHERS

PRACTICAL WORK IN THE TEACHING OF SCIENCE

You are asked to participate in a state examination into the purpose, nature and organisation of the practical work component in the sciences at high school and matriculation level. Letters of explanation and questionnaires have been included for distribution to all your science and physical science (matriculation) teachers.

The following procedures are suggested to facilitate collection of the questionnaires:

1. All science teachers (at High School level) and all teachers of physics or chemistry (at Matriculation level) should complete the 'QUESTIONNAIRE TO ALL HIGH SCHOOL AND MATRICULATION TEACHERS'.

2. Completed questionnaires should be returned to the Senior Science Teacher.

3. The entire set of completed questionnaires should be posted as soon as possible to: Project Practical Work,
Centre for Education,
University of Tasmania,
G.P.O. Box 252C,
HOBART. 7001

An addressed envelope is provided.

Names of schools, and teachers will not be published. Your assistance is greatly appreciated as a high percentage return of questionnaires is essential for the success of this venture.

Paddy Lynch

Senior Lecturer in Science Education.

The University of Tasmania

CENTRE FOR EDUCATION
Department of Teacher Education

Box 252C, G.P.O., Hobart,
Tasmania, Australia 7001
Telephone: (002) 202101
Cables 'Tasuni'
Telex: 58150 UNTAS

LETTER TO SCIENCE TEACHERS

PRACTICAL WORK IN THE TEACHING OF SCIENCE

A State enquiry is under way into the nature, organisation and assessment of practical work used in the sciences at high school and matriculation level.

In recent years a major effort has been made to improve conditions for the teaching of science. The scale of provision of laboratories and apparatus is based on the view that unique values arise from experimental work, expecially if pupils have direct experience. These values are largely peculiar to scientific endeavour, and the justification for the inclusion of science in the school curriculum is based on them to a considerable extent. Yet a recurring criticism of the teaching of science throughout its development has been the neglect of practical work, and particularly of any real investigational exercises. What is the place of experimentation in Tasmanian schools today? Since the sciences now make up a considerable proportion of the school curriculum, it is essential that they should be taught in such a way as to secure the widest possible values. It seems that further renewal and development of science curricula is imminent. But before new ideas can be implemented or even planned and put to trial, it is imperative to know what the practising science teacher is thinking and doing and what impression existing practices are making on students.

To this end, a research team has been formed to undertake a questionnaire survey. Questionnaires are to be sent to science teachers, and high school and matriculation science students.

The research team is being assisted throughout by an Advisory Steering Committee comprising personnel drawn from University, and the Tasmanian College of Advanced Education, as well as representatives of the Education Department. The function of this committee is to evaluate, analyse and criticise the work of all stages right up to the production of the report. The advice given by this Committee will lend additional validity to the results of the enquiry. The final report will be made available to universities, colleges, schools and other interested bodies. Names of individual schools and teachers will not be published.

The team is very grateful for, and appreciative of, any assistance you may give.

Please return the completed questionnaire to the Senior Science Teacher.

Paddy Lynch

Senior Lecturer in Science Education.

The University of Tasmania

Postal Address: Box 252C, G.P.O., Hobart, Tasmania, Australia 7001

Telephone: 23 0561. Cables 'Tasuni' Telex: 58150 UNTAS

IN REPLY PLEASE QUOTE:

FILE NO.

IF TELEPHONING OR CALLING

ASK FOR

REQUEST TO PROSPECTIVE MEMBERS OF THE ADVISORY STEERING COMMITTEE REGARDING THE SURVEY OF PRACTICAL WORK IN THE PHYSICAL SCIENCES IN TASMANIAN SCHOOLS

Dear

Towards the end of 1980 we intend to collect data from a stratified sample of Tasmanian schools regarding the nature, organisation and assessment of practical work in the physical sciences. School information will be elicited from pupils and school teachers in High Schools and Matriculation Colleges.

It is hoped that the descriptive statistics and correlation studies will provide a useful stimulating baseline for grappling with the problems of science teaching as a whole in the 80's.

As you will appreciate the questionnaires used in a survey study need to be validated. A technique widely favoured is to use an Advisory Steering Committee for the purpose of validation.

We would be most grateful for your help and cooperation as a member of this Committee, in a venture which we hope will prove to be of interest and value to all science teachers, educators and administrators in Tasmania.

Yours

LETTER TO PRINCIPALS

PRACTICAL WORK IN THE TEACHING OF SCIENCE : QUESTIONNAIRE TO STUDENTS

Dear

Your school has been selected to participate in a State enquiry into the nature, organisation and assessment of the practical work component in the sciences at high school and matriculation level. The questionnaire is to be answered by a representative sample of about 30 Grade 9 students taking science, and/or all Grade 11 students offering Physics A or Chemistry A.

Enclosed with this letter are the following:

1. Explanatory letters for your science teachers.

2. Questionnaires for your Grade 9 science students.

Please ask your staff teaching science to administer the questionnaires according to the directions in the explanatory letter. Most classes should complete their questionnaires in 20 to 30 minutes.

The entire set of completed questionnaires should be posted as soon as possible to:

PROJECT PRACTICAL WORK
FACULTY OF EDUCATION
UNIVERSITY OF TASMANIA
G.P.O. BOX 252C
HOBART
TASMANIA, 7001

Names of schools, teachers and pupils will not be published.

Your assistance is greatly appreciated.

LETTER TO SCIENCE TEACHERS

PRACTICAL WORK IN THE TEACHING OF SCIENCE

A State enquiry is under way into the nature, organisation and assessment of practical work used in the sciences at high school and matriculation level.

In recent years a major effort has been made to improve conditions for the teaching of science. The scale of provision of laboratories and apparatus is based on the view that unique values arise from experimental work, especially if pupils have direct experience. These values are largely peculiar to scientific endeavour, and the justification for the inclusion of science in the school curriculum is based on them to a considerable extent. Yet a recurring criticism of the teaching of science throughout its development has been the neglect of practical work, and particularly of any real investigational exercises. What is the place of experimentation in Tasmanian schools today? Since the sciences now make up a considerable proportion of the school curriculum, it is essential that they should be taught in such a way as to secure the widest possible values. It seems that further renewal and development of science curricula is imminent. But before new ideas can be implemented or even planned and put to trial, it is imperative to know what the practising science teacher is thinking and doing and what impression existing practices are making on students.

To this end, a research team has been formed to undertake a questionnaire survey. Questionnaires are to be sent to science teachers, and high school and matriculation science students.

The research team is being assisted throughout by an Advisory Steering Committee comprising personnel drawn from University, and the Tasmanian College of Advanced Education, as well as representatives of the Education Department. The function of this committee is to evaluate, analyse and criticise the work of all stages right up to the production of the report. The advice given by this Committee will lend additional validity to the results of the enquiry. The final report will be made available to universities, colleges, schools and other interested bodies. Names of individual schools and teachers will not be published.

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At this stage we are asking for assistance with the 'Questionnaire to Students'. Early next year we will be sending out the 'Questionnaire to Teachers' to all teachers of science in Tasmanian schools.

The team is very grateful for, and appreciative of, any assistance you may give.

Return address: PROJECT PRACTICAL WORK
FACULTY OF EDUCATION
UNIVERSITY OF TASMANIA
G.P.O. BOX 252C
HOBART
TASMANIA 7001

DESCRIPTION OF SAMPLE

1. Questionnaire to Teachers

It is intended that the 'Questionnaire to Teachers' be sent to all science teachers in Tasmanian High Schools and Matriculation Colleges and their equivalent in the Private and Catholic sector.

- approx. 500 teachers

2. Questionnaire to High School Pupils (Grade 9)

It is intended that the sample chosen will be representative of State, Private and Catholic Schools. To this end a stratified sample of State High Schools (approx. 15); Private Schools (2) and Catholic Schools (2) will be used.

Approximately 30 pupils at the end of Grade 9, will complete the 'Questionnaire to High School pupils'. This 30, needs to be representative of the grade.

- approx. 600 H.S. pupils

3. Questionnaire to Matriculation Pupils (Grade 11)

It is intended that four matriculation colleges and the equivalent sections of the private (4 schools) will provide this second school sample.

The questionnaire will be given to all pupils offering Physics A or Chemistry A at Grade 11.

- approx. 400 matriculation students

INSTRUCTIONS FOR CONDUCTING 'QUESTIONNAIRE TO STUDENTS'

In order to standardise the method of giving the questionnaire to the Grade 9 students, the following procedure is suggested:

1. Explain for 2-3 minutes, to the students, that the purpose of this enquiry is to improve conditions for the teaching of science. Emphasise that an honest and thoughtful answer is required to the questions if the enquiry is to be of value.

2. Hand out the questionnaires.

3. Read clearly through each question with the pupils before they mark their answers.

The questionnaire should take no more than about 25 minutes.

The numbers next to the boxes are for computer purposes.

> Questionnaires should be returned to the Principal as soon as possible.

INSTRUCTIONS FOR CONDUCTING 'QUESTIONNAIRE TO STUDENTS'

In order to standardise the method of giving the questionnaire to the Grade 12 students, the following procedure is suggested:

1. Explain for 2-3 minutes, to the students, that the purpose of this enquiry is to improve conditions for the teaching of science. Emphasise that an honest and thoughtful answer is required to the questions if the enquiry is to be of value.

2. Hand out the questionnaires.

3. Read clearly through each question with the pupils before they mark their answers.

The questionnaire should take no more than about 30 minutes.

The numbers next to the boxes are for computer purposes.

The entire set of completed questionnaires should be posted as soon as possible to:

PROJECT PRACTICAL WORK
FACULTY OF EDUCATION
UNIVERSITY OF TASMANIA
G.P.O. BOX 252C
HOBART
TASMANIA, 7001

Names of schools, teachers and pupils will not be published.

Your assistance is greatly appreciated.

WELLINGTON RD., CLAYTON, VICTORIA, AUSTRALIA 3168
PHONE 541 0811

MONASH UNIVERSITY
DEPARTMENT OF CHEMISTRY

CHAIRMAN OF DEPARTMENT PROFESSOR R.D. BROWN
INORGANIC CHEMISTRY PROFESSOR B.O. WEST
ORGANIC CHEMISTRY PROFESSOR W.R. JACKSON

11th November, 1981

Mr. V.L. Ndyetabura,
University of Tasmania,
Faculty of Education,
Teacher Education Department,
G.P.O. Box 252C,
HOBART. TAS. 7001

Dear Veddy,

I've been asking questions about practical examinations and I confirm that, as I mentioned to you, most university chemistry departments stopped using them between 1955 and 1960.

One reason for this was the increase in class numbers which simply made it too much work for the technical and academic staff. The major reason, however, was the unfairness of placing all of the students' mark on one performance: a dropped beaker or a correct, but inappropriate, weighing (weighing out ten times the required sample, for instance) could ruin everything. The best students usually did quite well and the worst performed as expected. In between, most of the students were at risk.

The system which replaced the practical examination is weekly assessment of laboratory performance, by which I mean both accuracy of results and clarity of a report. One problem with this newer system is that marking is done by junior people, demonstrators and graduate students, who usually award a mark of 7 or 8 out of 10 for each report. Most places watch this carefully, and insist on a better range of marks, e.g. 4 to 10 out of 10.

Our biologists still use practical examinations but they combine the marks with those of week-by-week assessment or those of four or five 'marked' exercises. Only one department at Monash, Biochemistry, has a 'theory of the practical' examination, but I think such an examination is a good idea.

In high schools, there haven't been practical examinations at all (I checked back to about 1930). Senior Technical Schools had them, of course, because their Diplomas were much more 'practical'. Now that they have become CAE's, however, I believe they have dropped them and gone to a system much like ours. In High Schools, there is no practical mark in the final assessment, but the teacher must certify that a satisfactory course has been completed before the candidate is allowed to sit for the final examination.

I hope your stay in Australia is a fruitful one. I certainly enjoyed meeting you and I look forward to (perhaps!) seeing you in Tanzania one day.

Kind regards,

Ian D. Rae

Ian D. Rae,
Associate Professor.

APPENDIX FIVE

STRUCTURED INTERVIEW TO TASMANIAN SCHOOLS' SCIENCE SUPERVISORS

INTERVIEW QUESTIONS TO TASMANIAN SCHOOLS' SCIENCE SUPERVISORS

1. What was the role of science supervisor in Tasmania in regard to the science syllabus and assessment when you held that position?

2. What major changes or developments took place in the syllabus in science at High School level and at Matriculation level (in physics and chemistry) during your time?

3. (i) What was your attitude towards those changes at that time?
   (ii) What is your attitude now, with hindsight?

4. What major changes took place in regard to practical work at High School level and at Matriculation level during your time?

5. (i) What was your attitude towards those changes at that time?
   (ii) What is your attitude now with hindsight?

6. What major changes took place in regard to assessment of practical work at High School and Matriculation level.

7. (i) What was your attitude towards those changes at that time?
   (ii) What is your attitude now with hindsight?

Advisory Steering Committee List

D. Bradley	Rosetta High School
S. Eldridge	Kingston High School
G. Fish	Tasmanian Education Dept.
D. Fisher	T.C.A.E. Launceston
B. Jones	Faculty of Education: University of Tasmania
J. Laver	Friends School
B. O'Grady	Chemistry Dept., University of Tasmania
J. O'Grady	Research Branch: T.E.D.
V. Osborne	Hutchins School
R. Pallett	Tasmanian Education Dept.
B. Scott	Physics Dept., University of Tasmania
J. Scott	Tasmanian Education Dept.
L. Scott	Bridgewater High School
B. Stoessiger	Research Branch: T.E.D.
B. Tracey	Kingston High School
M. Walsh	Faculty of Education: University of Tasmania.