Science and Mathematics Education Centre

Finding The Balance: Comparing The Effectiveness of Student-Managed And Teacher-Directed Learning in Science Classes

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ABSTRACT

The purpose of the research was to form a defensible basis for considering possible changes in classroom practice within a small rural state school, and it involved four, mixed-ability coeducational classes comprising Year 9 and 10 students. These classes were taught an energy-related module by the researcher. In the preliminary phase, which involved two classes, resources were developed to produce a more student-centred module. These resources, and the constructivist approach which informed their development, are described. In the subsequent comparative phase, the reformed module was taught using two contrasting strategies – one teacher-directed and the other, student-managed. During this phase individual achievement and group investigative skills were assessed. Student perceptions of classroom environment were probed using an existing instrument, the ICEQ. The range of classroom activity and level of student engagement was continuously monitored by independent observers using a specifically developed instrument, termed the SALTA.

No overall learning advantage was demonstrated to either teaching strategy. A small strategy advantage favouring Year 10 students in the student-managed strategy was offset by a similar disadvantage to the Year 9 cohort. A cohort penalty was found to apply to Year 9 students under either strategy, with a paradox in its application. The role of the teacher was found to change significantly under each strategy, with a consistent hierarchy of student engagement with activity emerging. Boys were found to have significantly higher levels of engagement than girls under either teaching strategy. However, this was associated with only modest advantages in achievement. The relationship between engagement and achievement was stronger and more positive under the student-managed strategy. Mismatches between preferred and actual classroom environment were found, particularly in the dimension of independence. This mismatch was less in the student-managed setting. Increased potential for learning was noted under each strategy.

DEDICATION

This work is dedicated to my wife, Jeni, who has cheerfully, willingly and unfailingly supported me during all stages of this project.

And also to the memory of my parents, Stanley and Gladys Bell, who always encouraged my educational development.

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INTRODUCTION

The introduction of the document *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) was a watershed in the development of science teaching in New Zealand, and as such, had a major influence on the writer. Reflection on learning outcomes noted as the constructivist philosophy of the document was introduced into personal teaching practice, ultimately lead to the research considered in this thesis.

The purpose of the research was to form a defensible basis for considering possible changes in classroom practice within a small rural state school, and involved four, mixed-ability coeducational classes comprising Year 9 and 10 students. These classes were taught an energy-related module by the researcher. In the preliminary phase, which involved two classes, resources were developed to produce a more student-centred module. These resources, and the constructivist approach which informed their development, are described. In the subsequent comparative phase, the reformed module was taught using two contrasting strategies – one teacher-directed and the other, student-managed. During this phase individual achievement and group investigative skills were assessed. Student perceptions of classroom environment were probed using the ICEQ (Fraser, 1990). The range of classroom activity and level of student engagement was continuously monitored by independent observers using a specifically developed instrument, termed the SALTA.

The thesis report is set out in the following manner.

Chapter 1. Background describes how the personal teaching observations of the researcher led the development of research questions, and states the research objectives. The scope, significance and limitations of the research are outlined. Relevant school features are described, including the special features of composite classes and a modular teaching programme. The course structure, teaching philosophy and assessment policy of the science department are detailed.

Chapter 2. Responding To The Curriculum gives an overview of the foundation policy statement, the *New Zealand Curriculum Framework* (Ministry of Education, 1993a), including examples of the essential skills relevant to the research module. The science statement, *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) is described in more detail with particular reference to its constructivist epistemology. The research module, *Energy*, is linked to relevant strands of the science statement, and its themes, lesson structure and learning outcomes are stated.

Chapter 3. Learning And Learners contrasts epistemological positions, establishing a basis for the constructivist referent adopted. Features of subject-centred and student-centred learning are contrasted, providing support for the student-centred reform undertaken. Seven key influences on the learner are discussed.

Chapter 4. Methodology defines and justifies the research perspective. An overview of the research design and teaching sequence is provided. The contrasting teaching strategies are described and practical considerations discussed. The development and operational procedures of the SALTA instrument are detailed. The five dimensions and descriptors of the ICEQ (Fraser, 1990) are given. The sources and formats of the tests used are described, and ethical questions addressed.

Chapter 5. Science Students At Work focuses on student-centred developments made during the preliminary phase. The science perspective of learners known as "children's science" (Osborne, 1985) is discussed. The use of cooperative group learning techniques to foster conceptual change is outlined, and methods of group formation discussed. Classroom metacognitive strategies are described and the development of three conceptual-thinking resources is detailed. An example each of a conceptual-challenge activity, a context-rich investigation and a rotated group activity is described. A specimen lesson is described.

Chapter 6. The ICEQ Findings compares student perceptions of preferred and actual classroom environment. An environmental mismatch index is established and trends across all four classes are investigated. Covariate control is applied to allow comparison between the two classes involved in the comparative phase and the resultant differences in mismatch in each dimension are compared and interpreted.

Chapter 7. The Achievement Findings compares achievement data gathered in the comparative phase. A measure of teaching strategy advantage is developed, and class results compared on a year group basis after application of covariate control. Intra-class comparisons are made of the cohort penalty faced by Year 9 students under each teaching strategy, with two paradoxes discussed. Group investigative data is compared.

Chapter 8. The SALTA Findings compares the range of student activity, level of student engagement, and range of teacher activity observed under each teaching strategy, with relationships between these variables explored. Gender-related differences of engagement level are analysed. The problematic relationship between perceived level of engagement and individual achievement is investigated under each teaching strategy. Gender-related differences of engagement level are related to corresponding individual achievement.

Chapter 9. Evaluation examines issues of internal validity, in particular, the control of variables, and the validity of the instrumentation. An index of common learning is developed to compare the prior learning experiences of the classes, and other effects, such as class composition, are discussed. The appropriateness and strength of each instrument is discussed.

Chapter 10. Summary Of Findings is a descriptive summary of the main findings presented in the three preceding chapters. Local implications of the research are discussed. These relate to the combined effect of composite classes and modular teaching on Year 9 achievement, and perceived gender-related differences in achievement. The contrasting teaching strategies are discussed in terms of short and long-term effectiveness. A conclusion is reached concerning the nature of the balance between strategies.

CHAPTER ONE

BACKGROUND

This chapter discusses the origin of the research, outlining the development of the research questions, stating the research objectives, indicating its scope, application and limitations. It examines the school setting in which the research took place, discussing the general nature of the school itself, and the pertinent specific features of composite classes and modular teaching. It briefly discusses the New Zealand science curriculum, and examines how the philosophy and practice of the science department address some of the issues it raises.

GENESIS

During 1994, the science-teaching fraternity of New Zealand spent much time coming to grips with the newly-published document, *Science in the New Zealand Curriculum* (Ministry of Education, 1993b). This document replaced earlier prescriptive syllabuses and defined the future direction of science teaching in New Zealand state schools in many ways. It prescribed science learning in terms of a framework of broad, spirally-developed achievement objectives. From these, teachers were to develop contextually-based science programmes which were appropriate to the learning needs of their students. These programmes were to have specific learning outcomes against which achievement was to be measured, by both teachers and students, using a range of assessment procedures.

The document stated that the curriculum in science was "designed to encourage all students to continue their participation in science education beyond the years in which it is required as a school subject." (Ministry of Education 1993b, p8). It set encouraging general aims, outlined research-based ways of enhancing achievement, and pointed to the need for inclusive approaches which, by considering the perspectives and needs of all students, would enrich the education of all. It provided an exciting vision of teachers as facilitators in a cooperative, student-centred learning environment informed by constructivism, although the word itself was not mentioned.

During late 1993 the writer took up the position of Head of Department (HOD) Science at Lakeside College, a small, rural Year 7-13 state school in the South Island of New Zealand. In this role, he had the responsibility during 1994 of developing a school science programme which would meet all the requirements of the new curriculum, which was due to be implemented in 1995.

There were at least four features to be considered:

1. The overall structure of this programme had to provide balanced spirally-developed coverage of the prescriptive achievement objectives.
2. The specific learning outcomes of each module had to encourage the development of investigative skills and attitudes.
3. The structure and delivery of the programme both had to support the philosophy of the document, for example by providing student-centred learning experiences in a classroom environment which encouraged the use of student initiative.
4. The programme structure had to dovetail immediately into two structural features of the school teaching system - a modular teaching system, and composite classes.

During the next three years these matters were addressed as an appropriate modular scheme was developed, introduced and refined. It was from an acknowledged increase in interest and achievement in science within the school over this period that the writer was stimulated to pursue a course of academic study at Curtin University which ultimately lead to the development of this research project.

THE RESEARCH QUESTIONS

There appeared to be a large variation in the degree of student-centred work contained in the various modules, and in their perceived success by both students and teachers. However, it was apparent from observation and feedback that modules containing extended opportunities for the use of student initiative, engaged high student interest.

For example, the two Year 7/8 modules *Investigating One* and *Investigating Two* each contained formative 'mini-investigations' in three different content areas, followed by an extended (four period) assessed investigation of the students' choice into one of these areas. Students, working in groups of two or three, had first to decide what to investigate, then plan, carry out and modify their investigation, analyse results, draw conclusions, and produce an appropriate report. The teacher became a facilitator of this learning process as students became engaged in meaningful investigations at their level. As the teacher stepped back, encouraging increased student responsibility for choosing courses of action, students learned to take increased ownership. There was evidence of a real sense of excitement in these classes as students cooperated together on authentic group tasks. They were obviously enjoying the experience, and appeared to be gaining confidence in some of the processes of learning. Written and oral student feedback was positive, resulting in the growth of positive attitudes needed for future progress.

Another module which was successful in gaining student interest at the Year 9/10 level was the module called *Using Technology*. Students were introduced to this module via four periods of teacher-directed work and then split into four groups, with each group spending four periods on each of four rotated student-centred activities, for which written and practical resources had been previously prepared. Each activity contained a variety of tasks, graded in level, with associated criteria-based assessment. Practical activities included electronics construction, Lego construction, 'tinkering' with items of technology, and, at times, photography. A further activity was based on comprehension of a specially-written science-related text selected by the student. Student involvement was high, while the logistics and management aspects associated with running different practical activities simultaneously became readily manageable with experience. The use of rotated group activities with consequently smaller student numbers involved in any one activity at a particular time, resulted in a very economical use of equipment, leading to the advantage of a wider range of equipment able to be provided.

In this environment, with groups focused on defined tasks, and working cooperatively, the teacher role was primarily that of a facilitator, with quality time spent interacting with students. Such discussion often resulted in the development of improvements to the module - a tangible benefit of student and teacher negotiating their way through the curriculum. A secondary teacher role was that of in-class assessor, a role which was readily incorporated into this style of teaching strategy. Such assessment gave benefit to both parties: it motivated students to improve their grades by completing the next level of the task, and reduced teacher out-of-class marking workload. Student feedback from this module was also positive - students enjoyed the nature of the activities, working in groups, and managing their own learning.

Teaching approaches such as those just described, had been resisted with the Year 9/10 module, *Energy*, which forms the basis of this research. It was felt that the course overall contained an appropriate balance of teaching strategies, and that the appropriate strategy for this module was teacher-directed. The mathematics involved, and the emphasis on developing a robust understanding of the relationship between energy-related concepts, was felt to require significant teacher-led discussion for effective learning. Hence until 1998 this module had been taught in a more traditional lock-step style, although a four-period open investigation similar to that described above, had been incorporated.

As the writer reflected on the apparent success of modules such as those just described a number of questions arose:

- Could the *Energy* module be made more student-centred, even if it were still taught in a lock-step manner?
- Could strategies be developed to foster student involvement and cooperation?

- Could rotated group methods be used?
- How would the effectiveness of learning compare between student-managed rotated group work, and teacher-directed work if cooperative learning methods were used for both?

From these questions the following specific research objectives were developed.

THE RESEARCH OBJECTIVES

The primary research objectives were to:

1. locate and evaluate research into student-centred learning, applicable to a constructivist-oriented science curriculum, and which appeared both appropriate and feasible to incorporate into this particular module and teaching situation.

2. develop a rotational series of student-centred activities and incorporate them into the teaching programme. These activities were to involve the use of a range of cooperative learning strategies.

3. compare the impact of the module on student engagement, understanding and achievement when two randomised classes were taught using cooperative learning strategies applied to the alternative class settings of either lock-step teacher-directed learning activities or the same activities set as rotated group work managed by the student members of the group.

SCOPE AND SIGNIFICANCE

The prime intention of this research was to provide a strong foundation for considering the implications of any possible structural changes to the science teaching pedagogy at a particular secondary school in New Zealand. It was also intended to improve the writer's personal teaching practice both specifically in terms of the *Energy* module, and in general terms. Specific improvements were anticipated as a result of refinements to the structure of the module, and in the focused development of teaching resources. These would be of immediate significance within the science department of Lakeside College, as the module would be taught by a variety of science teachers. Any improvements to student understanding achieved at this level would help future progress, particularly with the mechanics topic in the compulsory Year 11 science course. General improvements to the writer's teaching practice were also expected. These would result from an enhanced personal understanding of the classroom implications of constructivism, and the wider implementation of teaching approaches to reflect this.

Improvements to the *Energy* module are of particular significance to New Zealand secondary school teachers since their courses cover the same curriculum objectives. Specific resources developed for teaching this topic, and other more general resources, will also interest a wider field of educators intending to incorporate cooperative concept-oriented tasks and investigative approaches into their teaching.

The presence of two independent classroom observers (as will be described later) for the whole of the comparative phase resulted in the collection of a wealth of data, analysis of which contributes to an understanding of the classroom dynamics and student achievement in these specific settings. Specifically:

- the features of the role of the teacher under teacher-directed and student-managed regimes are contrasted.
- relationships between observed student involvement and achievement are examined.
- the relative achievements of Year 9 and Year 10 students in composite classes is examined.
- the relative achievement of boys and girls is examined.

Theory-into-practice initiatives in general help bridge the gap between the theoretical perspectives of the educational researcher and the classroom practitioner - not only for the individual, but as steps towards the wider reform of teaching practice. Hence this research may serve as an encouragement to other teachers of science contemplating classroom research, as well as providing one particular professional development perspective.

All research has limitations. The findings of this research are necessarily limited by the:

- closeness of fit between the direction of the existing science teaching programme and the developments introduced.
- restricted sample size.
- validity of the assessment tasks.
- inexperience of the researcher.
- potential bias of the teacher-researcher paradigm.

Specific discussion of these limitations, and an estimation of their effects, is left until Chapter Nine.

THE SCHOOL SETTING

General

Lakeside College is a rural, co-educational Year 7 - 13 state school, with a roll of some 270 students. Approximately 95% of these come from the local catchment area, with the remainder being fee-paying international students. Most of the local students enter the school with similar prior learning experiences (having mainly come from one primary feeder school), but display a wide range of achievement and attitudes to learning. Mixed-ability classes are formed based on knowledge of both prior academic progress and social interaction. The ethnic composition of the school population is approximately 85% New Zealand European (or Pakeha), 5% Maori, 5% Other (Local) Students, 5% International Students.

Each year the Ministry of Education compiles a socioeconomic status decile rating of state and state-integrated schools, based on Census information from the school catchment area together with school-supplied ethnicity data. Decile ten indicates schools drawing on the highest 10% of socio-economic backgrounds, with decile one representing the lowest 10%. Lakeside College is typically and currently rated at decile eight, indicating that the students come from socio-economic backgrounds exceeded by less than 30% of the nation's students. (Ministry of Education, 1996).

All students appear well-integrated socially into what is a very predominantly monocultural environment. All classes are taught in English.

Composite Classes

One special feature of the school is the composite nature of the junior classes. This means that classes consist of approximately equal numbers of students from two consecutive year groups. Typically, for example, the school will run four composite Year 9/10 classes, rather than two Year 9 and two Year 10 classes, with similar composite grouping of the Year 7/8 students. Both academic and social aspects are considered in allocating students to these classes. Each composite class contains students with a similar range and distribution of academic abilities (as measured by previous achievement using standardised testing in mathematics and english). This means that each cohort consists of four academically comparable classes, all of which are taught the same core curriculum to the same level. Socially, classes reflect other parameters considered in their formation -for example the perceived need to allocate certain students to certain form teachers. This often results in classes having a significantly different tone.

The feature of composite classes was essentially created to enable more timetabling flexibility with regard to optional subjects, with the additional advantage of allowing a better mix of students for social reasons. Given that there are typically only about 40 students in each of these year groups, and that most have progressed through the primary school system together before entering Lakeside College, this approach does have merit. However, some members of the school community perceive other social, and also some academic, drawbacks to this system. Perceived social drawbacks relate to some negative influences on younger students by their older peers; academic drawbacks relate to the perceived holding back of older students by their younger peers. Nevertheless, it is a well-established system, and the staff consensus appears that the advantages outweigh the disadvantages.

Modular Teaching System

A second special feature is the modular teaching system which applies throughout the school. The teaching programme for all subjects is constructed in discrete, (relatively) independent blocks, or modules, which, especially for junior classes, may be taught in any order, and by different teachers. Each module consists of 22 hours guaranteed class contact (normally four hours per week), forming one semester. The school teaching year is structured into six semesters overall. A variety of course aspects are assessed in each module using an achievement-based system of five grades. Assessment methods reflect the variety of skills emphasised in the module. Reporting is done immediately after the completion of each semester, and in addition, individual student records are kept for every learning area. Over the duration of a course, all course aspects are assessed in different contexts using a variety of methods, producing a balanced profile of individual achievement.

The modular system offers considerable advantages in timetabling flexibility, readily allowing, for example, for a particular teacher to teach a specific topic (as was required in this research). It can likewise readily respond to changes of staffing or class needs. The system focuses both teacher and student attention on the defined learning objectives of the module, which are publicised to all students by the teacher. Science teachers become used to having a range of science classes, and students similarly become used to being taught by a range of teachers. This can allow students to benefit from the combined insight and expertise of their teachers, and learn to relate to a variety of teaching styles. From a teaching perspective, especially an HOD role, it encourages an overview of the learning occurring at each level. However, the lack of overall teacher-class continuity is often perceived as a disadvantage by teachers (in particular) since long-term teacher-class relationships are the exception rather than the norm.

A third feature of significance arises from the student intake being at primarily at Year 7 level, rather than the more common Year 9. This feature means that students are taught by specialist teachers, and have access to specialist facilities, several years earlier than the norm. This is perceived to give an educational advantage to some students, allowing for faster progress.

The Science Department

Staffing.

In 1998 the science department consisted of the writer, four part-time science teaching staff, and a laboratory technician. Year 12 and Year 13 courses in Biology, Chemistry and Physics were taught respectively by two part-timers and the writer, who also taught the two Year 11 science classes. Between them, the other two part-timers taught the entire Year 7/8 course, and everything in the Year 9/10 course except the *Energy* module in the Year 9/10 course, which was taught by the writer. The school operates two well-resourced laboratories in which virtually all teaching occurs. These laboratories are serviced by a technician, operating for six hours per week.

Scheme Of Work.

The science department scheme of work was developed from the appropriate curriculum document, *Science in the New Zealand Curriculum* (Ministry of Education, 1993b). This document, and its parent document *The New Zealand Curriculum Framework* (Ministry of Education, 1993a), are discussed in Chapter Two. The scheme has addressed the student-centred philosophy of these curriculum documents, as well as providing an appropriate and structured learning programme. After reviewing this scheme the Education Review Office (1997, p9) described it as a "well-balanced, high-quality science programme that meets all requirements except that of monitoring student progress against the national achievement objectives."

Philosophy.

In addressing student-centred teaching approaches the scheme discusses the importance of :

1. Encouraging student ownership of learning by stating:

> The teaching approach of the College is student-centred learning, and increasingly new science modules reflect this. We must allow and encourage students to take increasing responsibility for choosing learning starting-points/options/ planning and investigative approaches etc. That, in the short-term, these may prove to be "wrong" is not to be seen as a problem; but rather as a stage necessary in the students' development. However, students do need help and training in taking responsibility for managing their own work, and some teacher direction or guidance is always necessary.

2. Providing an appropriate learning environment by stating:

> As well, we need to create a supportive atmosphere in which we provide effective help to enable students to increase their confidence in the processes of learning. Learning implies risk-taking in a non-risky situation; something that can only happen in an atmosphere in which encourages it.

3. Teaching learning skills by stating:

> We also need to <u>teach students how to learn</u>, by actively providing different learning strategies as part of our teaching repertoire. i.e. teaching the students how to make links between ideas using concept mapping exercises, flow diagrams as summaries, Venn diagrams to display hierarchies etc.

Lakeside College Science Department: Scheme of Work, 1997.

Course Structure.

The Year 9/10 science course consists of four compulsory core modules per year, over each of the two years of the course. The titles of core modules taught in even and odd years are shown in Table 1.1.

EVEN YEARS	ODD YEARS
Beginning Biology	Not So Shocking!
Energy	Life goes On
Nature's Resources	Earth and Beyond
Using Technology	Chemistry in Action

Table 1.1. Titles of the core modules comprising the Year 9/10 science course.

One important outcome of the composite nature of classes, is that modular courses, such as the Year 9/10 science course, are written around a two-year teaching cycle as shown. Interestingly, this is the time-scale envisaged by the curriculum writers for an average student to attain the broad achievement objectives specified for this level (Level 5) of the defining curriculum statement, *Science in the NZ Curriculum* (1993b, p21). Although this suggests that the curriculum writers visualise little difference in depth of understanding between Year 9 and Year 10 students, it must be kept in mind that the prior formal learning experiences of each group will be different in composite classes. This can create a teaching dilemma since many concepts are inter-related, even though modules are constructed to be independent. To such avoid problems, some concepts must deliberately be taught twice in quite separate contexts. For example, students use electrical symbols both in the *Using Technology* module taught in 'even' years, and in the electricity module, *Not So Shocking!*, taught in 'odd' years. In any given year, the Year 10 cohort of the class will already have encountered this symbology in the context of the module taught the previous year. In practice, the apparent teaching disadvantages implicit in this situation seem to be balanced by corresponding learning advantages: Year 10 students benefit by re-visiting concepts in a different context, and peer-assistance benefits both Year 9 and 10 students.

In addition to the core modules, an optional extension module is typically offered once per year in semester six. This module caters to a variety of student needs: originally intended for weaker Year 10 students as course revision, it now also caters for a variety of Year 9 and 10 students interested in their own project work.

Module Outlines.

For each module a single-page modular outline has been developed for teacher use. These outlines define the specific learning outcomes for the module, and refer to the curriculum achievement objectives from which they have been derived. The outlines also refer to specific aspects of investigative skill which are targeted as learning experiences in the module. The process of creating a modular outline is further described in Chapter Two, using the *Energy* module as an exemplar. In addition to the 'bare bones' of the module outlines, master copies of modules have been gradually produced. These contain a variety of supporting resources so that modules can be taught readily and efficiently by a range of teachers. These resources typically include student guides, teaching notes, resource sheets, assignments, and tests. A wide variety of recently-purchased student texts are used to support modules - although the earlier text *Kiwi Integrated Science Series* (Sweeny, Relph & DeLacey, 1989) is used extensively.

Assessment.

Learning in science has been divided into six course aspects representing both knowledge and investigative skills. These six aspects, with typical methods of assessment, are shown in Table 1.2. (p14). The aspects numbered 3 - 6 represent specific sub-skills of the overall investigative skill, Carrying out an Investigation.

Individual student content knowledge is assessed in every module, with test and assignment marks averaged and converted to a grade. Additionally, either two specific investigative sub-skills are individually assessed, or the overall skill of Carrying out an Investigation is assessed by means of an extended group investigation - in both cases generating a numerical grade.

COURSE ASPECT	TYPICAL MODE OF ASSESSMENT
1. Content Knowledge	Test and assignment
2. Carrying out an Investigation	Extended investigation, often in groups
3. Planning an Investigation	Planning exercise
4. Gathering Experimental Information	Observation of practical performance
5. Processing and Interpreting	Analysis of experimental or supplied data
6. Researching and/or Reporting	Written or oral reporting in a format chosen by the student

Table 1.2. The six assessed course aspects, and typical mode of assessment.

Generic grading criteria for all course aspects are shown in Appendix One. Individually assessed tasks are graded by reference to specific task criteria, created from the generic criteria, to produce an overall individual achievement profile.

For extended group investigations, however, the situation is quite different. These are intended to provide opportunities for authentic work, and although a range of possible investigations is suggested, groups are encouraged to negotiate alternatives, within the modular theme, to suit their interests. These investigations are also intended to foster essential skills (discussed in Chapter Two) and provide important opportunities for peer-assistance. Teacher input is often significant over the timeframe of an investigation, and may involve, for example, offering suggestions, posing further questions, or supplying equipment previously unconsidered by the group. Students almost invariably carry out such investigations with enthusiasm, and often with surprising insight. For example, the effect of certain experimental variables may be carefully considered. Evidence of the depth of student thinking often arises only if the teacher is present at that time, or later, asks the right question - such evidence seldom appears in written reports. The nature and intention of this learning situation directs assessment. Generic criteria are used, often with reference to exemplars. Grade boundaries are defined by teacher professional judgment, with early indications of likely grades given, and suggestions for grade improvement offered. Students are encouraged to evaluate their own work, and peer assessment methods may be used. Within a group, students occasionally make significantly different contributions to the overall investigation. Such differences, after discussion, may be reflected in the award of different individual grades. However, in general, all group members receive the same grade.

SIGNPOST ONE

The purpose of this chapter has been to introduce the reader to the background of the research. The position of the researcher as a teacher-participant in an evolving learning situation, encouraged by perceptions of student success as new curriculum-espoused initiatives were introduced, has been outlined. Research questions have been posed, their objectives, and scope discussed. The school setting, with its particular features of composite classes and a modular teaching structure, has been described. The policy and practice of the science department in responding both to these school features and the science curriculum have been outlined.

The research has been placed in the context of an introductory module in mechanics taught to all Year 9 and 10 students. The focus of the research initiative is firmly on improving teaching practice by the use of research-based student-centred learning strategies informed by constructivism. It includes developing resources, and rotational activities involving cooperative learning strategies; and comparing the effectiveness of lock-step teacher-directed methods with student-managed group work. The methodology by which this is investigated will be discussed in detail in Chapter Four. Chapter Two focuses on the science curriculum and the *Energy* module itself.

CHAPTER TWO

RESPONDING TO THE CURRICULUM

This chapter discusses the New Zealand curriculum with reference to the educational principles and essential skills defined in the founding document. Key features of the resulting science statement are discussed, including the aims and teaching approaches. A curriculum basis for the reform of the research module, *Energy* is established. The relationship of the module to the curriculum strands, levels and achievement objectives is described, and specific learning outcomes are defined. The structure, lesson sequence and resources are outlined.

THE NEW ZEALAND CURRICULUM

The Framework

The *New Zealand Curriculum Framework* (Ministry of Education, 1993a) is the foundation policy document for all New Zealand state school education, and has been so since 1993. It is based on two key premises, namely that:

1. "the individual student is at the centre of all teaching and learning"
2. "the curriculum for all students will be of the highest quality".

(Ministry of Education, 1993a, p9).

These twin premises underpin the development of nine curriculum principles which direct the day-to-day practice of schools towards providing an appropriate educational programme for all students. This programme is to be broad, balanced, flexible, relevant, empowering and inclusive. It should recognise and value the unique place of Maori, and encourage the growth of a multicultural perspective. The learning experiences themselves should be meaningful, both at the time, and as steps towards a positive future.

Seven broad essential learning areas (including science) and eight groupings of essential skills are defined. These groupings, encompassing a total of 57 generic skills overall, are shown in Table 2.1.

THE ESSENTIAL SKILLS			
Communication	Information	Numeracy	Problem-solving
Self-management & Competitive	Social and Cooperative	Physical	Work and Study

Table 2.1. The eight groupings of essential skills defined in the N.Z. Curriculum.

Contexts for the development of the skills are the essential learning areas themselves. Consequently, courses must be appropriately designed to challenge "all students to succeed to the best of their ability" (p17) in their development of the skills. Suitable opportunities for this development arise through the use of group learning activities. Eleven skills which are particularly relevant to the context of the *Energy* module are shown in Table 2.2.

SKILLS	EXAMPLES Students will:
Communication	communicate competently and confidently by listening, speaking, reading, and writing, and using other forms of communication where appropriate
Numeracy	calculate accurately recognise, understand, analyse, and respond to information which is presented in mathematical ways, for example, in graphs...
Problem-solving	inquire and research, and explore, generate, and develop ideas make connections and establish relationships
Self-management & Competitive	set, evaluate, and achieve realistic personal goals manage time effectively
Social and Cooperative	develop good relations with others, and work in cooperative ways to achieve common goals take responsibility as a member of a group for jointly decided actions and decisions
Work and Study	work effectively, both independently and in groups take increasing responsibility for their own learning and work

(Ministry of Education, 1993a, pp18-19). Re-arranged form.

Table 2.2. Examples of the essential skills relevant to the *Energy* module.

Values and attitudes are also addressed by the curriculum document, with a key outcome being the growth of positive attitudes towards future learning. These will be encouraged by appropriate and challenging learning activities, with constructive feedback. Educational practice must also foster core societal values of individual and collective responsibility, since such values are "mostly learned through students' experience of the total environment" (p21), rather than taught.

Learning and assessment are linked closely, with school-based assessment viewed primarily as a diagnostic tool to improve learning. By responding to revealed learning needs, teachers can improve teaching programmes. A range of appropriate student-centred assessment tasks are to be used, with student progress measured against learning outcomes developed from defined achievement objectives. Individual student learning profiles are to be built up to enable targeting of resources, as well as to inform caregivers.

In defining the New Zealand curriculum as a "set of national curriculum statements which define the learning principles and achievement aims which all New Zealand schools are required to follow" (p4), the framework document (Ministry of Education, 1993a) gave direction to all subsequent curriculum statements, in particular the science statement.

SCIENCE CURRICULUM

Format

Science in the New Zealand Curriculum (Ministry of Education, 1993b) was amongst the first of the new national curriculum statements to appear, and thus reflect the principles established in the framework document. The curriculum document divides science learning into four broad fields or contextual strands. Two additional fields, known as integrating strands, address the areas of investigative skills and the nature of scientific progress. The titles of these six strands are shown in Table 2.3. overleaf.

CONTEXTUAL STRANDS	INTEGRATING STRANDS
Making Sense of the Living World	Making Sense of the Nature of Science and its Relationship to Technology
Making Sense of the Physical World	Developing Scientific Skills and Attitudes
Making Sense of the Material World	
Making Sense of Planet Earth and Beyond	

(Ministry of Education, 1993b, p14). Re-arranged form.

Table 2.3. The six learning strands of the science curriculum.

The curriculum is divided into eight levels (spanning the thirteen years of schooling), with broad achievement objectives defined for each level. From these objectives teachers are to derive appropriate schemes of work, with specific learning outcomes developed for each unit or module. Individual modules must address both contextual and integrating strands, fostering an integrated development of knowledge, skills and attitudes. The scheme overall must be comprehensive and balanced.

Theme.

The recurrent theme of "making sense of" science learning indicated by the titles of the strands, is significant. The interpretation that students often make of their everyday experience can lead to strongly-held but limited conceptions which are at variance with scientific views (Osborne & Freyberg, 1985). The achievement aims in each strand are directed towards helping students to understand and "make sense of" experience from a wider, scientific perspective. Teaching approaches, reflecting an underlying constructivist epistemology (Burns, 1997; McMillan, 1995), have been developed to help students in this process. There are five features which typify the reorganisation of science curricula when approached from a constructivist perspective (Duit & Confrey, 1996), and these are reflected in the aims and teaching approaches of the curriculum document. The "making sense of" ethos is one of these five features. Others are reflected in the student-centred approach to learning, with its inclusive and responsive focus, and in the attention paid to both meta-cognitive issues and authentic applications.

Aims.

Twelve general aims, through which teachers are to advance learning in science, are defined. The language throughout all twelve aims is consistent in envisaging teachers as working in partnership with students to help, assist and encourage their scientific development. Such a partnership reflects the student-centred philosophy of the framework document, and provides a necessary setting for implementing constructivist teaching strategies later described.

Teachers are first to help students "to develop knowledge and a coherent understanding" (Ministry of Education, 1993b, p9) of the science about them. This raises the immediate questions of what is meant by the terms "knowledge" and "coherent understanding", as well as the subsequent question of how students may be helped to develop these qualities. Although teachers as individuals have intuitive feeling for what is meant by these terms, the range of such personal epistemologies has significance in curriculum implementation for which, ideally, teacher perspective should match curriculum intent. The perspective of the researcher is developed in Chapter Three.

The development of scientific skills and attitudes, addressed in the second and third aims, is "inextricably linked to the development of ideas" (p14), exemplifying the 'situated cognition' characteristic of the constructivist view. In portraying science as an evolving human construct, other aims demonstrate a constructivist epistemology. Social implications of science and technology addressed in other aims, illustrate a 'knowledge in action' ethos of constructivism.

Teaching Approaches

A large number of teaching approaches and learning experiences which take into account the learning needs and perspectives of the student, are described, and support the student-centred philosophy of the framework document. By advocating that teachers provide all students with opportunities to share, compare, apply, and reflect on ideas, the curriculum illustrates that it is by such processes that knowledge and understanding are constructed i.e. that students "make sense of" the learning experience. Similarly, in encouraging teachers to help students become aware of how they learn effectively, the curriculum illustrates the importance of meta-cognition.

The eight essential learning skills, and possible learning experiences through which these may be developed, are also discussed. In particular, the development of problem-solving and information skills is related to scientific investigation work, and the importance of teamwork to such investigations in real-life, is stressed. Group investigative work is promoted as a strategy to encourage the development of scientific understanding and essential skills.

In advocating a partnership in which teachers work with students to engage them with ideas, the curriculum challenges teachers to reconceptualise traditional roles. Rather than being primarily teachers of content knowledge in a topic-driven curriculum, it challenges them to become more effective teachers of learning in a student-centred one informed by constructivism. These challenges create the referents used for the reform of the *Energy* module.

Assessment

The curriculum statement is explicit about the purpose of school-based assessment, stating that its primary purpose is "to improve students' learning and the quality of learning programmes" (Ministry of Education, 1993b, p18). Assessment, according to this approach, should be integrated with the learning programme, and responsive to student needs, interests and perspectives. Examples of such assessment tasks are stated for each curriculum level. These include the assessment of group tasks involving, for example, planning, performing and reviewing the results of practical tasks, analysing data, and reporting the results of investigations. They also include the assessment of individual tasks including, for example, individual performance of the group tasks just described, and the ability to answer test questions. Teachers are to devise and use a wide range of assessment tasks to reflect and enhance student learning.

Motif

A nautilus shell motif features on the cover of all curriculum documents as an unstated metaphor, perhaps with several layers of meaning. The compartments represent understanding in the essential learning areas - understanding which deepens and overlaps as the learning experiences spiral ever outward. The learner, placed at the centre where all learning overlaps, and nurtured and strengthened by those experiences, is set free on a life-long educational journey. Certainly, this interpretation represents a worthy ideal for which to aim in implementing the curriculum.

THE *ENERGY* MODULE

Introduction

The *Energy* module is an introductory mechanics module intended for the use of all Year 9 and 10 students within the school. It was developed from the curriculum statement *Science in the New Zealand Curriculum* (Ministry of Education, 1993b), in particular the contextual strand *Making Sense of the Physical World*, and aspects of the two integrating strands. The three broad themes of energy transformation, forces, and movement form the learning focus, and there is an emphasis on investigative work both in the themes themselves and in the extended investigation which completes the module. An overview of the relationship between the contextual and integrating strands, and the module themes is shown in Figure 2.1.

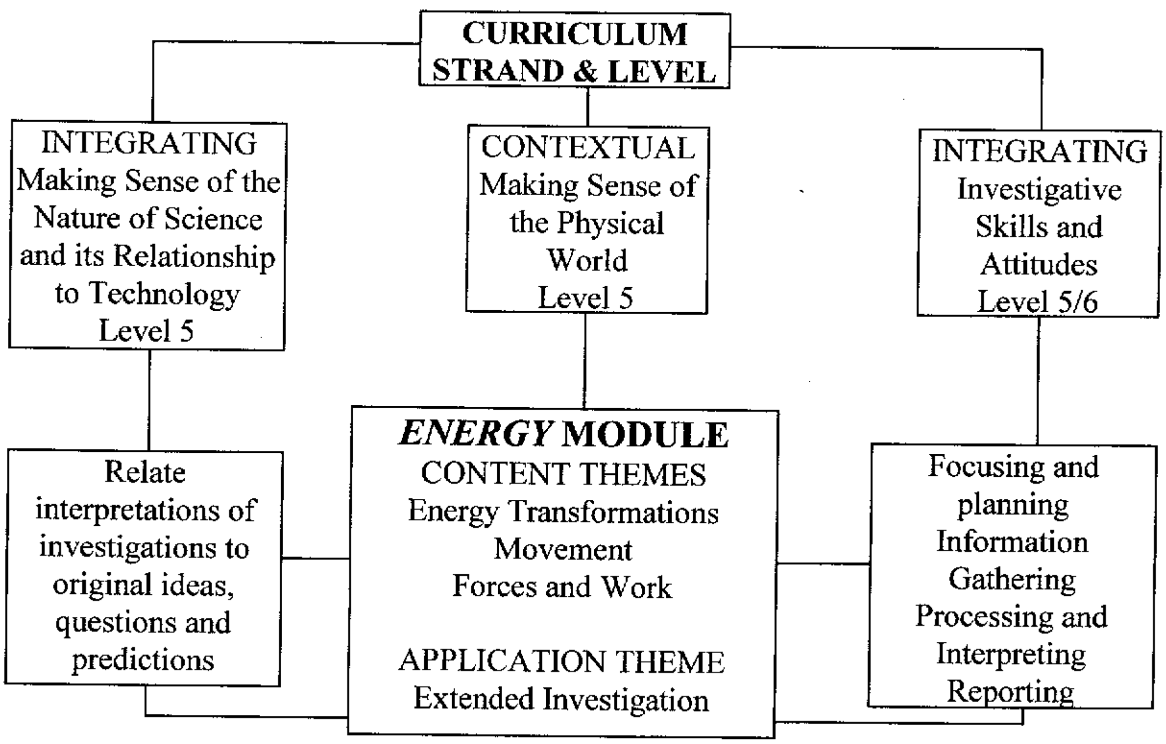


Figure 2.1. Overview of the relationship between the curriculum strands and the module themes.

Curriculum Level And Objectives

Figure 2.1. also reflects the curriculum level of the module. The curriculum document recognises that students learn at different rates, and illustrates (Ministry of Education, 1993b, p 15) that Year 9 and Year 10 students are typically achieving between Level 4 and Level 6 of the eight defined curriculum levels. Given that previous science learning within the school had addressed the Level 4 achievement objectives, this module was primarily developed around the Level 5 curriculum objectives referred to below. However, during the preliminary phase of the research (described in Chapter Five), the scope, specific learning outcomes and assessment tasks of the module were refined to match student learning needs. As a result, several concepts were developed to a level from which many students could demonstrate achievement of several Level 6 objectives. The achievement objectives of the *Energy* module in its final form are now specified.

1. Contextual Strand: *Making Sense of the Physical World.*

Three out of the four prescribed achievement objectives at Level 5 were selected as relevant to the work envisaged, namely, that students can:

1. carry out simple practical investigations, with control of variables, into common physical phenomena, and relate their findings to scientific ideas, *e.g. forces and motion;*
2. describe various ways in which energy can be transformed and transferred in our everyday world, *e.g. rockets, electric blankets, hair driers;*
3. investigate and describe patterns associated with physical phenomena - some patterns may be expressed in graphical terms,

(Ministry of Education, 1993b, p80).

Note: The examples in italics are relevant examples selected from those in the curriculum statement.

2. Integrating Strand: *Making Sense of the Nature of Science and its Relationship to Technology.*

Two out of the three Level 5 achievement objectives were selected as appropriate, namely, that students can:

1. relate interpretations of the result of their investigations to their original ideas, questions, and predictions;
2. use their knowledge of a scientific idea to identify and describe examples of technology in which that idea is applied;

(Ministry of Education, 1993b, p34).

3. Integrating strand: *Developing Investigative Skills and Attitudes.*

The achievement objectives for this strand are defined under four headings: focusing and planning, information gathering, processing and interpreting, and reporting. Additionally, achievement levels are paired in this strand. For example, Level 5 is paired with Level 6, with criteria defined only for Level 6. Four of the ten paired Level 5 and 6 achievement objectives were selected as appropriate skills for the type of investigation envisaged. These are shown in Table 2.4.

SKILL	LEVEL 5 and 6 ACHIEVEMENT OBJECTIVES
Focusing and Planning	design "fair tests", simple experiments, trials, and surveys, with clear specification and control of likely variables.
Information Gathering	systematically record observations and measurements.
Processing and Interpreting	identify trends relationships and patterns, in recorded data by analysing data using statistical and graphing procedures as appropriate.
Reporting	present well reasoned complete reports supported by relevant data in ways, and forms, appropriate to nominated audiences.

(Ministry of Education, 1993b, pp 44-47). Rearranged presentation.

Table 2.4. Achievement objectives selected for the extended investigation.

Note: The skill of Information Gathering referred to in Table 2.4. includes both practical laboratory skills, and written and oral research skills. Within Lakeside College itself, the more specific categories of Gathering Experimental Information, and Researching are used.

Structure And Delivery

Content Themes.

The module, after refinement during the preliminary phase, contained the four distinct content themes shown in Table 2.5. below with their period allocations. Effective period length averaged 55 minutes.

CONTENT THEME	Energy Transformations	Movement	Force and Work	Investigating
TIME (PERIODS)	6	5	7	4

Table 2.5. Content themes and period allocation for the *Energy* module.

Learning Outcomes.

Specific learning outcomes for each content theme were developed and refined during the preliminary phase, resulting in the final version shown in Appendix Two. These outcomes focused the on-going development of teaching resources as well as directing learning and assessment experiences.

Teaching Resources.

To support the intended learning outcomes of the module a large number of teaching resources were developed during the preliminary phase. These included a student guide, student-centred learning activities (written and practical), assessment tasks and teaching notes. The development and application of specific examples of student-centred learning activities which were found to be successful in encouraging student involvement and conceptual understanding, is discussed in Chapter Five.

Lesson Sequence.

The lesson sequence and themes are shown in Table 2.6. which indicates that the module takes 5.5 weeks at the normal teaching cycle of four lessons per week. The themes refer to specific activities forming the prime focus of the lesson.

1. Introduction	2. Energy types	3. Energy circus	4.Energy concept map
5. Clyde Dam Video	6. Energy test	7. Movement	8. Ticker timers
9. Graphs	10. Problem solving	11. Movement test	12. Forces
13. Forces	14. Forces	15. Work and Energy	16. Work and Energy
17. Work and Energy	18. Force/Work test	19. Investigation	20. Investigation
21. Investigation	22. Investigation/Eval		

Table 2.6. Lesson sequence and themes for the *Energy* module.

Texts Used.

Many of the learning experiences were structured around material within the specific chapters of the student texts shown in Table 2.7.

TEXT SERIES	REFERENCE
Kiwi integrated science series. (Sweeny et al.,1989, 1990).	**3 Science Book 1** Ch 4: Energy, Ch 6: Motion. **4 Science Book 3** Ch 3: Being Forceful.
New Zealand pathfinder series. Self-study guides. (Hook, 1998).	**Science Level 5 Book A** Unit E1: Nature Of Energy

Table 2.7. References to the student texts used.

Assessment.

Content knowledge of each of the three content sections was assessed by a written test immediately after completion of that section. Since this represented more testing than usual at this level, no assignment tasks were included. The two specific sub-skills of 1) gathering experimental data, and 2) processing and interpreting data, were developed through the content sections, with the overall investigative skill (Carrying out an Investigation) assessed by the extended group investigation referred to in Figure 2.1. Details of assessment are discussed in Chapter Four.

SIGNPOST TWO

This chapter has introduced the reader to aspects of the New Zealand curriculum, with respect to both the defining framework document, and the science statement in particular. These documents have been demonstrated to support and provide direction for the development of the *Energy* module described. This module has been located with respect to specific learning and integrating strands of the science curriculum, its learning objectives for each content section have been specified, and its lesson sequence outlined. Chapter Three provides insight into the epistemological basis for curriculum reform.

CHAPTER THREE

LEARNING AND LEARNERS

Key epistemological positions are contrasted and the researcher's viewpoint developed, establishing a basis for the use of constructivism as a teaching referent. Features of subject-centred and student-centred learning are discussed, including strengths and criticisms of each philosophy. A rationale for the student-centred teaching model espoused by the curriculum is discussed, with significant differences in teaching challenges and role noted. The central position of the learner is considered, and seven key determinants of learning are discussed.

EPISTEMOLOGY

Introduction

One aspect of teacher quality universally recognised and valued in New Zealand education is the possession and use of a well developed philosophy of education (Ramsay & Oliver, 1995) since day-to-day teaching practice springs from such philosophy, especially its epistemological basis. Across the continuum of possible epistemologies, two extremes are the positivist and the constructivist positions (von Glaserfeld, 1991), with each generating significantly different pedagogical approaches. Key qualities of knowledge fundamental to each position are contrasted in Table 3.1. (p30), then briefly discussed to provide a reference point from which the researcher's perspective is established.

Positivist Perspective.

Under this viewpoint, knowledge is viewed as information which can be transmitted from the teacher to the learner. The learner can, in principle, totally learn this information to produce, in effect, a carbon copy of the knowledge. Knowledge itself can therefore be viewed as having absolute qualities in the way that an object has physical qualities.

POSITIVIST	QUALITY	CONSTRUCTIVIST
Knowledge exists independently of the individual and can be transmitted.	INDEPENDENCE	Knowledge is constructed by, and exists only within, the mind of the individual.
The absolute truth of an observer-independent world can be found.	TRUTH	Knowledge that 'works' in context is viable, and may approximate the inaccessible truth.

Table 3.1. Key qualities of knowledge viewed from two perspectives.

Two such qualities of knowledge are its independence and truth. The teacher is essentially an agent who transfers quantities of independently-existing knowledge to students, just as an object may be passed from person to person. As knowledge is passed independently from teacher to student its truth remains intact, as, for example, when an object is similarly passed, its composition remains unchanged.

Teaching strategies revolve around the best way to achieve this transfer effectively. Strategies typically involve careful, logical development of content ideas, well-presented in a lock-step teacher-directed manner. Exposure of the prior conceptual knowledge of students is of limited importance. The absolute qualities of knowledge similarly suggest that the differing social and cultural perspectives of students are of no significance to the process of knowledge transfer.

Constructivist Perspective.

Constructivism as a learning theory is based on the principle that knowledge must be actively constructed by the learner, and that this process occurs as the learner reflects on the learning experience. Knowledge exists only within the mind of each learner, and as such, can only represent personal understanding, not absolute truth. Knowledge is viable to the extent that, when shared, it represents the common understanding of others within the learning situation, including students and teacher. Teaching strategies are focused on engaging students in the process of reflecting on the required concepts (Treagust, Duit & Fraser, 1996). The exposure of prior knowledge is important, and appropriate learning experiences are designed in response. The social and cultural perspectives of students are significant in their interpretation of learning experiences, and the sharing and testing of ideas plays an important part in the construction of viable knowledge.

The Importance Of Reflection.

Knowledge may be considered as the data-base from which an individual constructs personal understanding by reflection on what is already known. Reflection involves active processes of inter-relating and re-evaluating existing concepts to produce an evolving conceptual network into which new knowledge, produced by future learning experiences, may be similarly integrated. In such a way the individual makes sense of experience, learning new knowledge and gaining increased understanding, which in turn provides the key to further purposeful action. Recognition of the central role of reflection in this ongoing developmental process provides the basis for the use of constructivism as a teaching referent.

Figure 3.1. (p32) illustrates the central role of reflection in knowledge construction. The deliberate linking of each concept to several others illustrates that concepts are ultimately defined in terms of their relationship to other concepts. Expressing this relationship requires additional concepts, creating a "concept web" which in some ways may model the neuron linking process occurring within the brain during learning. More links become possible with more extensive knowledge - and the more connections actually made, the richer the understanding created, both in depth and scope. Meaningful knowledge (later discussed) has this quality of being strongly linked to existing knowledge, extending its operational value. Additionally, interconnections across specific knowledge bases, help make a range of knowledge more accessible via lateral thinking. The use of concept-web bridging strategies as a learning tool in this research is discussed in Chapter Five, while the layout of Figure 3.1. itself provides an example of the completed process.

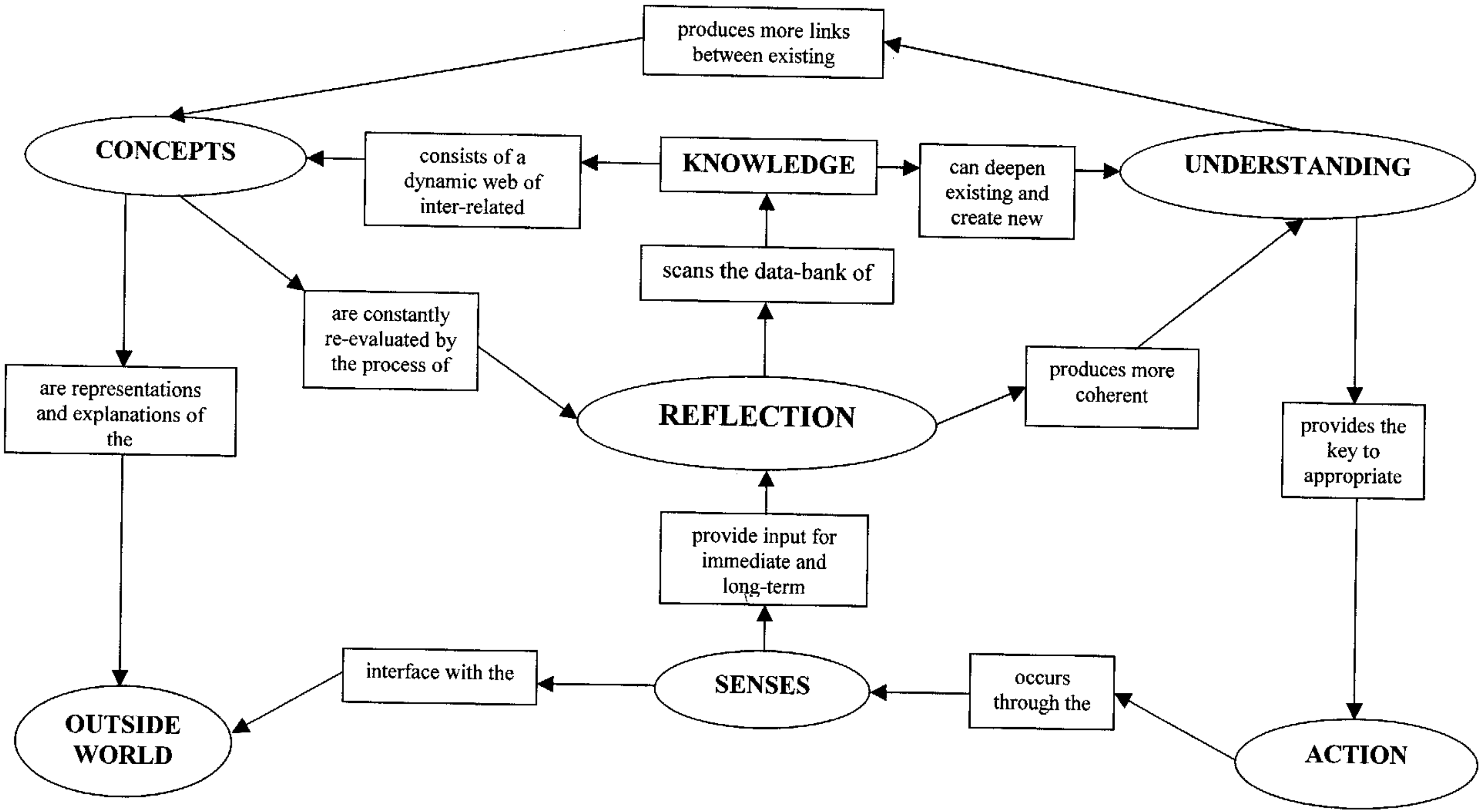


Figure 3.1. Concept-web illustrating the central role of reflection in knowledge construction.

The process of reflection operates from an individual's earliest days as a child learns to attach meaning to the environment it senses. In time, increased knowledge leads to an increased potential for understanding (Nickerson, 1985), and hence more meaningful action. As the reflective process develops, more thoughtful investigation becomes possible - doubt as to outcome leads to the formation of hypotheses, and their testing increases both knowledge and understanding. The intrinsic student satisfaction noted by Dewey (1916) in such curiosity-driven investigation provides a historical basis for the concurrent development of scientific knowledge and methods espoused by the science curriculum (Ministry of Education, 1993b).

Uniqueness Of Learning.

Personal learning as described arises from interaction between the learning experience, the existing knowledge and the reflective processes. Since these three qualities differ for each individual, the personal learning of every individual is unique. The viability of such personal learning is constantly tested by the social interactions in which the individual takes part, and successful application of knowledge to a variety of contexts increases its sense of worth to the learner. Over time, understanding, refined and strengthened by the test of past experience, filters and guides the interpretation of future experience (Osborne & Freyberg, 1985). Students therefore bring their own perspectives to the classroom - perspectives coloured by social and cultural aspects for example, as well as formal and informal learning experiences. This range of personal learning in science, referred to by Osborne (1985) as "children's science", has important implications for the successful teaching of science. Teachers, likewise, bring the perspectives of their own personal learning, including philosophies of learning, to the classroom.

Viable Knowledge.

Knowledge which produces a shared, common understanding between members of a community of interest, is viable in that context, not absolute. In another learning community, or in another time, such knowledge may not be considered viable. The evolving understanding of the solar system provides examples. The earth-centred solar system model was considered correct by the general population long after it had lost viability amongst astronomers, for whom the Copernican model was more viable. Likewise, Newtonian concepts of gravity create viable explanations for that model at, and beyond secondary school level, yet provide an inappropriate model for more subtle effects better explained by Einstein's theory of general relativity. The constructivist view of knowledge expressed by Bodner (1986) as viable "if and when it allows us to achieve our goals" (p873), relates well to the acknowledged tentative nature of all scientific explanation. Similarly, the fit of knowledge to reality likewise described by Bodner (1986) as like the fit of many keys to a lock, sits comfortably with the scientific concept of measurement, with its implicit uncertainty.

Meaningful Learning.

Meaningful learning implies a broadening and deepening of viable understanding; the new learning is linked to that which is already known in a way which enriches the learner. This may be as simple as the defining moment in which the reason for a procedure becomes evident, and an operational understanding becomes a conceptual one. Or, perhaps more significantly, the connection between related concepts becomes able to be correctly expressed through new concepts, and the learner's conceptual network consequently becomes more extensive and robust. Previously strongly-held concepts of limited applicability may be deliberately replaced by the learner with more powerful ones but hitherto rejected ones, and a new personal world-view of the topic is perceived.

Understanding not only changes the scientific intellectual world of the learner, causing that person to see the world differently (Goldstein & Goldstein, 1978), but also has another far-reaching consequence of crucial importance for teaching. The gaining and expression of such new insights affects not only the learner individually, but also those interacting with that person, both within the class and beyond it. The view of schools as "communities of learners" suggests just this very ethos, with intellectual excitement abounding as learners (students and teachers alike) interact cooperatively to create a climate of meaningful learning.

By contrast, some learning may have little intrinsic meaning to the learner. It may be retained by rote methods, and recalled if required, but it cannot be applied effectively.

Such learning is often evanescent because it is not linked to the learner's existing meaningful knowledge.

Constructivism As A Teaching Referent.

Referents are underlying values or concerns used to inform and guide action. For example, a universal concern of science teachers is safety issues. In adopting this referent, science teachers may initially focus on developing long-term procedures to enhance safety, and use their increased awareness of safety issues to guide their day-to-day action. Consciously adopted referents may, if successful in practice, become core values in time. The conscious adoption of constructivism as a referent by the researcher has proved such a case.

Previous teaching practice had sprung from the belief that, at heart, all students want to learn, and can best be encouraged to do so by the provision of an environment which is both intellectually appropriate and personally supportive. Involvement was perceived as the major key to learning: if students could become involved in the learning activities, they would reach their potential. The provision of a wide range of interesting "hands-on" activities was, in turn, the key to such involvement. A variety of teaching strategies were employed, varying from forthright teaching of concepts to the use of group tasks. The implicit assumption, however, was that, with rare exceptions, students automatically held, or could develop over time, the internal learning skills needed to construct knowledge - it was a matter of motivation. Such "naive constructivism", as Prawat terms the "tendency to equate activity with learning" (Treagust, Duit & Fraser, 1996, p5), denies a growing professional realisation that students do not automatically have, nor gain, the necessary learning skills: but they can be taught them.

Constructivism as a teaching referent focuses on ways in which students can be helped to "learn how to learn", and so take control of the learning experience. Content matter is specifically used to foster this process of learning-to-learn by providing a context for conceptually-focused interaction between students. (Duit & Confrey, 1996). This changed view of content represented an important touchstone, resulting in lesson planning focused on answers to new types of questions e.g. What activities will best:

- elicit existing student ideas and value their learning perspective?
- engage students in thinking about specific ideas?
- challenge students to reconsider their existing ideas?
- help students link new ideas to related ideas in different contexts?
- help students think about how they learn?

The focus on developing learning activities which specifically addressed such questions represented a new view of the teaching process to the researcher and resulted in professional growth. The supportive learning environment required for constructivist teaching approaches to operate (Driver, 1996) coincided with humanist educational values already held by the researcher, and served to validate rather than change previous practice. Nevertheless, the structured and purposeful use of group work as the social means for knowledge construction and mediation represented a new emphasis. Specific learning activities resulting from this focus are discussed in Chapter Five.

CENTRED-LEARNING

Locating The Centre

The term centred-learning refers to the primary beliefs of the teacher as to where the focus of classroom learning lies, and how the teaching should be directed. Is the intended learning of the class centred "in" the curriculum statements, the exam syllabus, or the textbooks used? Does it reside "in" the personal content knowledge of the teacher, or "in" the learning needs of individual students? The beliefs consciously or unconsciously held by the teacher as to where learning is centred, and under what circumstances learning occurs, are central issues which direct both long-term and day-to-day aspects of the teaching programme. As these beliefs are reflected upon and revealed, the teacher is then in a position to modify them, and consciously move the centre of learning adopted as a referent.

Two key positions are represented by the subject-centred and the student-centred teaching models. As all teaching occurs within wider educational and social contexts, features of each position are discussed within these broad frameworks.

Subject-Centred Learning

In a subject-centred approach to learning the teacher, as a subject expert, systematically develops and presents the content, usually by means of lock-step whole class instruction. The presentation and development is logical, at least from the viewpoint of a subject expert, if not from that of an individual student. In this traditional classroom setting there is a focus on memory work, with the drill and discipline required perhaps seen by teacher and parents (and to a lesser extent by students), as a useful preparation for adult life. There is an emphasis on content knowledge per se, rather than its application. Failure to learn is often considered to be the result of a lack of ability or effort on the part of the student.

Such traditional settings were perhaps a natural outcome of their times, reflecting both a positivist view of knowledge, and the expectations of society in the days when free, compulsory education was first introduced in New Zealand. Although there are shortcomings with the subject-centred teaching model, both in terms of its effectiveness and in its associated agenda, it nevertheless has strengths. It is a model which many teachers still use heavily, and one with which many students and their parents feel comfortable.

Strengths.

Strengths of the traditional subject-centred teaching model focus on the fact that all students are treated as one; all are given exactly the same information at the same time, and in the same way. All students, for example, would use the same text, take the same notes, and do the same exercises. Interaction is between individual students and the teacher, and the overall structure encourages individual competition. It can readily be argued that such a system is eminently fair: all students receive identical access to identical content knowledge - their individual mastery of it is over to them. Subsequent assessment with an emphasis on rote-recall of clearly-presented factual information can also be seen as eminently fair. (The researcher has clear memories of rote-learning geometrical theorems as a sixth-form student for such assessment). The element of competition fostered by the system can result in improved commitment to learning (Black & Atkin, 1996).

Criticisms.

Criticism of the subject-centred approach is based around the fact that it fails to take into account three essential requirements: the constructivist nature of learning, the uniqueness of the learning needs of the individual student, and the effect of classroom environment on viable learning. The approach assumes a transmission model of learning - the teacher assumes, perhaps unconsciously, that the learner will be able to make sense of the message, and does not deliberately foster that process. Class-pace may not suit the needs of every student: learning may become increasingly inaccessible to weaker students, and developing negative attitudes may then compound the problem. Lack of recognition given to the learning perspectives of students, including social and cultural perspectives, may mean that learning experiences produce unresolved learning conflict, and rejection. The growth of negative perceptions of either self or of the educational process may alienate students.

Student-Centred Learning

In a student-centred approach to learning, the teacher accepts and values the uniqueness of the student, both as a learner and as an individual. The learning perspective and needs of the student guide the teaching process within a social context which acknowledges the dignity of the individual. The teacher, as facilitator, adapts the learning experience in response to student needs and interest, and works in partnership with students to help them develop viable understanding and intellectual growth. Recognition is given not only to the necessity for different starting points for individual learning, but also to the development of end-points which differ in both direction and depth. Negotiation between teacher and students as to choices of action occur frequently as students are encouraged to pursue their own subject-related interests. Different students may use different books, and do different activities. Active participation in the processes of learning is viewed in general as more important than the acquisition of specific factual information.

A supportive atmosphere of mutual respect is essential for the learning partnership envisaged by student-centred learning. Cooperative groups provide an appropriate social context (Driver & Scott, 1996), and enhance the overall development of the supportive environment needed for intellectual risk-taking. Structured group tasks are often used to provide the intellectual opportunity for students develop viable understanding, and such tasks may be assessed. Fostering the processes of active enquiry and reflection are more valued by the teacher than the recall of factual information, and assessment tasks are structured to accommodate differences in content and level studied. Peer assessment methods may be used.

Strengths.

Strengths of this teaching model relate to the development of the individual learner, and the class as a learning community. Student involvement and the growth of positive attitudes to learning are fostered. The development of confidence, both in personal learning, and in the process of interacting cooperatively with others to negotiate meaning, is enhanced. In teacher-student learning negotiations, each gains an understanding of the other's perspective: additionally, students gain confidence in dealing with adults, and in seeing teachers as learners. The implicit power of the teacher provides both a scientific and personal role model. Attitudes of independence and self-responsibility are developed, and negative sub-communities of learners are encouraged to re-conceptualise themselves and develop their potential. Teachers remain in touch with their students, and are well-placed to avoid creating inappropriate learning demands. Teacher personal learning is developed, and insight for improving personal teaching and student learning is gained. Student-centred learning approaches are an essential component of constructivist teaching.

Criticisms.

Criticisms of student-centred teaching may arise from initial experiences of both teacher and student. The re-conceptualisation by the teacher of the classroom as providing opportunity for a variety of negotiated learning experiences may require significant attitudinal change. For example, a group of students may wish to pursue an investigation into a relevant hypothesis of particular interest to them, although with little awareness of the potential dependent variables. In allowing the investigation to occur, the teacher fosters the development of such awareness through personal experience.

Changed attitudes to learning include changed attitudes to resourcing. For example, smaller numbers of a variety of texts may be more appropriate than class-sets of the same text. Teachers used to the order of up-front lock-step teaching, may be threatened by the apparent chaos that can arise as new strategies are introduced. Conscientious, non-risk-taking students may likewise feel threatened by changes to routines, while others take time to adjust to working in an unfamiliar partnership role. As a result, some students may initially waste time, creating a dilemma for the teacher. Students with learning initiative may negotiate tasks which appeal to other students, creating possible envy initially. Some out-of-class learning opportunities create the potential for the abuse of privilege. Different learning tasks may create the need for different assessment tasks, resulting in more teacher preparation time.

Moving The Centre

Basis.

The student-centred philosophy of learning envisaged by the science curriculum statement (Ministry of Education, 1993b) contrasts strongly with the more traditional subject-centred philosophy, still commonly used as a teaching referent. It is therefore natural to question the need for change. Traditional subject-centred teaching practice is based on a number of assumptions as to how learning occurs. These assumptions reflect as much a teacher response to the demands of the structured school system, and to perceptions of the purposes of schooling, as they do to an understanding of the nature of learning. The consensus of a large range of recent research is that these traditional teaching assumptions are unjustified. Specifically, that teaching based on the assumptions of the traditional subject-centred model "will achieve successful learning with only a minority of pupils, while failing to tap the motivation and learning potential of almost all the rest" (Black & Atkin, 1996, p62). Research similarly indicates that student-centred learning, informed by constructivism, provides the route by which the potential for enhanced learning by the majority of students may be achieved.

The well-spring of teaching practice ultimately lies in the referents adopted by the teacher, in this case the contrasting philosophical positions represented by the two teaching models previously described. There is a continuum of philosophical viewpoints possible, with some elements of each model often used in practice. Moving from a subject-centred to a student-centred philosophy may be best represented then by relative movement across this continuum, and exemplified by the development and incorporation of student-centred teaching methods into teaching practice.

Teacher Responsibilities.

The responsibilities of the teacher as classroom manager remain the same in all respects under either teaching model. However, the different characteristics of each model create their own particular challenges. The provision of a safe and orderly environment for the performance of practical work provides one example of a possible difference in such challenges. Table 3.2. indicates structures of practical activity typical of each model, their different characteristic features, and some consequential challenges to a safe environment. In moving to a student-centred approach, teachers need to develop appropriate class procedures and strategies to respond to the different types of challenge this model of teaching presents.

	SUBJECT-CENTRED	STUDENT-CENTRED
ACTIVITY	Whole-class lock-step practical activity followed by written work.	Negotiated range of practical and written tasks performed in any order.
FEATURE	Intense practical activity for a short time using a large amount of equipment.	Less intense. Greater range of practical activity using a large range of equipment.
CHALLENGE	Greater potential for mishap as a result of student congestion.	Greater range of potential mishaps over a greater time.

Table 3.2. An example of different challenges to the provision of a safe environment under subject-centred and student-centred approaches.

Teacher Role.

The role of the teacher changes as teaching practice adjusts to reflect a developing student-centred philosophy. There is an increasing emphasis on establishing and responding to learning needs, and less on "covering the bulging textbook" (Tobin, 1996, p181). As student-centred learning activities are implemented, there is an increase in student-managed learning, and a consequent decrease in the in the role of teacher-as-director. Re-conceptualisation of the role of both teacher and student creates enhanced learning possibilities. As the concept of teacher as learning-facilitator spreads, students increasingly begin to re-conceptualise themselves as effective, independent learners, and the teacher as partner-in-learning. For some students, such re-conceptualisation may require significant time and teacher support, although for others it represents an existing perception. It is managing the range of such emancipatory developments within the constraints of the active classroom which provides the challenge in the student-centred model of teaching.

THE LEARNER

Introduction

The individual learner has been placed "at the centre of all teaching and learning" by the curriculum framework document (Ministry of Education, 1993a, p9). It is the learning needs (in particular) of the range of students who comprise each and every class to which teaching programmes and strategies must respond. Figure 3.2. (p43), which illustrates some of the main determinants of learning and sources of influence on the learner, is used to direct the discussion. Although the relationships represented by Figure 3.2. suggest that each learning determinant and source of influence is independent, this is purely for convenience of discussion. These determinants impinge on each other in a mutual and dynamic way, as do the influences. An awareness of these qualities indicates to the teacher "where the learner is coming from" enabling the provision of subsequent learning experiences and influences to help determine "where the learner is going to".

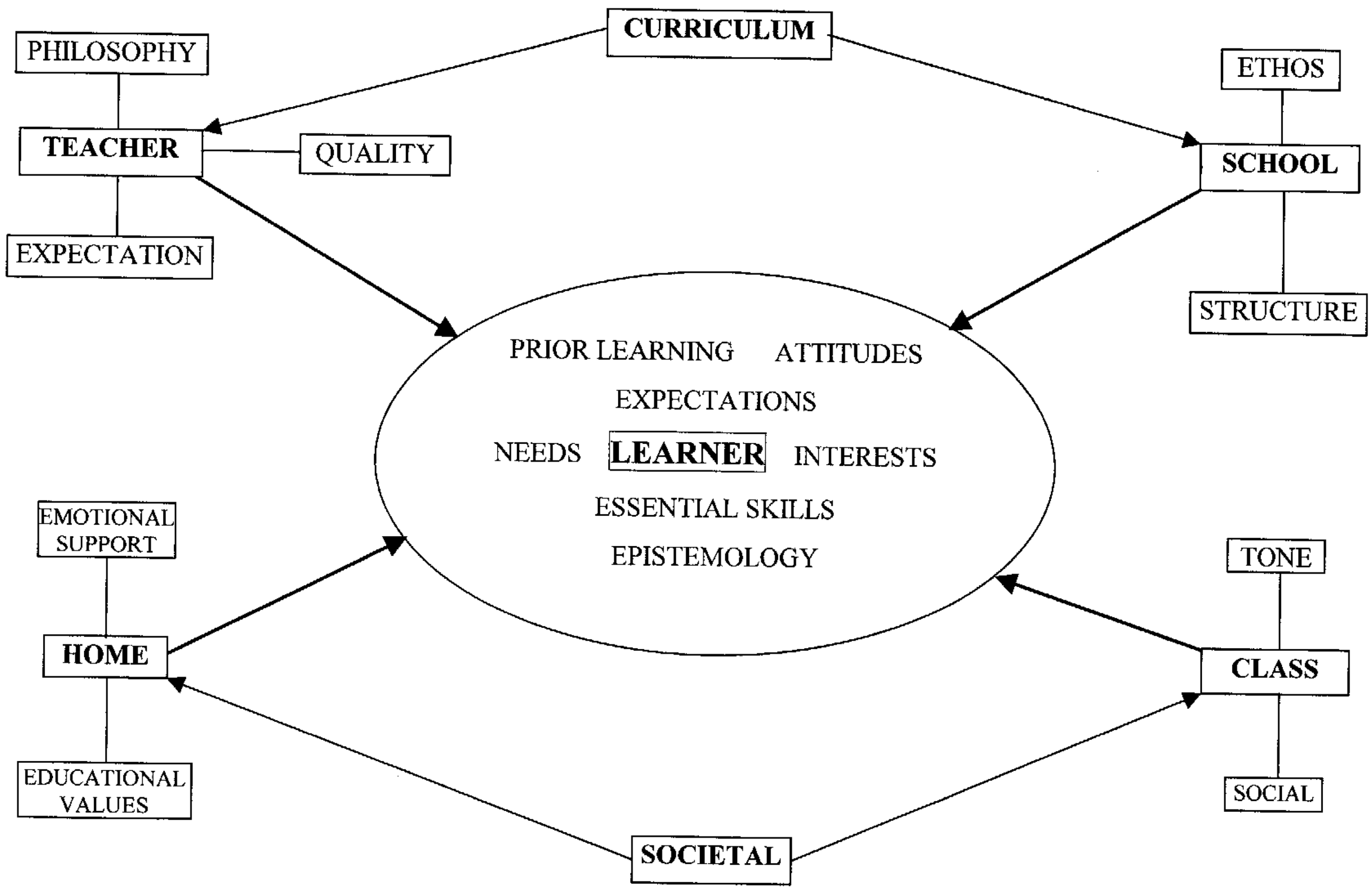


Figure 3.2. Internal and external influences on the learner.

Determinants Of Learning

Epistemology.

Personal epistemology directs the interpretation of learning experiences, and the possession and concurrent development of a self-consistent personal schema appears essential for interpreting ongoing learning experience and developing successful understanding. Student views of knowledge and understanding vary, with some NZ students viewing understanding in terms of factual and procedural knowledge and others in terms of coherent conceptual knowledge. In a survey of Year 12 students, Burns (1997) established that a greater proportion of high achievers (compared with low achievers) held a coherence view of understanding than a knowledge view, although there were some exceptions both ways. These students also felt that discussion fostered understanding, and such discussion was more likely to be with peers than with teachers.

Essential Skills.

The essential skills previously discussed may be considered to a large extent as tools for learning. To take full advantage of an intended learning experience students must possess an appropriate level of such skills, although the learning experience itself must also provide opportunity for their development. A relative lack of development in one skill grouping may be addressed by teaching strategies which make learning more accessible. For example, by using integrated video and worksheet resources, a poor reader is provided with alternative pathways to the primary goal of successful learning as well as a potential increase in reading skill. Reflective ability is at the heart of many of these skills. Students who have well-developed reflective ability are able to construct viable understanding from a broad range of learning experiences. However, reflection itself is an internal process and a capable reflective learner may not necessarily be able to communicate such understanding effectively, particularly in written form.

Prior Learning.

In suggesting that prior learning is "the most important single factor influencing learning", Ausubel (1968, in Osborne & Freyberg, 1985) was presumably referring to conceptual knowledge. The scope and depth of the existing concepts held by the learner pre-determine the effectiveness of proposed learning experiences. If these concepts have produced a viable and coherent understanding, the learner is well placed; however if alternative conceptions have resulted in an incoherent mosaic of conflicting concepts, future learning cannot proceed effectively. Ascertaining the learner's existing conceptual knowledge is therefore of prime importance to the teacher to provide the basis for determining appropriate future learning experiences.

Expectations.

The general expectations that students have of themselves, and of the learning situation in which they find themselves, are significant to their future learning. In particular, three factors have been found to exert a marked influence on the relative progress of students of all abilities throughout their secondary school years (Nash, 1998). These factors are student aspirations, academic self-concept, and perceptions of the fairness of their teachers. Students underachieve when combinations of these factors are negative, creating "one of the most formidable barriers to learning" (Nash, 1998, p77).

Attitudes To Learning.

Attitudes to learning are perspectives developed from prior experience of learning. Positive attitudes are often the result of interest and feelings of confidence developed in successful prior learning experiences. Indeed, the most important long-term gain of such prior learning may be the emerging intellectual self-confidence of the learner: the learner feels able to "handle" the work, and develops intrinsic motivation to continue learning.

Interests.

Student interest in a particular content area can provide an intrinsic source of motivation for further learning, and may reflect significant prior learning. The learning perspectives brought to the classroom by such interests may be significantly different than those intended by the formal classroom experience. Students with a practical interest in small-bore rifle shooting for example, may be more concerned with technical parameters affecting trajectory than with standard analytical physics problems which, at school level, neglect the all-important effect of air resistance.

Recognition of the validity of the variety of perspectives arising from learning experiences beyond the classroom provides an opportunity of enhancing the learning of both student and teacher. Negotiated learning tasks provide student ownership and control enabling students with expertise to pursue their learning beyond the level of their peers, or indeed, their teachers.

Needs.

There is a range of needs and concerns which may reduce effective participation in classroom learning experience. These include emotional needs, concerns for physical safety, hunger, cultural alienation, language difficulties, social difficulties and physical conditions. The motivation to fill such deficiency needs (Maslow, in Abrami et alia, 1995) decreases as that individual's needs are increasingly met. As that point is reached an individual becomes more able to focus on the intellectual growth needs. The use of cooperative group learning provides one practical way of meeting some deficiency needs within the classroom. The successful 'buddy support' of international students by local students provides a local example.

SIGNPOST THREE

This chapter opened by briefly contrasting positivist and constructivist interpretations of the concept of knowledge, and examined the constructivist -oriented perspective of the researcher. The use of constructivism as a teaching referent has been discussed in terms of its particular view of content. The application of this focus resulted in the development of specific resources detailed in Chapter Five. The curriculum framework document focuses on a student-centred teaching model: features of both this model and the more traditional subject-centred model have been discussed. The central position of the learner has also been discussed in terms of seven key internal determinants of learning.

Chapter Four describes the research design, details the methodology used in its implementation, and describes the assessment instruments.

CHAPTER FOUR

METHODOLOGY

The research perspective is first discussed and a basis for the design established. Key features of the design are illustrated, and the contrasting teaching strategies used in the comparative phase of the design are detailed. The implementation of the comparative phase is described, including discussion of the procedures used and an outline of difficulties encountered. Features of the four instruments used to assess the impact of the module are described, with an emphasis on the specifically-developed SALTA observational procedure. Ethical aspects of the research are also discussed.

RESEARCH DESIGN

Perspective

In challenging teachers to provide "science education of the highest standard" (p11) to all their students, the science curriculum statement (Ministry of Education, 1993b) outlines approaches by which this can be achieved. A key element is seen to be the adoption of a student-centred approach to learning, informed by constructivism. The development of knowledge and coherent understanding is a prime curriculum aim. Investigative work provides opportunities for encouraging the development of both investigative skills and scientific attitudes - another a prime curriculum aim. Within a group situation, such investigative work also fosters the development and application of essential skills. These elements collectively form the teaching referents underlying the curriculum-led pedagogical reform of the *Energy* module, and lead naturally to the key research question: namely, in which classroom setting will these reforms prove more effective? Is a traditional lock-step teacher-directed environment still appropriate, or will the previously-noted strengths of a student-managed environment be more appropriate?

The word effective may be defined as "successful in producing a result or effect" (Chambers Dictionary, 1993), which raises immediate questions as to the perspectives from which success may be judged, and the measures which may be used to quantify it. This study utilises the unique perspectives of independent observers, students, and teacher-researcher. A wide variety of data-gathering strategies are used to produce a profile of the operation and learning impact of the module in each setting. Both qualitative and quantitative data contribute to the profile generated, with a triangulation approach being used to establish points of reference from which comparisons of effectiveness are later made.

The effectiveness of learning can be evaluated in a variety of ways, and explained by a variety of models. Both Hotchkis (1995) and Matthews (1995) have cast doubt on the validity and interpretation of some research supportive of a constructivist model. The difficulty of providing evidence of success of constructivist approaches has also been commented on by Duit and Confrey (1996). Additionally, Hotchkis (1995) has pointed out that a large body of research knowledge exists which highlights the importance to student learning of effective instructional design, effective instructional practices and forthright concept teaching - factors traditionally valued in a teacher-directed approach.

The methodology chosen therefore necessarily must represent the researcher's position and belief. At one level, there is the desire to intervene and immediately incorporate reform developments into one's own practice - tempered with the realisation that the judgments of one's isolated professional experience alone normally determines the perception of what constitutes improvement. At another level however, there is the need for rigour, and for proposed changes in classroom practice to be defensible, both to other staff, parents and students. Contemplated changes must be clearly demonstrated to result in worthwhile improvements to learning within the specific context of the science programme of Lakeside College. Hence they must be data-based (Guskey & Gates in Hotchkis, 1995) using locally-generated research data.

Design Type

Consideration of these factors led to the development of an action research design, with two distinct teaching phases, separated by a reflective phase. While the research design overall can be considered a form of action research, the second teaching, or comparative phase, followed a more experimental approach. Before each of the phases is discussed, characteristics of action research and true experimental design are examined, and significant considerations addressed.

Action Research.

The word action suggests doing something about a situation, with an implication that what is done will be an improvement on what already exists. It also carries the inference that the situation itself is dynamic and evolving, and that intervention is a necessity. Similarly, the word research suggests more than merely a systematic investigation of a situation; it additionally suggests that the role of the researcher is restricted to that of impartial observer, and that the investigation itself will not directly affect the situation being investigated.

The term 'action research' is therefore in some ways a paradox since it explicitly acknowledges the researcher as deliberately intruding on a dynamic situation in a systematic way, and with a defined methodology, so as to make improvements, which can then be evaluated by others (McNiff, Lomax and Whitehead, 1996). Since action research includes the explicit dimension of seeking to improve the outcome of the events being enquired of, it is an approach particularly suited to the needs of the reflective classroom teacher. Within this context, action research involves putting into practice the research findings discovered by the researcher, who, as practitioner, is often the one person most able to pose questions appropriate for the specific situation, and is usually the only person able to intervene.

Action research is characterised by a cycle of planning, acting, observing, and evaluating outcomes. From such evaluation further cycles are developed, with long-term reflection on the process. Although this cycle is typical of the reflective teaching model practiced by many teachers, action research itself is more rigorous than such practice. In particular, classroom-based action research involves a deliberate and committed personal intervention to improve personal practice which is based on recognised educational values. From the researcher's existing knowledge of the learning situation, the cycle of action and reflection leads to an increase in personal knowledge and an improvement in practice.

True Experimental Design.

True experimental designs are specifically intended to investigate potential cause and effect relationships rigorously. i.e. to establish whether the independent (or treatment) variable really does cause an observed effect of interest. The potential influence of other (dependent) variables which could either mask or contribute to the effect of interest, must be eliminated or accounted for. To achieve such rigour, there are four key features which must be incorporated into true experimental designs, namely:

1. at least two comparison groups of adequate size are formed
2. participants are randomly assigned to each group
3. different treatment is randomly assigned to each group
4. only the treatment variable is altered: all dependent variables are controlled

Modified from Sproull (1988).

In cases where two groups are being compared, often one will receive no special treatment, and the effect of treatment is compared to the effect of no treatment. In other cases, both groups may receive different treatments, and a relative comparison is made. The purpose of random allocation to treatment is to ensure that the groups under comparison have a high probability of being identical in terms of all possible dependent variables. This probability rises as group size is increased; hence random allocation of large groups exerts a strong degree of control over the dependent variables. Where randomisation is not feasible, and quasi-experimental techniques must be used, the use of covariate control provides a measure of existing group differences prior to treatment.

Internal validity is concerned with ensuring that the independent variable alone is the cause of the observed effect. Although randomisation does to an extent control dependent variables, other design features can adversely affect the internal validity of such a research approach. For example, sequential, rather than simultaneous treatment, may allow the presence of an uncontrolled time-related dependent variable to cloud the effect of the independent variable. An example, pertinent to this research, would be the potential for students in the second class of the comparative phase (later discussed) to develop relevant knowledge before being taught the *Energy* module formally. To reduce such clouding effects, the second class was taught the module immediately after the first had completed it. External validity is concerned with the applicability of experimental findings to other and more general situations e.g. to different settings and different populations. Issues of internal and external validity are considered in Chapter Nine.

Practical Considerations.

The research design to be outlined was intended to be implemented within the researcher's normal school teaching programme of timetabled, composite classes. True randomisation of students-to-treatment was therefore excluded by design, although its academic control function was largely met by the method used to create composite classes, and the random allocation of classes-to-treatment. Nevertheless, a covariate control, in the form of a test (later described) was used to establish an independent, quantitative measure of initial class differences. A number of other variables associated with class composition had to be considered at the design stage e.g. the different ratios of Year 9 and Year 10 students in each class. The likely effect of these is discussed separately in Chapter Nine.

Structure

Introduction.

The research involved all four classes (labelled A-D) of the 1998 Year 9/10 cohort, and involved two distinct teaching phases, with two classes involved in each. The first (or preliminary) phase, which involved Classes A and B, was focused on reforming the *Energy* module to reflect the referents adopted. The outcome of this phase was a well-resourced module which more fully reflected the student-centred nature of the curriculum. Developments made in the preliminary phase are discussed separately in Chapter Five. After a reflective pause, the module then became available for more rigorous testing in the second, or comparative phase. This pause enabled consolidation of the module, and the development of instrumentation and assessment procedures later described. The comparative phase, involving Classes C and D, was focused on assessing the impact of the module, from a variety of parameters, when it was taught using two very different strategies. This difference represented the independent variable, and significant effort was made to identify and control associated dependent variables. An overview of the research design and teaching sequence is shown in Figure 4.1. (p53).

Contrasting Teaching Strategies.

Table 4.1. shows the contrasting teaching strategies used in the comparative phase for each of the four sections of the research module, and states the type of assessment used in each section.

SECTION and (ASSESSMENT TYPE)	**CONTRASTING TEACHING STRATEGIES**	
	CLASS C	**CLASS D**
Energy Transformations (Individual Test)	Lock-step teacher-directed Students work in dyads	Lock-step teacher-directed Students work in dyads
Movement (Individual Test)	Student-managed activities working in groups of four	Lock-step teacher-directed Students work in dyads
Force and Work (Individual Test)	Student-managed activities working in groups of four	Lock-step teacher-directed Students work in dyads
Investigating (Group skills)	Student-managed activities working in groups of four	Student-managed activities working in groups of four

Table 4.1. The contrasting teaching strategies used in the comparative phase.

The same teaching strategy was used for both classes in the first section of work (Energy Transformations) so that a covariate measure of initial class difference could be taken before the approaches diverged for the second and third sections. The teaching itself during this first section of work was implicitly assumed to be a controlled variable, and difficulties associated with this assumption are later discussed. The last section (Investigations) was inherently student-managed, and the teaching approaches converged in this section. The structure, purpose and functioning of the dyads/groups shown in Table 4.1. are later discussed.

Overview.

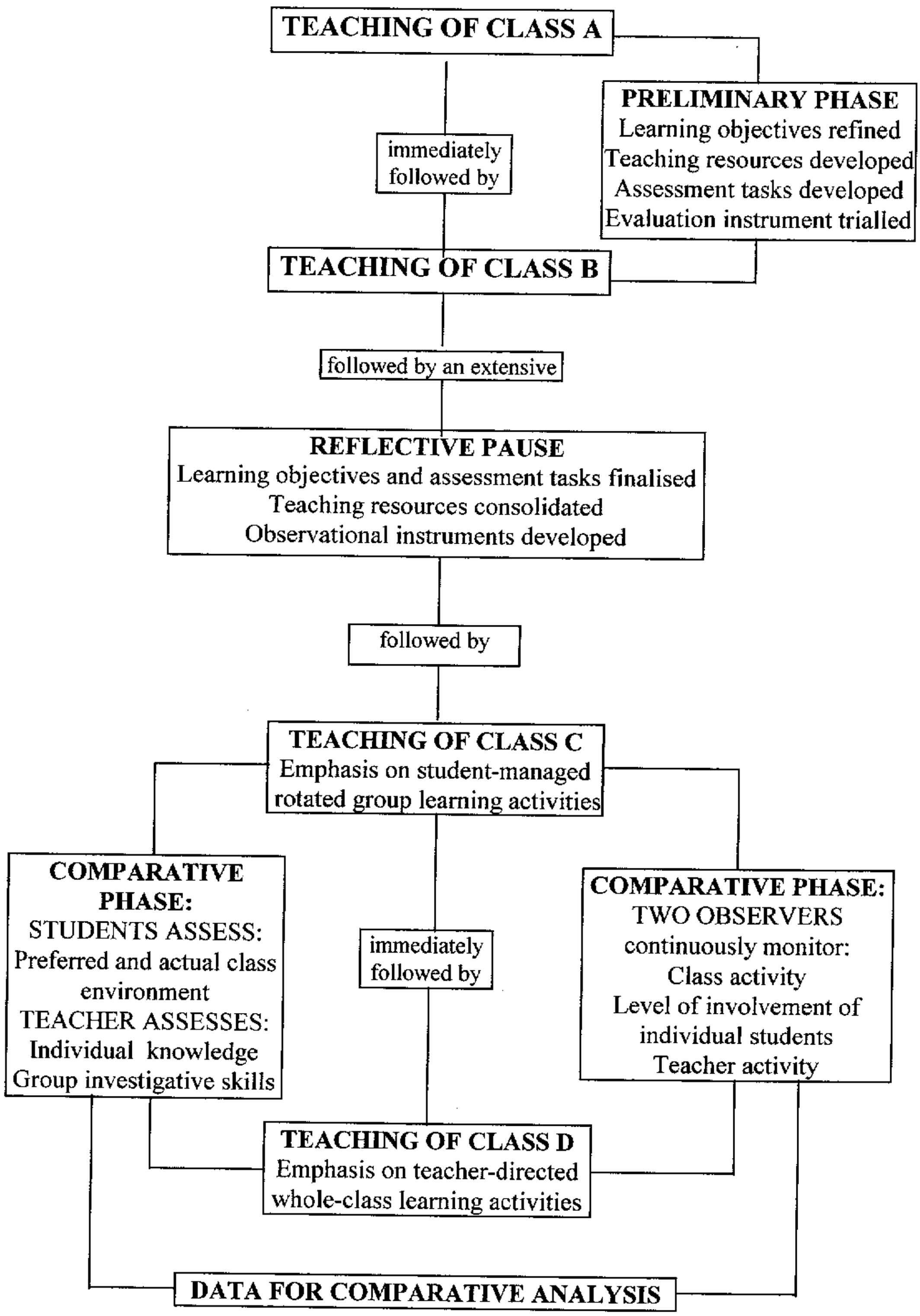


Figure 4.1. Overview of the research design and teaching sequence.

Assessment.

Figure 4.1. illustrates that students, teacher and observers all contributed to the assessment profile. Details of the assessment instruments used to construct this profile are included in the Instrumentation section. A team of two independent observers was engaged to administer the observational procedure which operated continually throughout the comparative phase.

IMPLEMENTATION

Preliminary

Timetabling arrangements were made so that the researcher would teach each of the four composite mixed-ability Year 9/10 classes in sequence for the *Energy* module. This sequence, and the position of the *Energy* module within the course presentation, is shown in Table 4.2., with the classes labelled A - D according to the order in which they were taught the module. Classes A and B commenced the year with the *Energy* module, while for classes C and D it completed the formal science programme for the year. The two-semester gap during which the *Energy* module was not taught provided the reflective pause.

	SEMESTER NUMBER, STARTING DATE and MODULE TITLE					
Class	**1**	**2**	**3**	**4**	**5**	**6**
	30 Jan	25 March	21 May	20 July	4 Sept	30 Oct
A	**ENERGY**	Using Technology		Beginning Biology		Nature's Resources
B		**ENERGY**	Beginning Biology	Using Technology	Nature's Resources	
C	Nature's Resources		Using Technology	Beginning Biology	**ENERGY**	
D	Using Technology	Nature's Resources		Beginning Biology		**ENERGY**

Table 4.2. The teaching order of the 1998 Year 9/10 science modules.

Procedures

The Research Ethos.

At the outset, the intended research was discussed with the students in each class, and, for the comparative phase, the need for the presence of the two independent observers explained. It was also explained to the students how the observers would operate. Students readily accepted the presence of the observers (who were already known to them through their roles as teacher aides), and within a period or two scarcely paid them any attention for the remainder of the module. The observers had minimal influence on the investigation.

The researcher was conscious of the need for the intended learning experiences to be as similar as possible for all students irrespective of grouping, as well as ensuring that previously developed procedures relating to timing and assessment were followed. Practical difficulties, as may be expected in naturalistic research, resulted in occasional minor differences of procedure occurring, and these are later discussed. From the researcher's perspective, these posed no threat to the integrity of the research.

Physical Setting.

The physical setting of the research was a school laboratory familiar to students, observers and teacher. Seating was in the form of ten free-standing benches, each capable of seating three students. For the introductory work in both classes, these benches were arranged formally in two columns of five, with an aisle between. This arrangement was continued for all of the individually assessed work in Class D. However, for Class C, once the introductory work was completed, the benches were re-arranged facing each other in pairs so that groups of four students could work together.

Formation Of Dyads.

To create the potential for cross-age tutoring it had been previously decided to form ten dyads comprising one Year 9 and one Year 10 student. This matter was first discussed with the students, and then dyads were formed on an alphabetical basis by the researcher from the class roll. This group formation process, while not popular, was acknowledged to be fair, and in fact its alphabetical basis was carefully examined by several students. Additional students were similarly allocated alphabetically, creating three groups of three students in Class C, and four such groups in Class D.

Although there was some initial resistance, most dyads either already had, or soon formed, cooperative working relationships. All of the students were already known to each other, often having been in the same class for some years previously. Some students held strongly-developed feelings as to whom they would or would not work with. One dyad refused to cooperate over the entire period of the research, while others, initially thought to be unlikely to do so, ended up forming extremely productive partnerships.

Teaching.

The module was introduced to both classes with six periods of teacher-directed work involving the resources and student-centred strategies previously developed. As far as possible, both classes were exposed to identical teaching and learning experiences. Each class then sat the same Energy Transformations test, under the same conditions, which was marked by the researcher. After the test had been gone over, and marks verified by the students, the scripts were collected in and retained by the researcher. The mean test marks for each year group formed the covariate control later used to establish any initial differences between the (essentially) randomised class memberships.

For the next 12 periods, the two classes followed the different teaching approaches previously outlined in Table 4.1., but each covered the same content, with the same time allocated for each section of work, and followed by identical assessments (which were marked and retained by the researcher). Class C followed a programme of rotational learning activities involving three rotations of approximately four periods each, with an emphasis on cooperative group work. Each group was responsible for self-management, with the teacher's role being that of facilitator. Class D followed an identical programme of learning activities, but had the programme presented and managed by the teacher-researcher on a lock-step basis.

Each class then commenced the student-managed extended group investigation, which was intended to last for four periods. For Class D, however, this had to be shortened to three periods due to the unavoidable loss of the last timetabled period.

Difficulties

In general, the comparative phase proceeded smoothly, with few difficulties occurring. The most significant related to absences and end-of-year effects.

Absences.

1. Observer absence contributed to the loss of some data in the first several periods of observations with Class C.
2. The teacher-researcher was absent for one period during which Class C were carrying out the assessed group investigation. The programme continued with an experienced teacher fulfilling the facilitator role. The observers continued their normal role, including observations of teacher role. They later reported that "the students knew what they were doing, and things basically continued as normal". Some researcher insight into the investigative process was lost.
3. Occasional student absences from each class resulted in minor loss of individual observational data.

End-Of Year Effects.

The comparative phase had originally been timetabled to occur in semester four and five. A timetable change forced its postponement to semesters five and six, resulting in the end of the module for Class D corresponding with the end of the school year, a time in which normal routines are liable to disruption. During this time:

1. Several periods were shortened, resulting in minor re-scheduling of some activities.
2. The last timetabled period was lost, resulting in some loss of researcher insight into the depth of the group investigations, and the loss of student observational data.
3. Student commitment reduced during the last few periods.

A more careful appraisal of the effects of these difficulties is discussed in Chapter Nine.

INSTRUMENTATION

Introduction

During the preliminary and reflective phases, a wide range of instruments required for use in the comparative phase, was prepared. These instruments were required to assess the following features:

1. student engagement with class activities throughout the module.
2. teacher activity throughout the module.
3. student perceptions of preferred and actual classroom environment.
4. individual student achievement.
5. student group investigative skills.

Student activity (SA), student level of engagement (L) and teacher activity (TA) were assessed on a continuous basis by two independent observers using an instrument (SALTA observational procedure) developed by the researcher. Student perceptions of classroom environment were assessed using the Individualised Classroom Environmental Questionnaire or ICEQ (Fraser, 1990). Individual student achievement was assessed by three written tests, and group investigative skill was assessed by an extended investigation. Further details of these instruments, including their development, will be described. Table 4.3. provides an overview of the instruments used, and their sequence of use.

FEATURE	INSTRUMENT	SEQUENCE OF USE
Student engagement	SALTA observational procedure	Taken minute-by-minute throughout the module
Teacher role	SALTA observational procedure	Taken minute-by-minute throughout the module
Preferred class environment	ICEQ short form	Administered in Period 6
Actual class environment	ICEQ short form	Administered in Period 20
Achievement	Test: Energy Transformations	Administered in Period 6
	Test: Interpreting Motion	Administered in Period 11
	Test: Forces and Work	Administered in Period 18
Investigative Skills	Group Investigation	Continuously in Periods 19-22

Table 4.3. Overview of the instrumentation and its sequence of use.

The instruments shown in Table 4.3. were intended to operate independently to provide a wide profile of data concerning the impact and operation of the module.

The SALTA Observational Procedure

Development.

The observations were intended to provide rich information about three classroom parameters: the scope of different learning activities scheduled and the time spent on each, the level of student engagement with each of these activities, and the time spent by the teacher in various class activities and roles. Continuous observation of these parameters on a minute-by minute basis throughout the module was considered necessary to attain the definition required. Two observers were considered the minimum required to achieve this. At any given time, one observer was to monitor the defined class activity, and the level of engagement of a chosen student, while the other was to monitor teacher activity. Experience gained during the preliminary phase had suggested a suitable range of categories to use for monitoring class and teacher activities. Student engagement was to be monitored by a moderate-inference technique (Croll, 1986) in which the observer monitored each selected student for one minute and ranked the level of engagement in terms of specified criteria related to the amount of time spent on task. Trial versions of observer guidelines, an observation proforma, and an observer notation sheet were developed.

Addressing Potential Bias.

In designing the instrument, three sources of potential bias were recognised, and three specific design features incorporated to address them, as shown in Table 4.4.

POTENTIAL BIAS		
SOURCE	**ADDRESSED BY DESIGN FEATURE**	**RESULT**
Individual observer judgment.	Observers to work as a team alternating observing roles on a ten-minute cycle.	Reduced.
Teacher influence on student engagement.	Selection of students for observation to be made by observers independently of teacher input or knowledge.	Eliminated.
Sample selection.	Observations to involve all students equally and randomly.	Eliminated.

Table 4.4. SALTA design features intended to address sources of potential bias.

The incorporation of these features gave considerable independence and responsibility to the observers, eliminating the teacher-researcher from day-to-day involvement with the operation of the instrument.

Operational Procedures.

The previously designed observational proforma was extensively refined after discussion with the observers to reflect the ten-minute observation cycle, and improve its efficiency. The final form of the SALTA observation proforma (Appendix Three) forms a convenient reference point from which to discuss the role of the observers and the operation of the instrument in context. (The final form of this proforma was used from the third lesson onward with Class C, and for all lessons for Class D).

Immediately before commencing observations, the observers would record (in random order) the names of the five Year 9 and five Year 10 students to be observed that period on their individual copy of the proforma, move to separate, unobtrusive locations, and start their stopwatches. The proforma shows that the observations are arranged in five ten-minute cycles. During any cycle one observer would focus on student activity and engagement, and the second on teacher role, with these foci alternating every cycle. For each minute of the cycle, the first observer would classify and record the defined class activity, and the level of engagement of the next unobserved student on the list. The second observer would similarly classify and record the predominant teacher activity occurring in each minute throughout the cycle. An observer notation sheet (Appendix Four), attached to each observer's clipboard, provided quick reference if needed, to the activity categories, abbreviations, and engagement criteria. At the end of each cycle, the observers simply changed roles (but not locations), and continued the process. The observations normally covered 50 minutes of the typically 55 minute periods, allowing the observers time to carry out necessary preliminary administration e.g. record observation lists, and verify seating arrangements. Immediately after observations were complete, the observers would leave the room, transpose the data onto one single sheet, which was then signed and filed.

Operational Comments.

The observations described are an attempt to categorise or quantify various classroom parameters. They are also an attempt to package a continuous event stream into discrete one-minute time-slots. Each of these attempts can be regarded as very successful in a practical sense: the observers found it a manageable task to make the scheduled observations, and there is no doubt in the mind of the researcher that they did so conscientiously and accurately. Within a few days they reported that the procedure was working well, although demanding full concentration. A high degree of consistency was quickly established between observers. Negligible instrumentation effects were observed.

Observer Judgment.

Observer judgments had to be made when the activity changed during the minute of observation e.g. a student activity starting as Listening (to instructions) may have changed to (commencing) Practical Work as the instructions were completed. In cases such as this, the level of student involvement may have also changed within the minute, also forcing the observer to make a judgment as to the level of overall involvement. Changes in activity midway through the minute occasionally resulted in the recording of an apparent anomaly between teacher activity and intended student activity if the observers each judged the major focus of the minute differently.

The Data Categories.

The complexity of classroom events means that there are potentially far more categories than have been created. An observation recorded as R (reading) may have formed part of a task involving both reading and writing e.g. making notes from a text. Neither do the categories identify the reading source or purpose. Observations recorded as W (writing) similarly do not identify the specific purpose of the writing. The observation L (listening) included times when the student observed was waiting 'in listening mode'. The reasons for having a relatively small number of categories related to the practicality of the situation: the observers of necessity had to work quickly, and an exhaustive list takes time to use. Too specific a list it would have forced the observers into making significant inferences rather than observations. The validity of the instrument is discussed in Chapter Nine.

Classroom Environment

Human environments can be conceptualised in the three general categories of dimensions identified by Moos (1974), namely Relationship Dimensions, Personal Development Dimensions and System Maintenance & Change Dimensions. The Individualised Classroom Environmental Questionnaire (ICEQ) is an instrument based on this conceptualisation which was rigorously developed by Fraser (1990) for the purpose of assessing educationally relevant aspects of classroom environment. It exists as two distinct questionnaire types: one to assess perceptions of the preferred environment, and the other, perceptions of the actual environment. The questionnaires are designed to distinguish between the five independent dimensions of Personalisation, Participation, Independence, Investigation and Differentiation - and to measure the extent of each dimension in the respondent's preferred or actual classroom environment. Descriptive information about the five dimensions and samples of the questions are given in Table 4.5. (p63). The instrument has high credibility and has been used extensively.

The ICEQ has both a long form and a short form, both of which were trialled in the preliminary phase. As a result of these trials, it was decided to focus on mean class perceptions rather than individual perceptions, and hence use the more economical short form as recommended by Fraser (1990) for this situation. In the short form used there are five questions in each category, making twenty-five questions in all. Each question is answered on a scale of 1 -5, indicating the extent to which the practice applies, or one would prefer it to apply.

Trials in the preliminary phase also suggested it would be appropriate to assess preferred and actual environment at significantly different times both to avoid confusion and the possibility of reduced interest in participation. Actual environment appears more validly assessed towards the end of the learning experience, while preferred environment may be better assessed earlier. Nevertheless, some experience

CATEGORY	**ICEQ**		**DESCRIPTION**	**SAMPLE QUESTION**
	DIMENSION	SYMBOL		
Relationship	Personalisation	Pe	Opportunities for individual teacher-student interaction are fostered. Teacher concern for personal welfare and social growth of students is emphasised.	The teacher helps each student who is having trouble with the work.
	Participation	Pa	The extent to which students are encouraged to be active participants in the learning processes.	Students' ideas and suggestions are used during classroom discussion.
Personal development	Independence	Id	The degree to which students are allowed to exercise control over their own learning and behaviour.	Students are told how to behave in the classroom.
	Investigation	Iv	Emphasis on the development of investgative skills, and their application.	Students carry out investigations to answer questions which puzzle them.
System maintenance and system change	Differentiation	D	The extent to which students are given different learning experiences to suit individual needs and interests.	All students in the class do the same work at the same time.

Adapted from Fraser (1990).

Table 4.5. The ICEQ dimensions of classroom environment and their descriptions.

of the environment actually operating appears necessary before any useful assessment of preference can be made. This is significant in a modular system because student expectations of preferred environment on entry to a science module are, in part, a reflection of their experience in the preceding environment. Since contrasting teaching approaches were used after the initial section of lock-step teacher-directed work, this seemed the appropriate point at which to assess the preferred environment for Classes C and D. Hence the preferred environment was assessed for each class during period six, and the actual environment during period 20 or 21 as convenient.

Individual Student Achievement

Student achievement of content knowledge was measured using three written tests whose title, format and source is outlined in Table 4.6. Questions used in the Energy test were assessment tasks taken from a new text specifically written to reflect achievement objectives at this level of the curriculum. The selection of suitable questions was based on trials and resulting feedback during the preliminary phase. The questions used in the Energy test represented an independent, external source of assessment, in contrast to the purpose-written questions of the Interpreting Movement test, which produced a local input. This test covered a section of work traditionally regarded as more difficult, and the questions were designed to bridge the three curriculum levels (Levels 4-6) across which experience indicates students in composite classes tend to work.

TEST TITLE	FORMAT	SOURCE
Energy	Mix and match. True/False. Short statements. Sentence completion.	Adapted from text: *New Zealand pathfinder series. Self-study guides. Science: Level 5 Book A* (Hook, 1998).
Interpreting Movement	Graphical interpretation. Short calculation. True/False. Descriptive statements.	Purpose written.
Force and Work	Multi-choice. True/False. Brief explanations. Concept recognition.	Part purpose written, part from assessment resource bank (NZCER, 1998).

Table 4.6. Title, format and source of the three common tests used.

The assessment resource bank referred to in Table 4.6. is an expanding web-based resource operated by the New Zealand Council for Educational Research (NZCER). This also formed an independent source of appropriate questions. The Forces and Work test included three Level 4 questions selected from this bank. Two of these concerned 'fair tests', the investigative skill developed in this section of work. Other questions in this section were developed by the researcher to reflect specific class learning experiences. All tests were in write-on format for convenience. A copy of each test is located in the Appendices as follows: Energy (Appendix Five); Interpreting Movement (Appendix Six); Forces and Work (Appendix Seven). Discussion of the validity of the tests is left until Chapter Nine.

Group Investigative Skills

Group investigative skills were assessed from the extended investigation defined in the learning outcomes for the module (Appendix Two), using the normal departmental generic criteria and approach previously discussed. The six specimen investigations listed in Appendix Two were developed by the researcher to provide a range of contexts considered both likely to appeal to many students and feasible to carry out. Students also had the option of negotiating their own choice of investigation. The validity of this measure is discussed in Chapter Nine.

ETHICS

The proposed research was discussed with the school principal, and his permission sought and obtained before the project commenced. He stated that as the research merely continued, in a more-formalised manner, the general line of curriculum-driven developments which were already being implemented within the science department, that neither the Board of Trustees, parents, nor students themselves need necessarily be informed. However, the decision was made by the researcher to inform students of the research, and explain that their feedback, both formal and informal was important. This contribution to an established climate of openness was viewed as an essential component of the learning environment.

The presence and role of the independent observers in Classes C and D was fully explained to those students, as previously discussed. The observers themselves were already familiar to the students in their other roles as teacher aides. Although one of the observers was the wife of the researcher, this did not compromise the independence of the role. Students were assured of their anonymity and a coding system has been applied to all data presented. The pseudonym Lakeside College has been used to protect the identity of the school concerned.

All original data collected in this research will be stored safely in the researcher's home for a period of five years from the acceptance date of this thesis. A copy will be lodged in either electronic or photocopied form with the Science and Mathematics Centre of Curtin University, to be retained for the same period. Any identifying information will be removed from such copies to protect the confidentiality of the participants.

SIGNPOST FOUR

This chapter began with a description of the research perspective, design and structure. The design contains two teaching phases, a preliminary and a comparative. Developments made in the preliminary phase are described separately in Chapter Five. The comparative phase involved the teaching of the *Energy* module to two composite Year 9/10 classes using different teaching strategies. The impact of these different strategies on a wide range of parameters was investigated. The methodology by which this was achieved has been discussed, and the instrumentation used to assess these parameters has been detailed, particularly the purpose-designed SALTA observational procedure. Practical difficulties in carrying out the research have been described. The effect and control of the range of variables identified is detailed in Chapter Nine. Consideration of the research ethics concluded this chapter.

CHAPTER FIVE

SCIENCE STUDENTS AT WORK

This chapter considers the preliminary phase of the research. The nature of children's science and cooperative learning are discussed. Three metacognitive strategies are described, and the method of group formation detailed. A number of resources specifically written for the module are listed and their development discussed. A sample teacher-directed lesson is described.

FOCUS

Introduction

The focus of the preliminary phase was student-centred reform of the *Energy* module. This process was informed by a constructivist view of learning described in Chapter Three. One of the central messages of constructivism (Black & Atkin, 1996) is the importance of learning experiences which take into account the learner's existing conceptions and perspectives – the "children's science" described by Osborne (1985), and previously alluded to. Constructivist approaches also emphasise that meaning is socially constructed, and the use of cooperative learning groups forms an effective strategy for this to occur within the classroom. Each of these positions is elaborated. Metacognition is a significant element of a constructivist teaching approach. The three strategies discussed focus on self- and peer-review of conceptual understanding and time-management within the context of day-to-day learning.

Two methods used to form cooperative learning groups are detailed. A laissez-faire approach used with Class A resulted in the use of a more structured approach for Class B. Criteria developed for group membership are detailed, and the formation of the groups discussed. Resource development is discussed, with some representative resources listed and later described, with comments on their operation.

Children's Science

As they interact with the world, children develop their own personal understanding and interpretation of the events in which they become involved. In playing "postbox" for example, they develop concepts of shape; in playing with wind-up toys they develop ideas about forces and movement. From a young age children are constantly making sense of the world about them on the basis of personal experience, driven both by natural curiosity and opportunity. Such opportunity may be influenced by caregivers whose own expectations may lead to enrichment or impoverishment of the child's learning environment. For example, gender and cultural expectations of the child may restrict the caregivers' perceptions as to what are appropriate play activities, just as economic considerations may also provide restrictions. The range of science-related ideas developed by this ongoing process can be referred to as "children's science" (Osborne, 1985). That such ideas may not be science, but rather children's beliefs about science (Matthews, 1995) is of less significance than the fact that students have often "hung their cap" firmly on ideas which have proven viable in the context of daily life. Similarly, the social or cultural perspective from which such ideas are interpreted is often strongly held. Formal learning in science can be strongly influenced by both of these aspects.

Examples

A relevant example of the first type arises from the lack of discrimination perceived by many students at this level between the concepts of mass and of weight. Everyday experience strongly reinforces the view that these are the same concept – people weigh objects, yet state the weight in kilograms, the unit of mass. The concept of "weightlessness" appears well-understood by students, possibly because it is invoked in space movies. A variety of learning experiences, including the use of video clips from space research, may be integrated to challenge the existing single-concept view of mass-weight, and help students realise that the development of both concepts provides a more consistent explanation of their overall experience. Since it is the learner who ultimately decides to accept or reject such conceptual change (Hewson, 1996), the teacher must both gauge existing student conceptions, and design learning experiences in response to these needs.

An example of the second type arises in the teaching of the evolution topic in Year 13 biology, in which a student's emerging understanding of the theory of evolution may be in conflict with a previously well-developed understanding of the origins of life arising from a creationist upbringing. In such a case, the learner may well find the learning experience threatening, and initially respond by developing co-existing concepts to suit the appropriate contexts.

Towards Conceptual Change

As previously discussed, students bring to the classroom prior intuitive understanding of science phenomena as well as a socially developed framework for its interpretation, and effective teaching must address both these issues. To encourage students to voice their understanding, classroom environments must both provide the opportunity for suitable discussion, and provide a supportive atmosphere in which this can occur. Such an atmosphere should affirm the worth of each individual while encouraging the debate and re-conceptualisation of relevant ideas in a non-threatening way. The use of cooperative group learning activities later described provides one avenue for achieving both of these factors. Group work also provides naturally-occurring opportunities for the teacher to interact with students by invitation. Such student-initiated discussion can open a window into the minds of students (Hewson, 1996) allowing the teacher to appreciate their conceptual understanding and learning concerns. This in turn provides an opportunity to respond flexibly to learning needs. For example, in a group discussion on friction, one student claimed that glass had more friction than sandpaper "because it's sharper", suggesting a confusion between surface and edge characteristics, a distinction not made explicit by the context. This position was partially resolved by discussion, but could have been more fully resolved by a brief investigation.

Cooperative Learning

Cooperative learning is a group teaching strategy in which the success of any group member leads to increased success for other group members (Abrami et al., 1995). This key feature, termed positive interdependence, may be contrasted with key features of two other strategies, namely individualised learning and competitive learning. In an individualized programme, the success of any individual has no direct effect on that of another; in a competitive programme, the relative of success of an individual leads to the relative failure of another. The intention of cooperative learning is to enhance the learning of all students by applying techniques which promote both positive interdependence among group members, and individual accountability.

Abrami et al. (1995) claim that cooperative learning acts directly in two interrelated ways to increase learning – it both actives global learning processes and increases motivation. Additionally, the structure of cooperative learning situations provides other learning benefits. Global learning processes relate to the range of mental processes by which human thought is developed, clarified and extended. These processes are enhanced by the focused interactions which cooperative group learning fosters. For example, students are forced to acknowledge and respond to the concepts, thinking approaches and working methods of others within the group. Such interaction may not only help students develop more viable conceptual knowledge but also widen their conception of creative thought. In working cooperatively, student discussion encourages individuals to examine and justify their actions. Such peer monitoring is viewed by Johnson & Johnson (in Abrami et al., 1995) as fostering the growth of metacognitive skill. Additionally, tasks which specifically involve students in explaining material to others, encourage the development of deeper thinking and better encoding of information – fostering both understanding and recall. The continuing development of oral and written skills is also significant for future learning.

There is evidence that student motivation can be increased by the use of cooperative learning strategies (Abrami et al., 1995). For example, the peer support provided by a group can not only help an individual student to learn, but can also improve that individual's confidence as a learner, and subsequent commitment to learning. As well as such intrinsic motivation, peer support also imposes a voluntary commitment on the individual to the fulfilment of group tasks, which may also provide a range of learning benefits. For example, a less conscientious student may initially benefit by the increased time spent on task, resulting in increased understanding. Longer-term gains may arise from the growing realization that others take learning opportunities more seriously, have developed personal learning strategies, and have long-term goals. Potential also exists for students to under-achieve, for example, when more-able students are able to "cruise", and both task and group structure must meet the range of learning needs.

A strong source of intrinsic motivation is provided when groups are able to take more control of their own learning, for example, by having choice of action which provide more freedom for student groups to pursue learning interests of genuine curiosity. The inclusion of the negotiated investigation (Appendix Two) provides one structured way in which this is achieved in the *Energy* module. Choice as to the level of challenge also provides an opportunity for students to work at their optimum.

The opportunity provided by successfully-operating group work for the teacher to respond to individual learning needs has previously been noted. Such quality instructional time provides a unique educational benefit since it occurs within the framework of a structured and ongoing learning partnership. It has the potential to open up new learning horizons to both student and teacher. Slavin (in Abrami et al., 1995) suggests that the greater time and energy available to the teacher within a cooperative learning situation provides part of the explanation of its success.

Metacognitive Strategies

Reflective Time.

Specific time was allocated to reflective activities on a number of occasions. During teacher-directed work for example, the last five minutes of the period was set aside for students to review their notes and check on their understanding. As part of this process, they were asked to either write a brief comment or draw a simple face to indicate their understanding. (This later provided a quick and useful source of feedback to the researcher. For example, the strength of the Energy Circus activity to help students develop an understanding of energy transformations became evident when even a weak student could write "I understand a whole amount", and draw a smiley face). This reflective time was used well by most students, with the researcher often being called over to clarify a point being reconsidered. Reflective time is a technique in common use, as is the use of emoticons (e.g. smiley faces to indicate understanding).

Questioning Technique.

During the teacher-directed summary of the section on Movement, a number of conceptual questions were directed to the whole class, with three students taking turns to select who was to answer. Six answers were received to each question, with no teacher judgment expressed until all six answers had been given. The specified intention was that students should listen to the preceding answer(s), and use these to create a better answer. The range of answers received in this situation reflected the breadth of understanding existing within the class more than is normally the case. The hearing of earlier answers provided a focus to those answering later. Some students who answered earlier later rephrased or qualified their answers in response to points later developed.

Group Grades.

Formative assessment was given orally to each group towards the end of the extended investigation. Groups were asked questions like: What have you done in relation to the criteria? What grade do you want to achieve? What will you need to do to achieve this? These questions provided strong review focus while leaving the initiative for action within each group. In one rather disorganized group, one student exhorted the other group member into action by saying "I don't want you to pull my mark down". Later, in selecting one book for grading, group members compared features of each other's work, often raising points previously unconsidered.

Group Formation

Class A.

In Class A students were allowed to choose their own work partners, and groups formed on a social basis. These groups were invariably comprised of students of the same gender and, generally, of the same year level. In some cases, super-groups formed i.e. a group would arrange to sit immediately behind or in front of another particular group. Several students ended up sitting on their own. Groups appeared to reinforce their perceptions of learning, with one group being noted as especially encouraging of each other's learning, while another was noted as discouraging it.

Class B.

These observations lead to the development of some criteria for group formation, which were subsequently applied to Class B. The criteria for group membership were:

Group size: two or three students. Year level composition: at least one Year 9 and one Year 10 student. Gender composition: at least one student of each sex. Cooperation: must be willing to work together as a partnership.

After discussion of these criteria, students were then invited to suggest their own group memberships, and record these on the whiteboard. Such group formation would be subject to teacher approval, both in terms of the particular group and the overall class balance achieved. Most students appeared to enjoy the process of negotiating group membership, although it was an obvious concern for some shy or less-popular members of the class. Within a few minutes, most group lists had appeared. However, several students were shunned in this process, and some sensitive teacher input was required before group formation was complete. The majority of groups functioned well throughout the module.

Note: The method of group formation used in the comparative phase has been previously described in Chapter Four. Student perceptions of the classroom environment, which may have arisen as a consequence of the method of group formation used, are later discussed in Chapter Six.

Resource Development

A number of resources, both written and practical, were developed during this phase. In some cases the ideas originated during normal classroom activities as a teacher response to student difficulties, from student-teacher discussion, or from student suggestions. Others represented teaching techniques which the researcher wished to explore. In all cases two referents were focused on: the activity must first appeal to student interest, and then engage the student in thinking about the intended ideas. Since cooperative learning was a major focus, where possible the activity was structured using cooperative learning techniques. The development of some specific and representative resources is next discussed. Table 5.1. lists those resources discussed, and their generic type.

RESOURCE TYPE	NAME
Conceptual-thinking Strategies	Energy Concept Map
	Mixed-Up Movement
Conceptual Challenge Activity	Perpetual Motion Machines
Context-rich Investigation	Team Task 1: Toy Car
Rotated Group Activity	Mini Activity: Gravity

Table 5.1. Name and generic type of specific resources to be discussed.

CONCEPTUAL-THINKING STRATEGIES

Concept Maps And Webs

Concepts can be defined as perceived regularities in events or objects (Novak, 1996). Concept maps use a simple diagrammatic form to illustrate relationships between concepts in the same content area and thus form an efficient way of representing a structure of knowledge. Features of true concept maps are the hierarchical form of the concepts, and the simplicity of the few words used to form links between concepts. Since the meaning of any concept is ultimately defined by its relationships to others, the exercise of creating a concept map forces a strong examination of personal knowledge. It is thus a valuable tool for refining personal understanding of the concepts, and for strengthening learning. Novak (1996) illustrates a number of ways in which concept mapping can be used to improve science teaching and learning. These include improvements in instructional design, identification of misconceptions, the development of a personal understanding of the constructed nature of knowledge, the facilitation of cooperative learning, and the evaluation of learning. He cites evidence that the routine use of this technique promotes meaningful, as opposed to rote, learning. There was thus a strong rationale for the incorporation of concept mapping techniques into this developmental phase of the Energy module. A variation of concept mapping known as a concept web was developed.

Concept Webs.

Concept webs are a free variation of concept maps in which little, if any, attention is paid to the hierarchy of the concepts. Thus a concept web may contain many important cross links between concepts: the deeper the understanding represented, the greater the number of valid cross links which are likely to appear. In the variation developed by the researcher, the links can include many, not necessarily simple, words. Such links themselves often involve significant concepts. Concept webs as described are inherently messy in form - hence the name.

Early Trials.

Early attempts with student-created concept webs with Class A were not particularly successful, probably because the technique, which was new to the students, was not taught carefully enough. An example of an Energy concept web developed on the whiteboard by teacher and students as a whole-class exercise was too extensive and too messy. Students started writing the concept labels in their books before the links were created, unaware both of the space needed, and the likely messiness of the result. Many students took part with great enthusiasm suggesting appropriate links and in some cases coming up and writing them on the board. Amongst this group were those confident enough in the process of learning to offer alternative answers: different wording or more significantly, different links. However, many others just waited, merely wanting the "right answers" to appear with a minimum of negotiated alterations. Amongst this group were some highly motivated students who characterised the exercise as a waste of time. Some students were agitated because there was no single right answer: the idea of each individual student being able to create a unique, personalised and correct mind map appeared a major threat to their strongly-held positivist views of knowledge. Some students appeared to perceive this exercise as a threat to their status of good science learners and were upset that others, whom they may have regarded as less able, coped better with the technique. Some were upset simply because the result looked messy; and there were some who showed little interest anyway. Negative reactions were not unexpected (Novak, 1996) since students had much to challenge them in this initial exercise.

However, those who did engage in the process appeared to gain personal understanding in at least four significant ways, namely:

1. strengthened understanding of the concepts and their relationships.
2. enhancement of generic learning skills through practicing a new learning technique.
3. appreciation of the constructed nature of knowledge.
4. affirmation of their integrity as independent knowledge constructors.

All four of these features represented an improvement over previous practice. The relationships between concepts were explored more thoroughly than was previously possible: concept webs being the ideal tool for economically and visually displaying such relationships. Nor would previous practice have helped students develop a new generic learning tool: it would merely have continued to employ existing modes of learning. The realisation that many different yet correct concept webs were possible forced some students to question their understanding of the basis of human knowledge in a natural and effective way - an issue students of that age do not readily engage with. The variety of correct answers was also an encouragement to those (naturally constructivist) students who like to do things their own way, and whose learning styles are too-often thwarted in tightly structured activity. This was of significance since the development of one's self-belief as an effective learner is a necessary and crucial step in the development of the positive attitudes needed to encourage further learning.

Developments.

Concept webs were similarly tried with other more senior classes taught by the researcher (an example of a more complex concept web involving electrical concepts is shown in Appendix Eight), convincing him of their potential, but also of the need to use a bridging strategy in introducing them, particularly for the significant percentage of students in many junior classes who are not intellectual risk-takers. The technique had to encourage not threaten, the confidence of the learner. Hence the tactic of using a highly simplified, pre-prepared concept web was developed, and a trial map of *Energy* produced. This turned out to be highly successful in terms of the two referents used, and in terms of fostering cooperative learning. Later an equally successful series of linked-statements concerning *Movement* was developed and introduced. After refinement, both were used in the comparative phase. Much of the success of these activities lay in the manner of their use, which is therefore described in some detail.

Essentially, each of these activities could be described as "cut, think and paste". Common features included the use of blocks of pre-prepared initial statements (or concepts) in one colour. After cutting these blocks into individual pieces, each student arranged these to suit the task, and their page layout, and then glued them into place. After receiving the second block, which was in a different colour, students similarly cut these into individual pieces. At this stage students moved into the real purpose of the activity i.e. they became engaged in matching the ideas to create related concepts. This lead to significant reference to the text and discussion with other group members, and often with the teacher. When a group consensus had emerged as to the arrangement of the pieces, the teacher was called in and was easily able to check one book, and after discussion suggest rearrangements where necessary. When this had been done, the second tier pieces were glued in and the third tier blocks (which were in a third colour) issued. The process was once again repeated to produce the final map.

There were two reasons for the use of differing colours for each sheet: the first as a learning strategy, the second as a logistical aid. In *The mindmap book*, Buzan (1995, p100) describes colour as "one of the most powerful tools for enhancing memory and creativity." The simple addition of the extra sensory dimension of colour into the learning task thus offered an enhanced learning opportunity. Certainly it is the researcher's experience, both in this research and in general, that students respond favourably to the use of colour. The second reason related to the distribution of sheets: with contrasting colours it was simply an easier task.

The Resources In Action

Energy Concept Web.

This mind map was used as a teaching tool, and was written to suit the specific text (Hook, 1998) to be used on that day with Class B. The group task was to first read the relevant information and then, working cooperatively, use that information plus prior knowledge to produce the correct mind map. (Although it was a group task, each student was intended to have an individual copy). As this was an introduction to the technique, large-scale copies of the first, and some of the second, tier concepts were written and attached to the magnetic whiteboard. Following some whole-class instruction, the teacher and class (with reference to the text) were then able to help one student volunteer to model the mapping process on the whiteboard using previously prepared cards (which attached to the whiteboard with magnets).

Once students became aware of what to do, they became strongly committed to the task: there was a high level of focused consultation as students considered both the new knowledge in the text, and their existing knowledge. Some of the second and third tier statements had been deliberately written so as to extend and complement the ideas encountered within the text creating further interest. Students often asked significant questions of the teacher, showing evidence of careful thought at a variety of levels. In these group or individual discussions a wide variety of student misconceptions were uncovered and addressed.

It was noted that students showed significantly more readiness to ask questions than is often the case with whole-class activities. Probable reasons for this include a greater opportunity to talk to the teacher, a smaller threat of potential embarrassment, more specific focus on the content, and a longer time-frame over which to ask. Most of these positive features can be considered a result of the student-centred structure of the activity.

One student, who normally did little writing, became heavily involved in the concept mapping exercise, displaying a large amount of knowledge in the process. Several commented at how quickly time had gone, with one student summing up by saying "I think we worked pretty well." The only grumbles arose from a few students who stuck pieces in incorrectly before they had been checked. However, when asked about how much they had learned, several said that they "would learn more with notes." One student, who was absent on that particular day, later examined another student's book and commented with evident disappointment "I missed a good period." After minor improvements this activity was ready for use in the comparative stage. A completed example of the Energy concept web is shown in Appendix Nine.

Mixed-Up Movement Statements.

This activity followed the format of the Energy mind-map just described, although it is best described as a series of linked-statements rather than a concept web. It originated from an exercise in three-tiered scrambled sentences used on a previous occasion by the researcher. The purpose of the activity was to allow the students to revise a number of concepts which they had encountered during the previous two years. The "cut, think and paste" three-tiered nature of the task was by now familiar, and minimal procedural instruction was required before work began. Once students became engaged with the meaningful aspects of the task, it became apparent that there was a wide variation in their retained knowledge, and there was much discussion and questioning. A procedure for checking just one book per group (as described previously) was once again shown to be an effective procedure for fostering positive group interdependence, as well as freeing time for the teacher to engage in significant discussion as required. Again, after minor improvements, this activity was ready for use in the comparative stage. A completed example of the Mixed-up Movement statements is shown in Appendix Ten. Note that some grammatical clues are provided. These were used effectively by some students in the trial versions, and were felt by the researcher to encourage the commitment of weaker students, without detracting from the learning potential of the task.

CONCEPTUAL CHALLENGE ACTIVITY

Prediction –Observation –Explanation

Existing conceptual knowledge can be tested and extended by the use of Prediction – Observation –Explanation activities (White & Gunstone in Duit, Treagust & Mansfield, 1996). Students are initially introduced to a situation of compelling interest. Typically, this will be a demonstration experiment with strong visual appeal, and capable, or apparently capable, of explanation in terms of existing concepts. Students are then asked to predict the behaviour of the situation under certain applied conditions. There is often a twist in the situation, leading to genuine doubt as to outcome. The experiment is then performed, and the subsequent behaviour observed. Discussion and explanation then leads to clarification and extension of concepts. An ideal opportunity to incorporate such an activity arose in the context of perpetual motion machines.

Perpetual Motion Machines

Background.

Energy conservation is an important concept which arises naturally in the context of the *Energy* module. The student text (Sweeney, Relph & DeLacey, 1990) states the energy conservation principle, and illustrates the concept with a diagram of a possible perpetual motion machine for students to consider. In this situation falling water drives a turbine to generate electricity. Some of this electricity is used to supply a house, and the remainder is used to pump the water back up to a dam, so as to continue the generating process. This situation both interested and puzzled many students, and there was much discussion before there was agreement that the machine would simply not continue to function, even if no electricity were used to supply the house. At this stage, students could identify sources of friction within the system, and accepted that it appeared impossible to eliminate friction entirely.

Students were then challenged to design (working in pairs) their own perpetual motion machine, with a large reward offered not as an inducement, but as an indication of the impossibility of success. There was much involvement in this activity, and the researcher was often invited to provide an opinion on proposed features. Most designs featured the direct conversion of energy between kinetic and gravitational potential, often using springs or magnets.

Conservation of Energy.

Students' developing concepts of energy conservation were then challenged by a new situation, known as Jupiter's Balls. This device consists of a central chrome-plated ball on a stalk, which is free to swing to and fro on a pivot. Attached to the stalk on frames are four, smaller chrome-plated balls, which are also free to swing or rotate about their own axes. When set swinging, the whole device displays a complex and interesting motion, particularly since there is a small magnet near one of the balls causing it to occasionally loop-the-loop.

Students were told that the friction on the bearings was low, and were asked to predict what would happen when the device was started. Everyone predicted it must eventually stop swinging, and the debate centred on how long this process would take. Stopwatches were set and informal bets taken. To the surprise of most students the device continued to swing throughout the period, with no sign of slowing down. Several students came in later in the day to see if it was still swinging. The next day a number of students checked up on the device immediately they came into the room. The device was still running, creating further discussion. A large number of students correctly inferred that there must be some internal source of energy. There was much interest when the presence of the hidden battery was finally revealed by the researcher, and an explanation of the operation of the device given. This simple situation had provided students with an effective test of their commitment to the consistency of explanation offered by the energy conservation principle.

CONTEXT-RICH INVESTIGATIONS

The use of context to enrich a learning situation is well recognised. Contexts which are relevant to the lives of the learner are more readily related to than those which are far removed. The use of relevant context encourages learning, since its value is immediately evident to the learner. Learning situations may be described as context-rich when they have been specifically designed to appeal to the learner or learners by the use of relevant context.

Two one-period context-rich investigations were developed to provide opportunities for group learning in a familiar context and to prepare students for the subsequent extended investigation. Both investigations featured role interdependence (Abrami et al, 1995) to strengthen group cooperation. Three specific roles (manager, recorder/checker and practical coordinator) were defined, and group members negotiated their roles before starting each investigation. (In most cases, roles were changed for the second investigation). A group report was completed for each investigation, and group members then decided which of the two reports to submit for formative group assessment. The first of these two investigations is described.

Toy Cars.

This investigation, featuring toy cars as the context, centred around the effects of differing surface friction on motion. The starting point was the scenario described on the group task sheet (Appendix 11) and shown in Table 5.2.

You are designing a toy car which must be able to travel across a wide variety of terrain e.g. sand, earth, gravel, lawn, asphalt, concrete – as well as vinyl and carpet. **Your hypothesis is that, for a given starting speed, the car will travel further on surfaces with less friction.**

Table 5.2. The scenario for the toy car investigation.

A number of students had previously driven a radio-controlled model car across many of the surfaces listed. (The external surfaces were conveniently available just outside the laboratory). An array of plastic toy cars was available for use (some of which were supplied by the students themselves), as well as the standard laboratory trolleys mentioned on the worksheet. Most groups showed an initial preference for the cars, although several groups later switched to the more massive trolleys for convenience of measurement of the forces involved.

Groups took some time to organize themselves and their equipment before attempting the initial task defined on the sheet. However, as soon as several groups got under way, the rest quickly followed. Students encountered problems with variation of force readings as they dragged their trolley or car steadily across the variety of surfaces, forcing them to estimate average values. For the second task, each group had to set up their launching ramp at every surface; much care was taken to get the slope the same each time, and to launch the car from the same position. Many groups of their own initiative took three readings of the distance travelled, and later averaged these. Most students were observed to be focused and busy, with some remaining behind during interval (at their request) to continue their work. Students from several groups realised that a full analysis of the situation involved more than just the effects of surface friction, discussing for example the effect of surface strength.

A ROTATED GROUP ACTIVITY

Four group tasks were created based on the group reading of a short section of text covering aspects of gravity. Two of these tasks led to a short practical, with a single group write-up; the other two led to a discussion topic, followed in one case by written questions. Each of these tasks was intended to take ten minutes of class time, after which the task sheet was passed to the next of the four groups, creating a one-period rotated activity. Desks were re-arranged for this activity to facilitate group interaction. The significant feature of this particular rotated activity was that each group had an assigned assistance role to another group. This role included both being assigned to assist, and being able to receive assistance. The initial task for Group Four is shown in Table 5.3. (p84) as an example.

The first ten-minute cycle of this activity was busy for the teacher, as each of the four groups tackled their different tasks. However, from the second cycle on, there was expertise within the class for each task, resulting in significant information and other traffic. It was observed that some groups worked well, and others less so. Both positive and negative feedback was received, with opinions being equally divided.

GROUP 4
Tasks Read 'What causes Gravity', Page 62. Discuss the theories people held. For each theory explain how you could test whether it is true. What theory does your group believe and why? You can get help from: **Group 1** You can help: **Group 3**

Table 5.3. Specimen task sheet used for the one-period rotated activity, Gravity.

One student wrote that "It was quite unorganized but rather fun, because we were all talking and socializing." Inter-group cooperation as structured appeared to be counter-productive to the more-significant development of intra-group cooperation, and was discontinued as a deliberate strategy. The mini-activities themselves, however, were refined and formed the basis of the extended rotated activities later successfully used in the comparative phase.

A TEACHER-DIRECTED LESSON

The specimen lesson described was intended to respond to student needs within a teacher-directed structure. It illustrates some of the range of activities involved, and the skills both needed and developed by students within the context of a typical learning situation.

Learning Activities.

A number of quite-different looking rocks were passed around the classroom at the beginning of the lesson as the basis for a focusing activity. These rocks varied in mass from about 2 – 8 kg, as well as varying in obvious physical characteristics like colour and texture.

Two challenges were put on the OHP:

Estimate the mass of any rock you wish. Estimate the weight of the same rock.

Several minutes of animated discussion ensued as students became involved in these challenges. Students hefted up rocks, made and compared judgments. They discussed the concepts of mass and weight. They also discussed features of the rocks themselves. Students' views of the difference between mass and weight were then elicited. Most Year 10 students were able to discriminate successfully between these concepts, citing previous experience from an astronomy module. For Year 9 students, however, the distinction was less clear.

Students then investigated the force of gravity using a force meter and a range of standard masses. From a table of results, most students readily established an intuitive relationship between mass and force, which they then used to establish the mass of unknown objects as accurately as possible. Students had previously discussed and accepted the concept of the earth having a gravitational field, and now readily assigned it a strength of about 10N/kg. Many students used scales to find their own mass, and then calculated their weight force in newtons.

After a short reading and subsequent discussion about possible causes of gravity many students accepted the explanation that gravity appears to be caused by the presence of a large mass. In discussing satellite motion, students readily accepted that the gravitational field strength is weaker high above the earth. Several students devised and, with assistance, carried out a short investigation to at least partially disprove atmospheric pressure as the source of gravity. (This involved the weighing of a ball bearing in a plastic soft-drink bottle before and after the air had been removed with a vacuum pump). Most students studied a table of astronomical information relating planetary mass and gravitational field strength. Some then used this information successfully to estimate their weight on various planets.

Teaching Intentions.

It can be seen that the learning experience described included a number of different activities involving a large range of skills. These skills included: listening, talking, reading, writing, assembling and manipulating equipment, reading and interpreting scales, recording experimental data, drawing graphs, reading tables, problem solving, working cooperatively and independently. Content knowledge was intended to be acquired via the application of those skills - just as the lesson itself was intended to provide an opportunity for those skills to develop. Knowledge, skill and understanding were viewed as inter-related parts of a holistic process of learning. Variation in task completion and understanding was expected, and responded to by the provision of a range of basic and extension tasks. During the practical tasks the teaching role was facilitative, being focused on responding to expressed student learning needs, and initiating discussion as appropriate.

Teacher's Perceptions.

In this lesson, reported in beta press admittedly, it is clear that most students at least attempted to engage with the intended concepts. Collectively, students appeared to have improved their understanding of gravity in a number of ways.

1. Many had demonstrated, through discussion, a conceptual understanding of the difference between mass and weight, and shown understanding of the cause of the weight force. (The deeper question "Why should mass be attracted to other mass?" had also been posed by the researcher to encourage deeper thinking).
2. They had demonstrated an operational knowledge of how to measure mass using a scale calibrated in newtons. They had physically measured the earth's gravitational field strength, gaining viable factual knowledge.
3. Most had developed an enhanced conceptual understanding of variation in planetary gravitational field strength.

Additionally, a number of knowledge-related issues had arisen naturally and were resolved in context. For example, to measure force students needed manipulative and scale-reading skills. The force meters had first to be checked, then zeroed if necessary. In taking a reading, knowledge of the unmarked scale divisions and interpolation was necessary. Some students meticulously zeroed their scales, and showed great care in collecting their data: they were then able to suggest 9.8 N/kg as a closer estimate of the gravitational field strength. In comparing estimates of mass with values from electronic balances, questions on accuracy arose naturally. This lesson was perceived as making a successful contribution to the overall understanding of the Forces topic.

SIGNPOST FIVE

This chapter commenced by discussing children's science and cooperative learning, complementing the constructivist perspective and student-centred philosophy developed in Chapter Three. A number of strategies and resources specifically designed to respond to these considerations have been discussed. These include metacognitive activities and conceptual-thinking strategies. Two activities designed as bridging strategies to introduce students to concept webs have been developed and found to be effective classroom resources. A conceptual challenge activity involving perpetual motion has been successful in engaging student interest and probing understanding, while a context-rich investigation involving toy cars has been found an effective strategy for cooperative group work. Features of a rotated group activity and a teacher-directed lesson have been described.

By the end of the comparative phase a large amount of data had been gathered. This data fell into three categories: student perceptions of classroom climate, formal assessment results, and the independent SALTA observations. Analysis and interpretation of this data forms the focus of the next three chapters, commencing with Chapter Six which examines the ICEQ data.

CHAPTER SIX

THE ICEQ FINDINGS

The preferred and actual perceptions of the classroom environment held by each class are presented, and an index of environmental mismatch established for each of the five ICEQ dimensions. An inter-class comparison of this mismatch is made for all four classes to investigate trends, and a covariate control established to enable fair comparison between Classes C and D. An hypothesis is presented, and an interpretation of the findings made for each dimension.

PRELIMINARY ANALYSIS

The data arising from the ICEQ was hand processed, checked and then collated on spreadsheets (Appendices 12-15) for ease of analysis. Figures 6.1a–d. (p89-90) illustrate the mean value of student perceptions of the classroom environment, both preferred and actual, for all four classes. Data from Classes A and B was available, and is included to enable more comprehensive investigation of a particular hypothesis later discussed. The long form of the survey was used only with Class A: graphical data has consequently been converted to the same numerical base as used in Classes B, C and D for ease of comparison. The y-values represent the class mean numerical score for each dimension rather than a percentage of the possible score, emphasising that there is no intrinsic value in a higher score; it is differences between preferred and actual scores which are significant. Although the data points are joined for visual clarity, it should be remembered that each of the dimensions is designed to be independent. For convenience in interpreting the graphs, the key to the standard abbreviations for the ICEQ dimensions is repeated: Pe - Personalisation, Pa - Participation, Id - Independence, Iv - Individualisation, D - Differentiation.

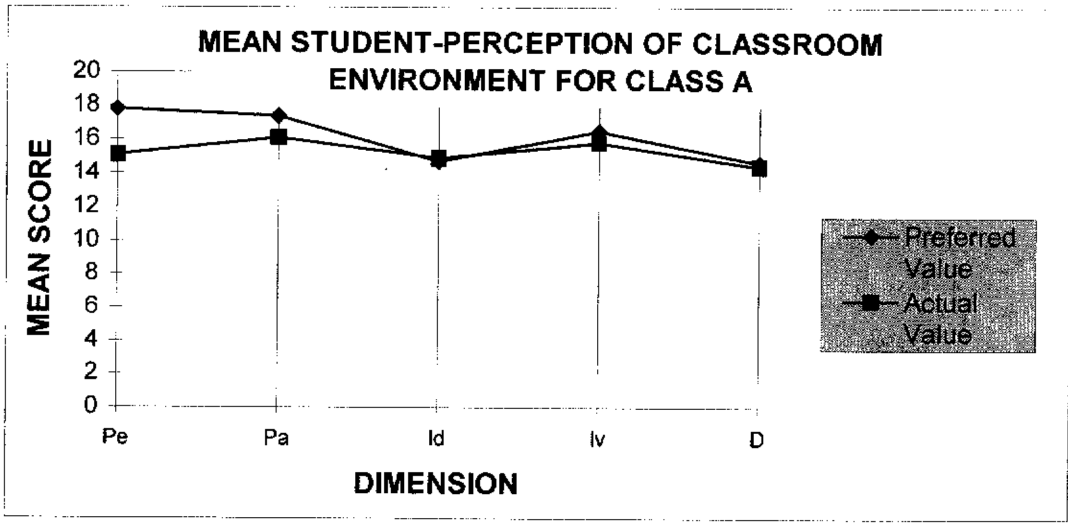


Figure 6.1a. Perceptions of class environment for Class A.

Figure 6.1a. illustrates that there was virtually no mismatch between preferred and actual independence for Class A. In sharp contrast, there was a distinct mismatch in this dimension in Class B, as illustrated in Figure 6.1b.

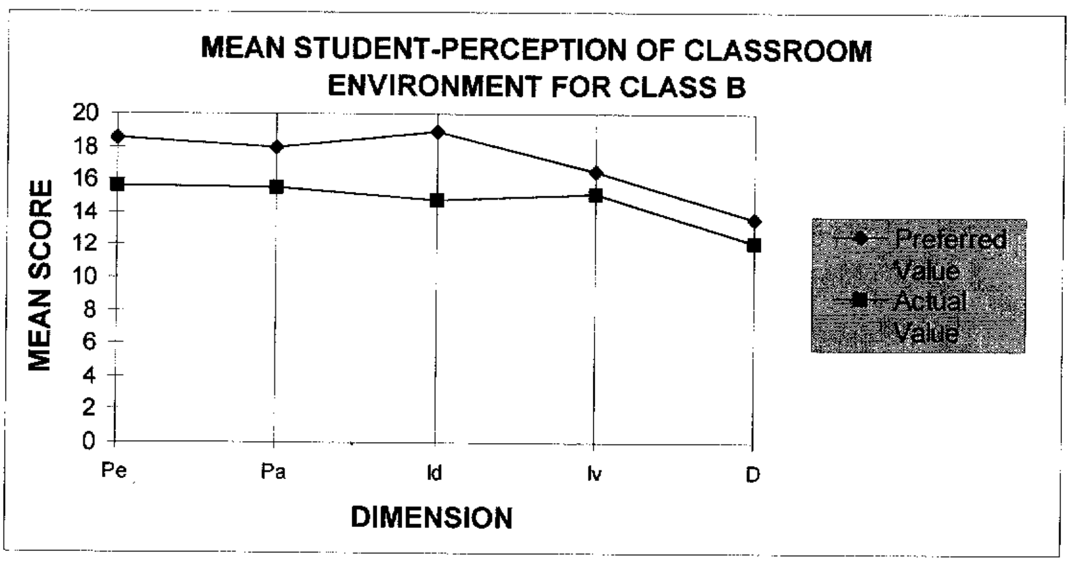


Figure 6.1b. Perceptions of class environment for Class B.

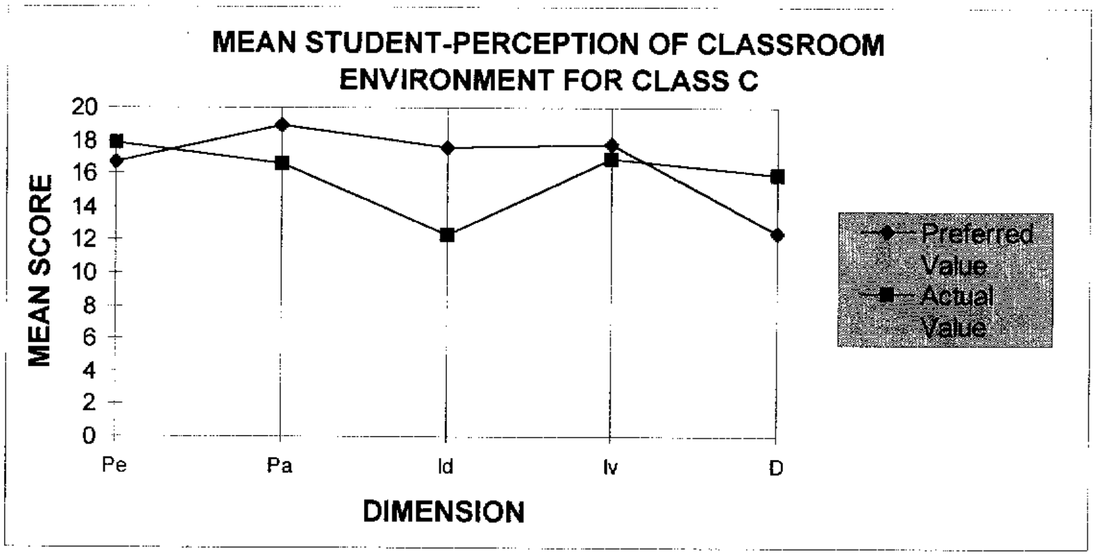


Figure 6.1c. Perceptions of class environment for Class C.

Figure 6.1c. illustrates that the student-managed Class C perceived their environment as offering considerably less than optimum independence, while at the same time being somewhat over-personalised and differentiating too much between students.

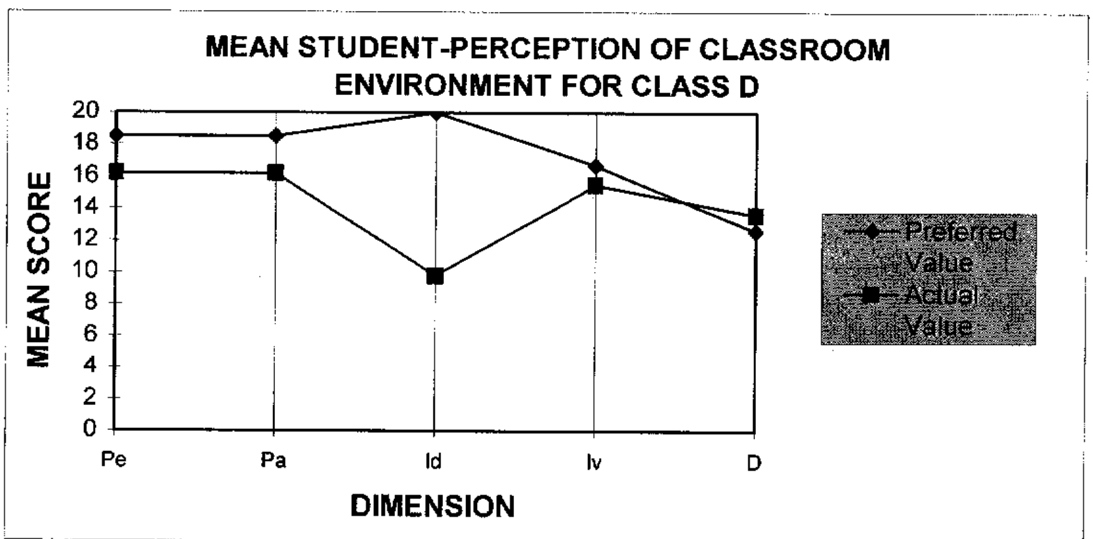


Figure 6.1d. Perceptions of class environment for Class D.

Students under the teacher-directed strategy applying in Class D perceived a very marked lack of independence in their environment as illustrated in Figure 6.1d.

ENVIRONMENTAL MISMATCH

The graphs shown in Figures 6.1a–d. indicate an increasing degree of mismatch between preferred and actual independence. To investigate this aspect further, a simple algorithm of percentage environmental mismatch was defined as the difference between preferred and actual values for each dimension, expressed as a percentage of the preferred value, as shown below.

$$\% \text{ Environmental Mismatch} = \frac{(\text{Preferred Value} - \text{Actual Value}) \times 100}{\text{Preferred Value}}$$

From the mathematical form of the algorithm it can be seen that a positive numerical value of the index indicates that the classroom environment is perceived by the student body to provide less of that quality than they would prefer, while a negative sign indicates that it provides more. Further, the greater the numerical value of the index, the greater the degree of mismatch.

Inter-Class Trends

Using this algorithm, the percentage environmental mismatch index was calculated for each of the four classes. Table 6.1. (p92) displays the mean ICEQ scores and percentage mismatch in each dimension for all four classes. In examining Table 6.1. it will be noticed that the actual ICEQ scores are higher for Class A than for the other three classes. This is because the long form of the ICEQ was used for Class A, while the short form was used for the other classes. The mathematical form of the index allows for this difference, and ensures that a meaningful comparison between classes can be made independently of actual scores.

The inter-class differences in preferred environments shown in Table 6.1. are of significance, particularly for Classes C and D, since they indicate the preferences of the two different classes arising after common initial experience. Such initial class differences can therefore be interpreted as a reflection of the individuality of their student body. Of particular note are the observations that students in Class C have a lower preference for a personalised environment and a lower preference for independence than students in Class D.

DIMENSION	PREFERRED VALUE	ACTUAL VALUE	% MISMATCH
	CLASS A		
Personalisation	35.5	30.2	**14.9**
Participation	34.8	32.1	**7.8**
Independence	29.4	29.8	**-1.4**
Investigation	33.0	31.6	**4.2**
Differentiation	29.1	28.8	**1.0**
	CLASS B		
Personalisation	18.5	15.6	**15.7**
Participation	18.0	15.5	**13.9**
Independence	18.9	14.8	**21.7**
Investigation	16.5	15.1	**8.5**
Differentiation	13.6	12.1	**11.0**
	CLASS C		
Personalisation	16.7	17.9	**-7.2**
Participation	18.9	16.6	**+12.2**
Independence	17.6	12.3	**+30.1**
Investigation	17.8	16.9	**+5.1**
Differentiation	12.4	15.9	**-28.2**
	CLASS D		
Personalisation	18.5	16.2	**+12.4**
Participation	18.5	16.2	**+12.4**
Independence	20	9.8	**+51**
Investigation	16.7	15.5	**+7.2**
Differentiation	12.6	13.6	**-7.9**

Table 6.1. Mean ICEQ scores and percentage mismatch by dimension for all classes.

The environmental mismatch data from Table 6.1. is summarized in Table 6.2. for ease of comparison between all four classes in each of the five dimensions.

	PERCENTAGE MISMATCH IN CLASSROOM CLIMATE			
DIMENSION	CLASS A	CLASS B	CLASS C	CLASS D
Personalisation	14.9	15.7	-7.2	12.4
Participation	7.8	13.9	12.2	12.4
Independence	-1.4	21.7	30.1	51
Investigation	4.2	8.5	5.1	7.2
Differentiation	1.0	11.0	-28.2	-7.9

Table 6.2. Inter-class comparison of percentage mismatch by dimension.

In interpreting the information in Table 6.2. it must be remembered that raw data has been used, with no attempt made to form a covariate control based on the preferred environment - the resulting mismatches are thus a reflection of both the individuality of the classes involved and the effects of teaching strategy. The data can therefore best be used to illuminate trends, reflecting both the reform of the module, and the different characteristics of the classes which were taught it. From this data a significant graph (Figure 6.2.) has been drawn. This graph enables a striking visual comparison to be made of the percentage mismatch across all five dimensions for all four classes, and is used to direct further discussion.

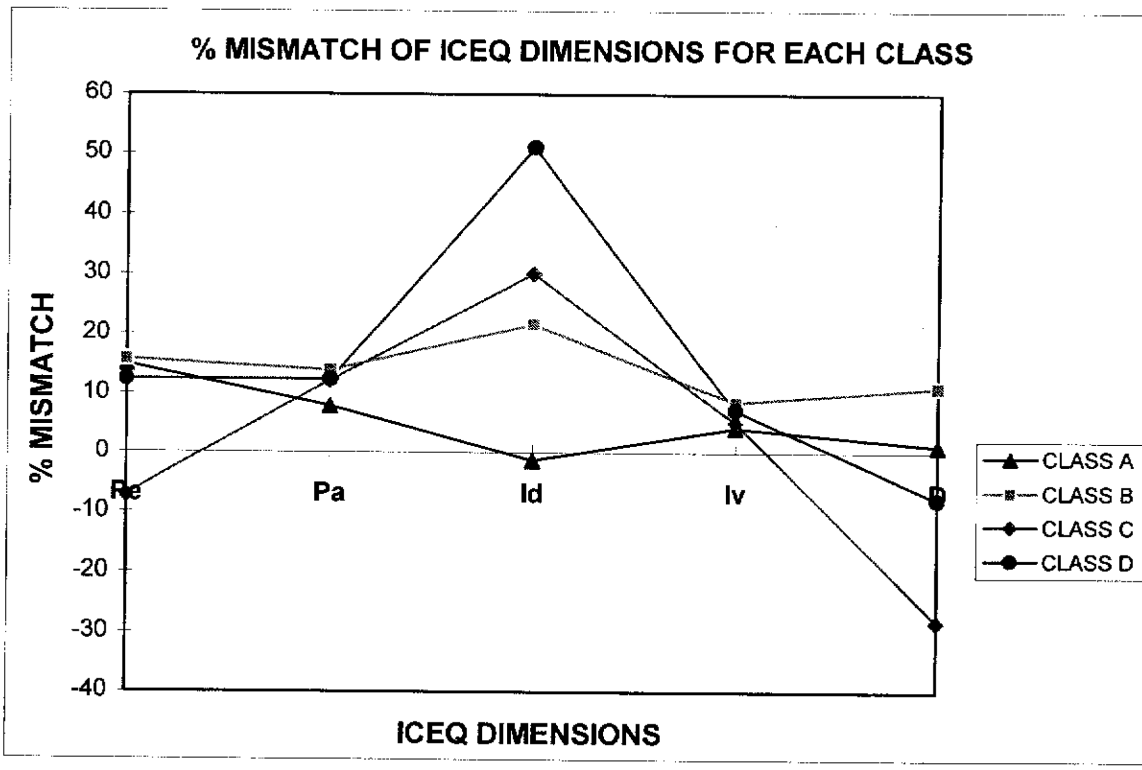


Figure 6.2. A graphical comparison of the percentage mismatches in classroom environment across all five ICEQ dimensions for all four classes.

1. The most striking feature of the four graphs displayed in Figure 6.2. is the increasingly high level of perceived mismatch in the dimension of Independence (Id).

Students in Class A perceived the class environment as offering slightly more independence than they preferred, while students in the other three classes increasingly perceived the environment as offering less independence.

2. There was a strong degree of concurrence amongst the classes in perceptions of percentage mismatch in the dimensions of Participation (Pa) and Investigation (Iv). All four classes perceived that the environment should have offered more opportunity for Participation (11.6% average percentage mismatch), and for Investigation (6.3% average percentage mismatch).

3. Three classes (A, B and D) all perceived the environment as offering insufficient Personalisation (Pe), with an average percentage mismatch of 14.3%, while Class C perceived the environment as slightly over-personalised (7.2% mismatch).

4. Perceptions of mismatch in the degree of Differentiation (D) varied significantly. Class C, in particular, perceived the environment as differentiating too much between students (28.2% mismatch). Classes C and D both perceived too much differentiation (18.1% average percentage mismatch) in contrast to Classes A and B, which perceived not enough (6% average percentage mismatch).

Applying Covariate Control

Before interpreting the key features noted above, the effect of class composition on the data was investigated by applying a covariate control to the data which could be fairly compared –namely, the preferred value of each environmental dimension arising from Classes C and D. This control took the form of an individual scaling factor for each dimension, and was defined as the ratio of the Class D mean to the Class C mean for that dimension, as shown below:

$$\text{Covariate dimensional scaling factor} = \frac{\text{Class } D_{mean}}{\text{Class } C_{mean}}$$

Table 6.3. (p95) shows the values of each of the five covariate scaling factors.

	COVARIATE SCALING FACTORS	
DIMENSION	**ClassD : Class C ratio**	**Value**
Personalisation	18.5 : 16.7	1.108
Participation	18.5 : 18.9	0.9788
Independence	20.0 : 17.6	1.136
Investigation	16.7 : 17.8	0.9382
Differentiation	12.6 : 12.4	1.016

Table 6.3. Calculation of covariate scaling factors for each ICEQ dimension.

These scaling factors were then applied to the corresponding value of each of the Class C perceptions of actual environment, and the percentage environmental mismatch index recalculated as shown in Table 6.4.

DIMENSION	RAW VALUE	SCALED VALUE	SCALED INDEX
Personalisation	17.9	19.8	**-7.0**
Participation	16.6	16.2	**+12.4**
Independence	12.3	14.0	**+30.0**
Investigation	16.9	15.9	**+4.8**
Differentiation	15.9	16.2	**-28.6**

Table 6.4. Calculation of the scaled environmental mismatch indices.

The raw and scaled values were then compared and the percentage difference between them calculated. The results of this calculation are shown in Table 6.5.

	ENVIRONMENTAL MISMATCH INDEX		
DIMENSION	**Raw Index**	**Scaled Index**	**Difference (%)**
Personalisation	-7.2	-7.0	**2.8**
Participation	+12.2	+12.4	**1.6**
Independence	+30.1	+30.0	**0.3**
Investigation	+5.1	+4.8	**5.9**
Differentiation	-28.2	-28.6	**1.4**

Table 6.5. Percentage difference between raw and scaled mismatch indices.

Table 6.5. shows that the raw and scaled mismatch index differ by surprising little – with the largest difference (5.9%) naturally occurring in the situation where the perceived mismatch is the least. It can also be seen that the scaled index values are

very close in absolute terms to the corresponding raw values. The data in Table 6.5. clearly demonstrates the robustness of the mismatch index in this situation, even without control, and suggests that the effects of class composition had little to do with the mismatches perceived, at least for Classes C and D. Unless the mismatches are an artifact of the ICEQ instrument itself, they are likely to be a reflection of the teaching strategy. As will be discussed, each of these factors has probably contributed to the creation of mismatches. Table 6.6. provides a convenient point for comparing the scaled mismatch indices for the two classes before the data is interpreted.

DIMENSION	CLASS C	CLASS D
Personalisation	-7.0	+12.4
Participation	+12.4	+12.4
Independence	+30	+51
Investigation	+4.8	+7.2
Differentiation	-28.6	-7.9

Table 6.6. Comparison of the scaled mismatch indices for Classes C and D.

INTERPRETATION

Independence.

Three out of the five questions used to measure Independence in the short-form of the ICEQ relate to the freedom of choice given to students in their seating and group working arrangements. Hence it is hypothesised that the striking pattern of mismatch noted in this dimension most likely reflects the way in which working groups were formed in this study. As previously discussed, students in Class A had free choice of group membership, while those in Class B had choice limited by defined criteria. Students in Classes C and D had no such choice, and the percentage mismatch could therefore be expected to be larger than for Classes A and B. Perceptions are usually conditioned by comparison with previous experience – in this case by comparison with the usual class expectation of relatively unrestricted seating and working arrangements. It is noteworthy that for students in Class A (for whom this anticipated situation did apply) the mismatch was minimal.

However, it is the large difference between the perceptions of the two compared classes (C and D) that is of particular significance, since the method of group formation was identical for each. As discussed previously, this difference is considered likely to be a reflection of the different teaching approaches used. The student-managed approach used in Class C quite simply gave students considerably more independence than the teacher-directed approach used for Class D. For example, the opportunity for student talking was greater in Class C and would have been reflected in more positive student answers to the ICEQ questions on the (lack of) teacher control of talking.

Differentiation.

Differentiation is an expected feature of a student-centred teaching approach. In responding to differing student needs teachers negotiate different learning experiences, for example, by providing task variation. Within the student-managed environment of Class C the role of the teacher-researcher as a learning facilitator became more fully realised than was possible in the lock-step teacher-directed environment of Class D. Assessing the need for task differentiation, and providing appropriate response became a more manageable task, and consequently a more significant feature of, the student-managed classroom environment. However, such differentiation may pose a learning threat to individuals as the worrying perception of "missing out" on important work can readily arise. This perceived threat may explain why Class C in particular, noted their environment as providing too much differentiation between students.

Personalisation.

The student-managed strategy applying in Class C supplied greater opportunity for increased personalisation of the environment as well as the increased differentiation previously discussed. The teacher-researcher was working more frequently with students both individually and in groups in this situation than was the case in Class D. As a consequence, student and teacher inter-personal characteristics became revealed in a more significant way within the setting of Class C than could occur in the more formal environment of Class D. Students who prefer a degree of anonymity within the classroom environment may have perceived such increased personalisation as an unexpected threat, resulting in the perception arising in Class C of a slightly over personalised environment. In contrast, students in Class D would have preferred a more personalised environment.

Participation.

The student-managed environment of Class C offered, from the researcher's perspective at least, an increased opportunity for students to participate in making sense of the learning experiences. For example, by debating and testing alternative explanations within their groups. The consistency of percentage mismatch between Classes C and D may be interpreted as a failure for this potential to be fully utilised within Class C.

One possible explanation is that students in Class C, being themselves unfamiliar with their new learning roles, did not use the opportunity to participate in this way as fully as possible. Additionally, the practical demands on the teacher-researcher's time may have resulted in insufficient emphasis being placed on stimulating appropriate group discussion. It has been previously noted that rotational activities are particularly demanding during the first cycle of use with a class; the development of enriched learning experiences to stimulate across-the-board engagement is an on-going characteristic of such approaches.

It must also be noted that the ICEQ questions on participation focus particularly on participation in discussion – and it may simply be that the stimulation possible within a whole-class discussion is just as effective in promoting the wider participation of the student body as the smaller, informal discussions typical of the small-group strategy.

Investigation .

The student-managed strategy of Class C was perceived by the researcher to offer more freedom for investigative opportunity than the teacher-directed strategy of Class D. Nevertheless, students perceived the percentage mismatch similarly in each setting, with the relatively low level of percentage mismatch in each class suggesting that students are used to about this level of investigative opportunity. Some students in Class C appeared not use the potential available to them simply because they were still unfamiliar with their new learning roles, and lacked the confidence to respond.

SIGNPOST SIX

This chapter has examined the data arising from the ICEQ, an instrument previously discussed in Chapter Four. The current chapter has developed a percentage environmental mismatch index, and examined the mismatch occurring between the preferred and actual environment perceived by each class.

Comparisons using the raw index have allowed trends to be seen as the module was developed. The increasing mismatch in the dimension of Independence has been explained in terms of changes made to class seating arrangements, and the way in which these were reflected in answers to the ICEQ questions assessing this dimension. A covariate control has been applied to the data allowing comparisons to be made, and incidentally demonstrating the robustness of the mismatch index. The student-managed setting has been shown to provide considerably less mismatch in Independence than the teacher-directed setting, whilst over-differentiating considerably more between students. These and other features of difference have been explained from the perspective of the researcher.

Chapter Seven next examines the achievement data, while Chapter Eight focuses on the data arising from the SALTA observations, including the relationship between student achievement and level of engagement.

CHAPTER SEVEN

THE ACHIEVEMENT FINDINGS

Raw data from the three tests of individual achievement is analysed and a covariate control established. A measure of strategy advantage is developed, and class results compared on a year group basis. A measure of the cohort penalty faced by Year 9 students under both teaching strategies is developed and intra-class comparisons are made. Twin paradoxes emerge in comparing the achievement of students under each of the teaching strategies used. Group investigative achievement data is analysed and compared.

INDIVIDUAL ACHIEVEMENT

The three tests used to measure individual achievement were each remarked, and the resulting raw percentage marks collated on spreadsheets for analysis. This data is summarised in Appendix 16, with the symbols N/A used to represent student absence for a particular test. Analysis of achievement has been based on the overall mean test results, rather than the separate results of the three individual tests. This provides a more comprehensive measure of overall achievement, and reduces the impact of variation in test standard. In cases of absence for a particular test, the raw mean percentage mark for that student was calculated by averaging his or her remaining test results. Where inter-class comparisons are made, they are made on a year group basis, and the covariate control established by the first test has been applied. However, initial trends are first examined by graphically contrasting the raw data.

Figures 7.1a-b. illustrate the raw mean test results of Classes C and D on a year group basis, and also indicate the overall raw mean achievement for each year group.

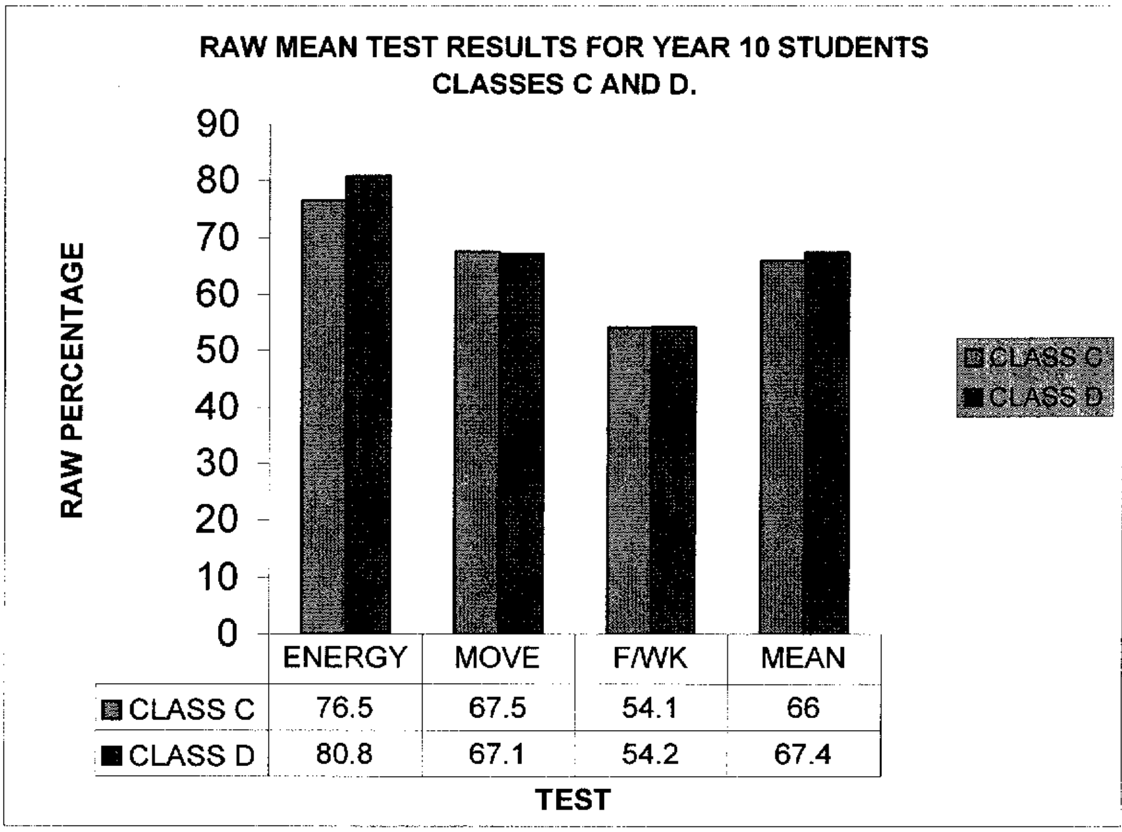


Figure 7.1a. Comparison of raw mean class achievement for Year 10 students.

Figure 7.1a. illustrates that although the Year 10 students of Class D performed better in the initial test, their subsequent performance was on a par with their Class C counterparts. The difference of 1.4 marks in the raw overall mean favours Class D, and represents an apparent disadvantage of 2.1% to Class C.

Figure 7.1b. (p102) illustrates that the Year 9 students of Class C initially achieved significantly better than their counterparts in Class D. This advantage was lost in the second test, but enhanced in the third. The 7 mark advantage to Class C in the overall raw mean represents an apparent advantage of 13.9%.

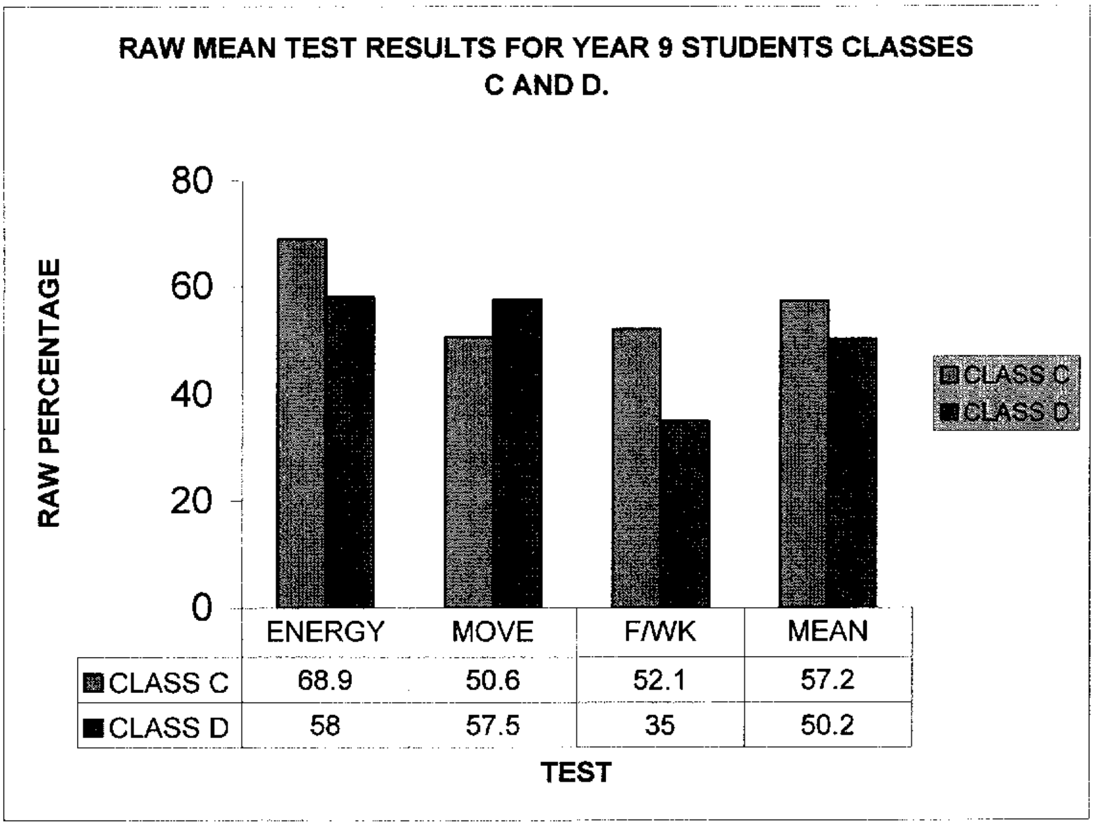


Figure 7.1b. Comparison of raw mean class achievement for Year 9 students.

Figures 7.1a-b. also illustrate that the mean test results for Year 9 and 10 students in both classes fell over the course of the module. This is hypothesised to be a reflection of both the increasing complexity of the work, and a variation in test standards. The first test involved concepts only, while the second additionally involved their more-searching mathematical application. The third additionally contained several questions involving the investigative concept of "fair testing", and proved somewhat problematic. This matter is discussed more fully in Chapter Nine.

Inter-Class Comparisons

The data represented by the two graphs comprising Figures 7.1a-b. does not, as it stands, form a suitable basis for comparing class achievement means in tests two and three since the effect of initial class differences has not been taken into consideration. To provide a measure of comparability, a covariate control was created based on the results of the initial test, Energy. This test took place immediately before the teaching strategies diverged, as previously discussed. The control took the form of a proportional scaling factor defined as shown overleaf, and applied to the results of

Class C.

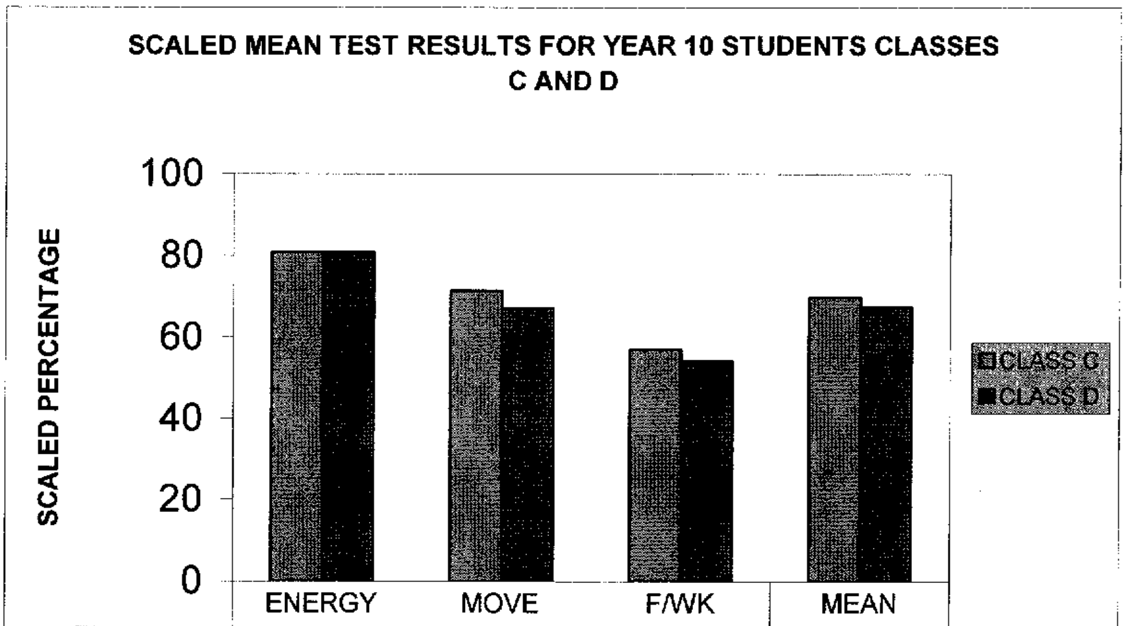
$$\text{Covariate scaling factor} = \frac{\text{Class } D_{mean}}{\text{Class } C_{mean}}$$

The results of Class D were used as the reference point since the subsequent teaching of this class most closely represented the normal teaching situation. Separate scaling factors were calculated for each year level as shown in Table 7.1.

	COVARIATE SCALING FACTOR	
YEAR LEVEL	RATIO	VALUE
10	80.8 : 76.5	1.056
9	58.0 : 68.9	0.8418

Table 7.1. The covariate scaling factors for each year level.

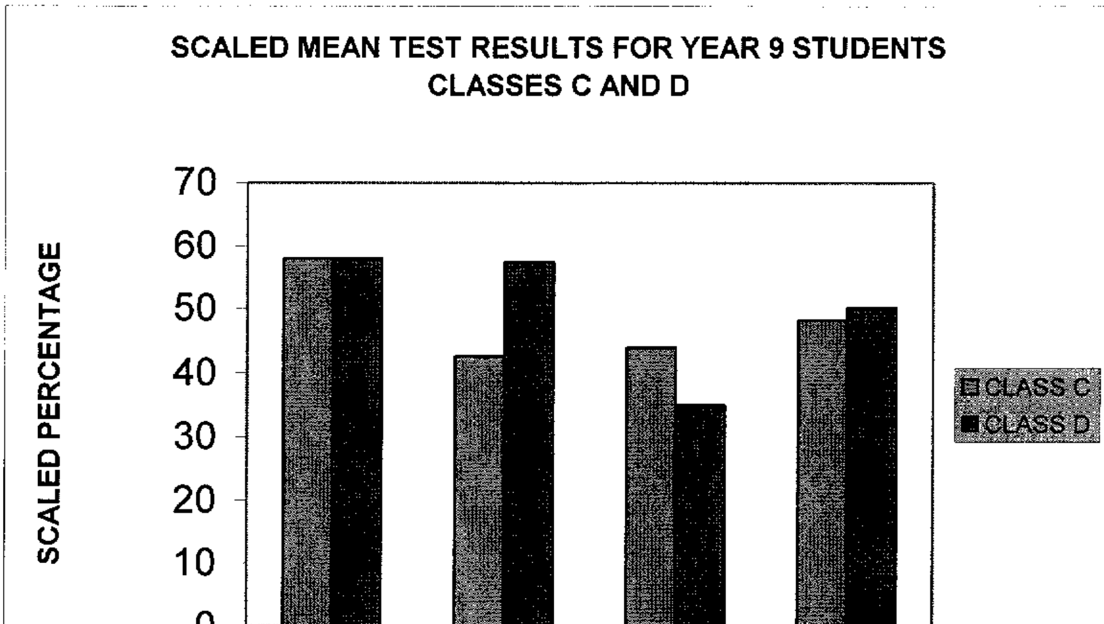
These scaling factors were applied to the results of the latter two tests to produce the Tables and graphs shown in Figures 7.2a-b.



	ENERGY	MOVE	F/WK	MEAN
CLASS C	80.8	71.3	57.1	69.7
CLASS D	80.8	67.1	54.2	67.4

Figure 7.2a. Comparison of scaled mean class achievement for Year 10 students.

The scaled data of Figure 7.2a. indicates a slight and consistent numeric advantage to the Year 10 students of Class C in both the tests which occurred after the divergence of class treatment. However, no clear trends are evident in the scaled data for Year 9 students presented in Figure 7.2b. Students in Class C achieved significantly lower than their Class D counterparts in the first test after divergence of treatment, and slightly better in the second.



	ENERGY	MOVE	F/WK	MEAN
CLASS C	58	42.6	43.9	48.2
CLASS D	58	57.5	35	50.2

TEST

Figure 7.2b. Comparison of scaled mean class achievement for Year 9 students.

Strategy Advantage

An additional measure was created to further compare the scaled data arising from application of the two different teaching strategies used. The new measure, termed the strategy advantage, was defined as:

$$\text{Strategy advantage} = \frac{(\text{Class } C_{mean} - \text{Class } D_{mean}) \times 100}{\text{Class } D_{mean}}$$

From the mathematical form of this measure it can be seen that it expresses the percentage by which the mean results for Class C exceed those of Class D, and that a negative result indicates that the reverse situation has occurred.

This measure was then applied to the scaled mean of the two tests following divergence of treatment for each year group separately. Table 7.2. shows the data used and the results of the calculation for the Year 10 students.

COMPARISON	CLASS C	CLASS D
Movement Test (%)	71.3	67.1
Forces/Work Test (%)	57.1	54.2
Mean of these two tests (%)	64.2	60.7
Actual advantage	3.5 marks	-
Strategy advantage	**+ 5.8%**	-

Table 7.2. Calculation of the strategy advantage to Year 10 students in Class C.

It can be seen that the Year 10 students of Class C achieved a strategy advantage of 5.8% when compared with their Class D counterparts following divergence of class treatment.

Table 7.3. displays the results of a similar analysis performed on the Year 9 results, and demonstrates a strategy disadvantage to the Year 9 students in Class C of 6.5%.

COMPARISON	CLASS C	CLASS D
Movement Test (%)	42.6	57.5
Forces/Work Test (%)	43.9	35.0
Mean of these two tests (%)	43.3	46.3
Actual advantage	-3.0	-
Strategy advantage	**- 6.5%**	-

Table 7.3. Calculation of the strategy advantage to Year 9 students in Class C.

The strategy advantage, or disadvantage, to Class C is strongly related to the year level of the students concerned, suggesting that age-related factors are significant in this situation. The greater maturity and more-fully developed learning skills of the Year 10 students, for example, may have enabled them to achieve a comparative learning advantage from the freedom offered by the strategy of student-management, while for their younger counterparts this freedom produced a comparative disadvantage. To investigate this hypothesis further, intra-class comparisons were made of the data on a year level basis.

Year 9 Cohort Penalty

The comparative level of achievement for each year group is best examined independently for each class using the raw mean percentage marks. Analysis shows that Year 10 students, considered as a group, always achieved at a higher level than their Year 9 classmates, regardless of teaching approach. This result, which was not unexpected, is illustrated in Figures 7.3a-b. (p107) and leads to the question as to which teaching strategy produces the smaller penalty to the Year 9 cohort of the class.

A measure of the achievement penalty faced by the Year 9 cohort of a composite class in relation to their Year 10 classmates was defined as:

$$\text{Year 9 cohort penalty} = -\frac{(\text{Year } 9_{mean} - \text{Year } 10_{mean}) \times 100}{\text{Year } 10_{mean}}$$

It can be seen that the penalty measures the percentage by which the mean test achievement of the Year 9 cohort lags behind that of the Year 10 cohort. In this study it is always a positive quantity, and the larger its value, the larger the disadvantage suffered by the Year 9 cohort.

This measure was applied to the appropriate raw test mean for each year group in each class as shown in Table 7.4. (p108), producing significant insight into the situation.

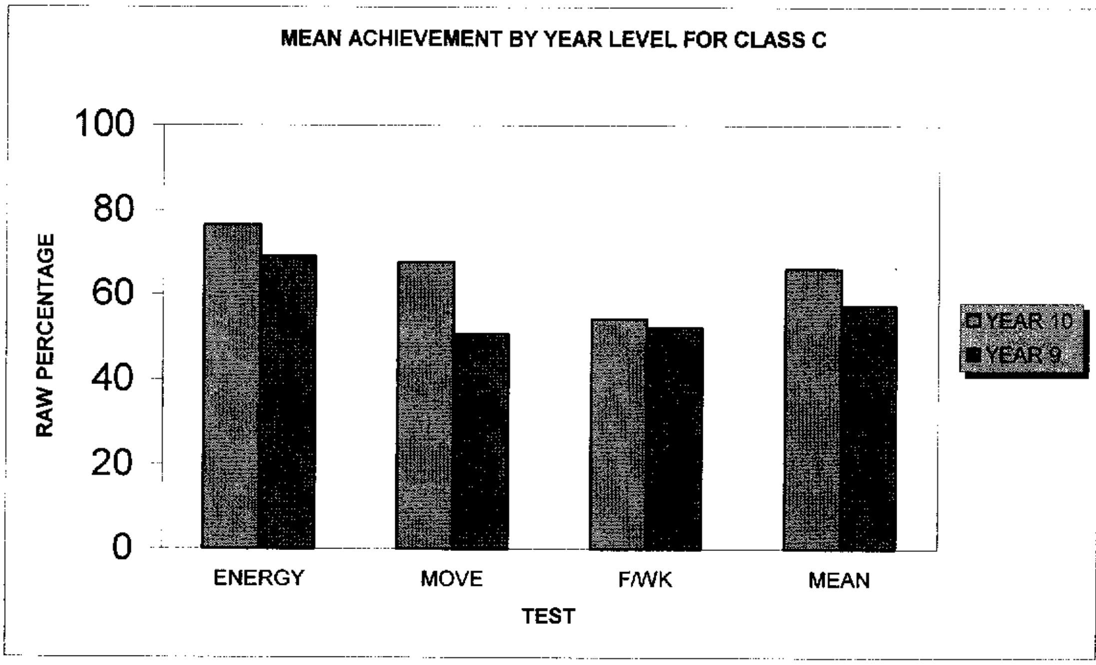


Figure 7.3a. Comparison of raw mean achievement by year level for Class C.

Figures 7.3a-b. indicate that, regardless of the teaching strategy used, the Year 10 students of the research classes always achieved higher mean test results than their Year 9 classmates. This advantage was more pronounced in the teacher-directed environment of Class D than in the student-managed environment of Class C.

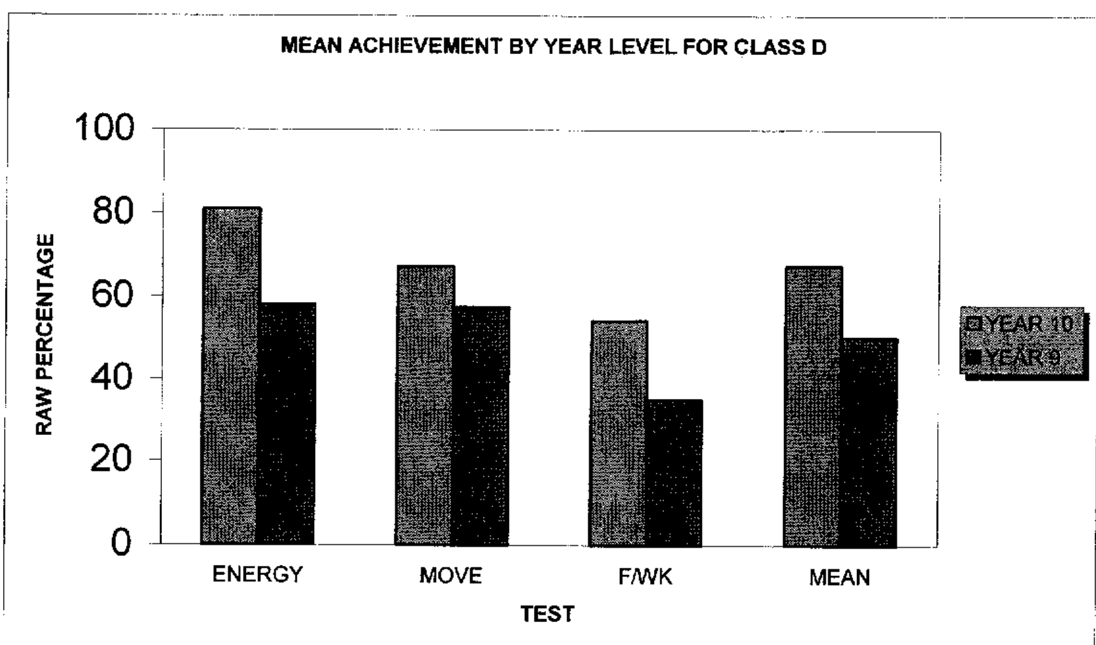


Figure 7.3b. Comparison of raw mean achievement by year level for Class D.

	CLASS C		CLASS D	
MEASURE	YEAR 10	YEAR 9	YEAR 10	YEAR 9
Movement test: raw mean %	67.5	50.6	67.1	57.5
Forces/Work test: raw mean %	54.1	52.1	54.2	35.0
Raw test mean %	60.8	51.4	60.7	46.3
Actual disadvantage	-	9.4	-	14.4
Year 9 cohort penalty	-	**15.5 %**	-	**23.7 %**

Table 7.4. Calculation and inter-class comparison of raw Year 9 cohort penalty.

Table 7.4. indicates that the Year 9 students taught under the teacher-directed strategy (Class D) had a substantially greater cohort penalty than Year 9 students taught under the student-managed strategy (Class C), when raw scores were compared. However, the situation is considerably different if the calculation is repeated using the covariate scaled scores previously discussed. Table 7.5. displays the results of this calculation.

	CLASS C		CLASS D	
MEASURE	YEAR 10	YEAR 9	YEAR 10	YEAR 9
Movement test: scaled mean %	71.3	42.6	67.1	57.5
Forces/Work test: scaled mean %	57.1	43.9	54.2	35.0
Scaled mean test %	64.2	43.3	60.7	46.3
Actual disadvantage		20.9		14.4
Year 9 cohort penalty		**32.6 %**		**23.7 %**

Table 7.5. Calculation and inter-class comparison of the Year 9 cohort penalty using scaled data.

It can be seen from Table 7.5. that the situation is reversed when scaled data is compared – the Year 9 cohort penalty is actually substantially greater in the student-managed setting of Class C than in the teacher-directed setting of Class D.

Both the raw and the scaled data are significant in understanding the comparative disadvantage to Year 9 students which can arise in the situation of composite classes. Comparison of raw data indicates the actual disadvantage potentially observed by students within each class setting, and is the characteristic which would influence student perceptions as to their comparative level of achievement. Thus Year 9 students within Class C are less likely to have perceived themselves at a learning disadvantage compared with their Year 10 classmates, than would have been the case in Class D. Attitudes formed as a result of such perceptions may potentially have an important influence on future progress, both of the individual, and of the cohort. The apparent potential of the student-managed teaching strategy to reduce the perceived Year 9 cohort penalty may be significant for this reason alone.

However, it is the scaled data which supplies the best basis for making inter-class comparisons. As Table 7.5. indicates, the evidence suggests that Year 9 students are at a greater disadvantage compared with their Year 10 classmates in the student-managed setting of Class C. This comparative disadvantage is approximately 38% more than that applying in the teacher-directed setting of Class D, and may result from the age-related factors previously discussed i.e. reflect the relative lack of self-management skills of Year 9 students. However, more subtle factors related to the different ratios of Year 10 to Year 9 students within each class may confuse this issue. The higher ratio of Year 10 to Year 9 students in Class D is hypothesised to have exerted a positive influence on the overall learning atmosphere (reasons for this are discussed in Chapter Nine), resulting in more effective peer-tutoring of Year 9 students by their Year 10 partners. For example, this higher ratio resulted in the formation of three groups containing two Year 10 students working with one Year 9 student, the exact reverse of the situation applying in Class C.

Twin Paradoxes

Several paradoxes have emerged in interpreting the data for individual achievement, and they appear inextricably interwoven into the composite nature of the classes.

1. The student-managed setting provided a demonstrable strategy advantage for Year 10 students, yet proved an equal disadvantage to the Year 9 cohort.
2. The student-managed setting produced a smaller perception of cohort penalty to the Year 9 students, yet its framework produced a larger one.

An explanation of these observations may be found by considering the learning opportunities encouraged by the student-managed environment. Such an environment provides extensive opportunity for individuals to develop essential self-management skills, including a sense of personal responsibility for learning. Qualities such as these, however, take significant time to develop. Year 9 students gradually learn to make effective learning choices as they work cooperatively with Year 10 classmates, who in general exhibit a greater awareness of the relationship between effort and progress.

GROUP ACHIEVEMENT

The extended group investigation was intended to provide students with an opportunity to use their initiative as they applied a range of skills to an investigation of their choice. Popular set investigations included variations on the height of a water rocket and the range of a projected duster. A novel investigation into the effect of clothing friction on swimming speed was also popular. Some projects involved students in considerable out-of-school organization e.g. bringing equipment to school, or conducting trials in their own time. Given the range of types of investigation performed, and the differing organisational and conceptual demands involved with each, the generic achievement-based criteria (Appendix One) were used to produce grades as a measure of group achievement. As previously discussed (p14), the learning intention of this investigative situation directed the assessment process. With high overall student interest in the extended investigation, and the supportive formative assessment associated with the approach, grades were expected to be high.

Class D was disadvantaged both by the shortening of the time available, and other end-of-year effects previously discussed. As far as possible, these disadvantages were compensated for by teacher judgment in grading the resulting work. Data for the extended group investigation is shown in Appendix 17.

After the group reports had been graded, the mean grades for each class were calculated. These grades, shown in Table 7.6. overleaf, indicate a slight (2.5%) advantage to Class C. However, it must be remembered that, with an average of three students in each group, the means are each based on only seven or eight reports. Additionally, since groups typically contained a mixture of Year 9 and 10 students, no analysis on a year level basis was possible.

	CLASS C	CLASS D
MEAN GRADE	4.1	4.0

Table 7.6. Comparison of class mean grades for the extended group investigation.

The mean class grades achieved for the group investigation appear to be virtually identical under either teaching strategy. This result came as a surprise to the researcher, as Class C students appeared to have shown a deeper understanding of their investigations on average, than Class D students. However, it is considered that the assessment process used was too broad to provide insight into such perceived differences, and no differences in group investigative skill are indicated by the class mean results.

SIGNPOST SEVEN

This chapter has examined individual and group achievement data. Inter-class comparison of the scaled individual achievement data has shown a small strategy advantage to the student-managed environment for Year 10 students, and an equivalent disadvantage to the Year 9 cohort. A Year 9 cohort penalty has been found to exist under both teaching strategies, with an irony in its application. The group investigative achievement data has, on a limited sample size, been found to show no advantage to either strategy.

Chapter Eight examines the SALTA data, providing an independent basis for further insight into student achievement.

CHAPTER EIGHT

THE SALTA FINDINGS

The nature and strength of the SALTA observations is briefly reviewed, and the treatment of missing data discussed. The range of student activity under each teaching strategy is analysed, and significant features interpreted. The difficulties of fair comparison are discussed, and an improvement suggested. The initial levels of student engagement are contrasted, and the percentage fall in levels compared. Covariate controls are applied and an inter-class comparison made. Gender-related differences of engagement level are analysed and interpreted. Teacher activity under each teaching strategy is compared. Two important relationships are explored: that between student activity and student level of engagement, and that between teacher activity and student level of engagement. Finally, the problematic relationship between level of student engagement and subsequent achievement is also explored.

INTRODUCTION

The SALTA observational procedure was a rich source of data. Its strength lay both in the unique perspective of the observers and in the quantity of data supplied. The approximately 1000 observations made in each category for each class, provided a strong basis for developing a representative and comprehensive view of the overall operation and impact of the module. For example, the mean value of student engagement later discussed, represents the mean of approximately 50 such observations made each and every period, and involving, over the duration of the module, all students.

For ease of analysis, the raw SALTA data was transposed to spreadsheets: Appendix 18 contains the data for Class C, while Appendix 19 contains that for Class D.

In examining these Appendices it will be noted that some data is absent. The reasons for this are outlined.

1. The absence of individual data during the first three periods of Class C observations is partly because the possibilities of what could be achieved were only just becoming evident to both researcher and observers, and partly the result of unavoidable observer absence.

2. The absence of all data towards the end of a period indicates that that particular period had been shortened, usually for administrative reasons beyond the control of the researcher.

3. The absence of student data within the bulk of a Table indicates that that particular student was unavailable for observation at that time e.g. being temporarily out of the room.

4. The absence of level of engagement data in Class D for the student labelled IS is because that student was an international student, and hence excluded from the comparison.

Initial analysis of the SALTA data is presented in three categories: student activity, student engagement, and teacher activity.

STUDENT ACTIVITY

Table 8.1. (p114) shows the nine categories of student activity, the number of observations made in each category, and the resulting percentage of time spent on each activity by the two classes over the duration of the module. Table 8.1. also gives an indication of the magnitude of the task carried out by the observers, with over 930 observations of student activity performed in each class. The percentages shown in Table 8.1. have been set in descending order using Class D as a reference point to enable comparisons to be made. Note that the Listening activity included listening to the teacher or to another class member. Activities recorded in the category labelled Other included, for example, the collection and return of equipment.

	OBSERVATIONS MADE		PERCENTAGE OF TIME	
ACTIVITY	**Class C**	**Class D**	**Class C**	**Class D**
Listening	138	237	14.8	24.9
Group Task	577	201	61.8	21.1
Practical	42	155	4.5	16.3
Writing	52	153	5.6	16.1
Reading	72	78	7.7	8.2
Class Discussion	0	45	0.0	4.7
Other	24	43	2.6	4.5
Video-related	27	30	2.9	3.1
Group Discussion	1	11	0.1	1.2
Total	933	953	**100.0**	**100.1**

Table 8.1. The number of observations made, and percentage of time spent on each set task by Classes C and D.

The data in the latter two columns of Table 8.1. has been used to produce Figure 8.1., which graphically contrasts the percentage of time spent on each activity in each class.

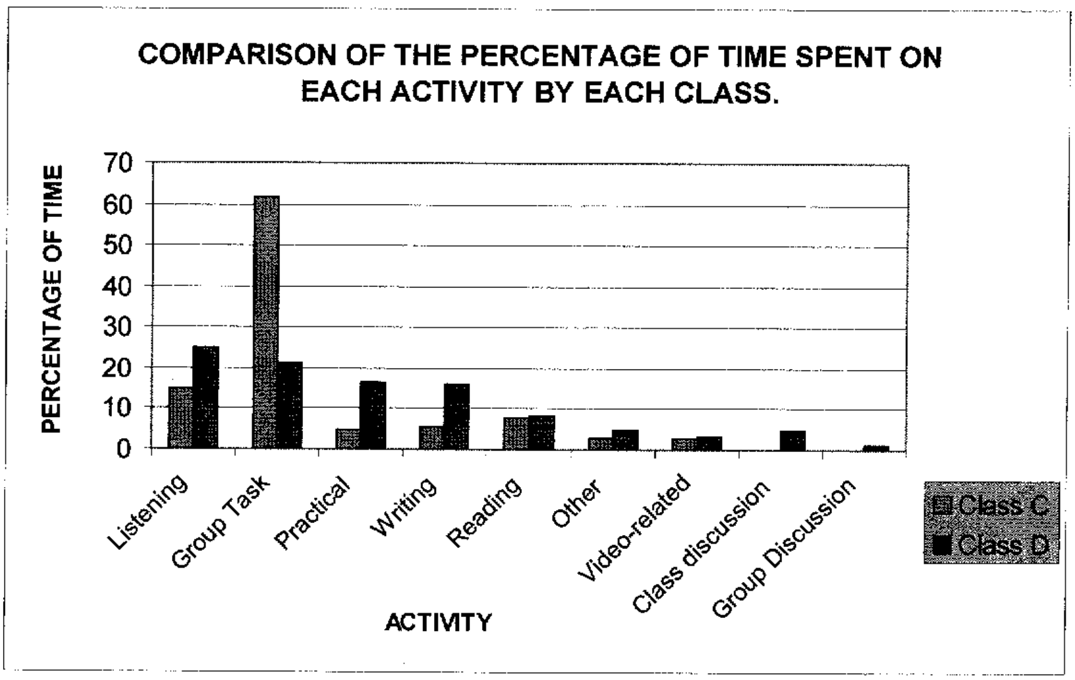


Figure 8.1. The contrasting percentages of class time spent on each activity by the two research classes.

From Table 8.1 and Figure 8.1. it can be seen that:

1. The main activity for Class D was Listening, closely followed by Group Tasks. In contrast, not only was the order of these two activities reversed for Class C, but the ratio was far different, with over four times as much time spent on Group Tasks as on Listening activities. Group tasks were a predominant activity for Class C, involving some 62% of class time.
2. The first four categories of activities together took up some 78% of the time for Class D, with a reasonably equal distribution of time to each activity. For Class C, some 77% of class time was spent on just the two main activities.
3. Class and group discussion were features of Class D, but were virtually non-existent in Class C.

It can also be seen that, compared with Class D, the student-managed strategy used for Class C appeared to involve students in considerably more group activities and significantly less listening, practical and writing tasks in particular. Although this data appears capable of further analysis, there are several factors which make a fair comparison difficult.

1. The missing data occurred during the initial common section of work, creating difficulties in establishing a baseline.
2. The Group Task (GT) category, while providing an essential indicator of the student-managed component of the module, subsumed several other categories. For example, many of the tasks coded as GT involved additional reading, writing and practical work, within the framework of student-managed groups.

Nevertheless, a number of features and trends are evident, and can be interpreted in general terms.

The student-managed strategy provided a major change to the delivery of the module by providing nearly three times the opportunity for students to manage their own study as was provided in the more usual setting of Class D. One consequence of this change of delivery was a significant reduction in listening activities as the role of the teacher altered. Another consequence was the demise of class discussion since whole class activities were not a feature of the student-managed strategy. The finding that group discussion was virtually non-existent in the student-managed classroom is considered misleading, as such discussion was a regular feature of group tasks. Such discussion, however, is recorded in the Group Task category, and effectively hidden. In retrospect, the Group Task category would have been better recorded independently by the researcher, leaving the observers free to record the specific activity occurring at that time.

STUDENT ENGAGEMENT

Figure 8.2. compares the mean level of student engagement with set activities for each class on a lesson-by-lesson basis throughout the module.

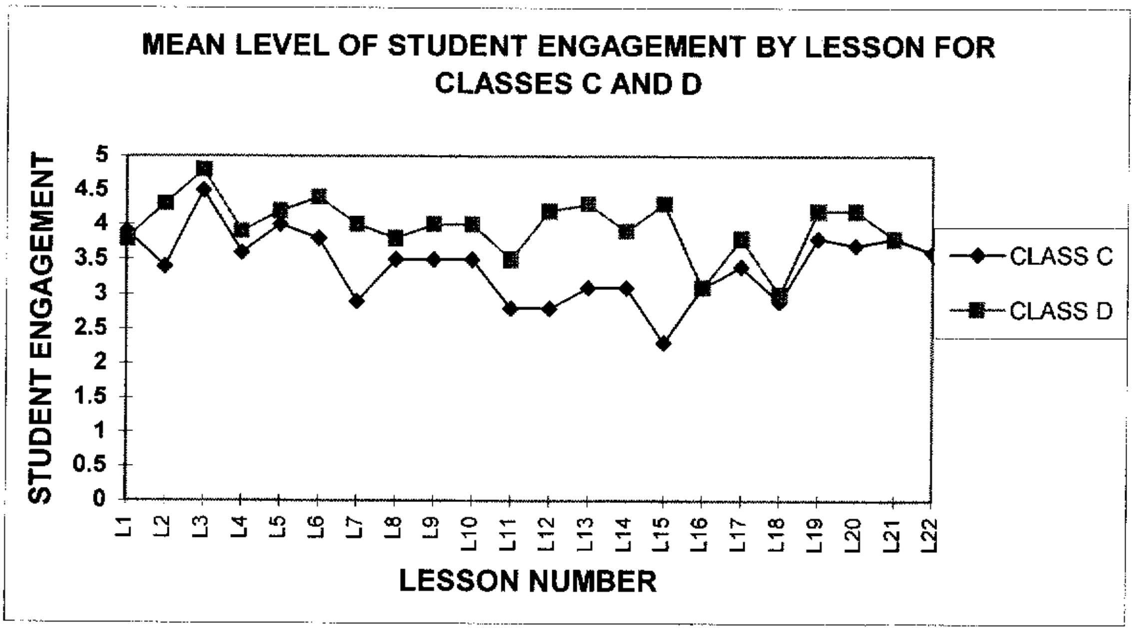


Figure 8.2. Comparison of levels of student engagement over the module.

Figure 8.2. clearly illustrates that this level is consistently higher for Class D than for Class C, as is reflected in the overall mean engagement levels shown in Table 8.2.

	CLASS C	CLASS D
MEAN ENGAGEMENT LEVEL	3.37	3.98

Table 8.2. Comparison of mean levels of class engagement over the entire module.

The difference of some 15% in favour of Class D appears significant and is investigated further by comparing the mean engagement levels for the first six periods (i.e. during the common initial teacher-directed section of work). This comparison, shown in Table 8.3., indicates an initial difference of only 9.9 % in favour of Class D, and suggests the need for further exploration.

	CLASS C	CLASS D
MEAN ENGAGEMENT LEVEL	3.83	4.25

Table 8.3. Comparison of mean levels of class engagement over the common initial teacher-directed section.

Comparison of Table 8.2. and Table 8.3. not only indicates that the mean level of class engagement over the whole module fell from its initial level for both classes, but also that this fall was greater overall for Class C (12%) than for Class D (6.4%). This difference was further analysed for each class on a separate year-group and gender basis. Table 8.4. shows the results of this analysis.

	RAW MEAN LEVEL OF ENGAGEMENT					
	CLASS C			CLASS D		
GROUPING	Initial	Overall	Fall (%)	Initial	Overall	Fall (%)
Year 10 Boys	4.06	3.57	**12.1**	4.46	4.15	**6.95**
Year 10 Girls	3.59	3.34	**6.96**	4.25	3.93	**7.53**
Year 9 Boys	4.15	3.56	**14.2**	4.22	4.05	**4.03**
Year 9 Girls	3.41	2.96	**13.2**	3.98	3.75	**5.78**

Table 8.4. Raw engagement level analysed by year-group and gender for each class.

Three key features emerging from Table 8.4. are the:

1. higher level of engagement of all four identified sub-groups in Class D compared with those in Class C, both initially and overall.
2. greater percentage fall in level of engagement for students in Class C compared with those in Class D for three of the four sub-groups identified.
3. consistently higher mean level of engagement of boys compared with girls of the same year level, both initially, and throughout the module, regardless of teaching strategy used. This finding is explored separately.

The first feature clearly identifies differences in the nature of the classes (later discussed) and suggests the need for a covariate control before the second feature is examined.

Inter-Class Comparisons

Comparison of levels of engagement during the common initial section was used to create individual covariate scaling factors for each of the four sub-groups identified in Class C, with the Class D data used as a reference point. These four scaling factors are shown in Table 8.5.

	COVARIATE SCALING FACTORS	
GROUPING	Ratio	Value
Year 10 Boys	4.46 : 4.06	1.0985
Year 10 Girls	4.25 : 3.59	1.1838
Year 9 Boys	4.22 : 4.15	1.0169
Year 9 Girls	3.98 : 3.41	1.1672

Table 8.5. Covariate scaling factors for engagement for each sub-group in Class C.

These scaling factors were then applied to the subsequent data to enable a fair comparison of engagement levels after the common section. Table 8.6. shows the results of this analysis, and in particular the scaled percentage fall in mean level of engagement for each of the identified sub-groups.

	MEAN LEVEL OF ENGAGEMENT					
	CLASS C (Scaled)			CLASS D (Raw)		
GROUPING	Initial	Subsequent	Fall (%)	Initial	Subsequent	Fall (%)
Year 10 Boys	4.46	3.73	**16.4**	4.46	4.03	**9.64**
Year 10 Girls	4.25	3.86	**9.18**	4.25	3.79	**10.8**
Year 9 Boys	4.22	3.49	**17.3**	4.22	3.98	**5.68**
Year 9 Girls	3.98	3.28	**17.6**	3.98	3.66	**8.04**

Table 8.6. Comparison of mean levels of engagement for each sub-group of each class after application of the covariate control.

The scaled data shown in Table 8.6. confirms that, for all sub-groups except Year 10 girls, the mean level of engagement after the initial section was substantially lower in Class C than in Class D. In other words, a considerably greater fall in engagement levels occurred for these sub-groups. Table 8.7. shows the full extent of this difference using the Class D values as a reference for the comparison.

	PERCENTAGE FALL IN ENGAGEMENT		
GROUPING	**CLASS C**	**CLASS D**	**COMPARATIVE**
Year 10 Boys	16.4	9.64	**+70**
Year 10 Girls	9.18	10.8	**-15**
Year 9 Boys	17.3	5.68	**+105**
Year 9 Girls	17.6	8.04	**+119**

Table 8.7. Actual and comparative falls in engagement for each sub-group.

In interpreting the data shown in Table 8.7. it must be remembered that the sub-groups themselves were necessarily small (typically consisting of five students), and hence the Figures must be treated with caution.

Interpretation

The student-managed teaching strategy used for Class C set those students a large responsibility for maintaining their own engagement with set tasks. The significantly lower level of engagement overall noted in Class C may therefore be interpreted as a comparative failure of the self-management strategy to achieve similar levels of engagement to those achieved within the teacher-directed strategy applying in Class D over the period of the module. The more pronounced overall fall in level noted in the Year 9 cohort of Class C is likely to be a reflection of self-management skills being less developed in this age group than in their Year 10 counterparts.

The significant difference in comparative fall in level existing between the Year 10 boys and girls in Class C suggests gender-related differences in self-management skills favouring girls, a hypothesis supported by anecdotal evidence within the school. However, the presence of such differences is not supported by the Year 9 data in which the difference is not only much less, but also favours boys. Gender and age-related differences are further explored next.

However, the perspective of the observers must first be considered, since the data produced reflects their interpretation of events, and the different class teaching strategies produced dramatically different operating environments in which to perceive and interpret such events. A student observed in the structured environment of Class D for example, may be perceived as more engaged in a set task than a counterpart working in the more dynamic and apparently chaotic environment of Class C because of an observer expectation. One specific type of situation exemplifying this dilemma was noted by the observers themselves. In Class C observed students occasionally left their set groups to confer with other students – and this behaviour was consistently categorised as off-task by the observers since the student was operating independently of the defined (group) task. Nevertheless, it was acknowledged that such discussion may well have been task-related. Although the potential of such instances to skew the data collection is acknowledged, it is the view of the researcher however, that the effect of any such bias on the overall collection of the SALTA data was minimal.

Gender-Related Issues

It has been previously noted that the mean level of engagement throughout the module was higher for boys than for girls of the same year level regardless of the teaching strategy used. This feature therefore appears to be a more general intra-class characteristic of the teaching-learning situation, and hence is analysed on a raw-data basis using the overall mean level of engagement. Table 8.8. (p121) shows in particular the percentage difference in overall mean engagement levels on a gender basis for each year group, using the data from the girls as the reference point. Table 8.8. also shows the percentage difference in engagement levels existing between Year 10 and Year 9 students of the same gender, using the Year 9 data as the reference point. These two measures may be described respectively as a gender gap and an age gap.

	MEAN LEVEL OF ENGAGEMENT & GENDER GAP					
	CLASS C			CLASS D		
GROUPING	Boys	Girls	**Gender Gap**	Boys	Girls	**Gender Gap**
Year 10	3.57	3.34	**6.9%**	4.15	3.93	**5.6%**
Year 9	3.56	2.96	**20%**	4.05	3.75	**8.0%**
Age Gap	**0.3 %**	**12.8 %**		**2.5 %**	**4.8 %**	

Table 8.8. Analysis of the percentage differences in raw mean level of engagement on a gender and year group basis.

Table 8.8. indicates two key features, namely that:

1. the gender gap consistently favours boys and is of a similar size for all sub-groups except for the Year 9 students in Class C, for whom it is much greater.
2. the age gap is larger for girls than for boys, and in particular, considerably larger for Class C girls than for any other sub-group.

The finding that boys in all sub-groups had a higher mean level of engagement overall with the activities of the module than girls in the same sub-group may suggest that the teaching-learning situation held a greater intrinsic appeal to boys. Such appeal could arise from the module theme (introductory mechanics) and consequential learning activities. The additional finding that there is a smaller age gap for boys than girls could suggest a combined experiential-attitudinal effect: boys may have had more experience of situations involving mechanics as a result of prior learning beyond the classroom, and developed a more authentic learning interest as a result. An alternative explanation is that being taught by a male teacher had a positive effect on the engagement of boys, lifting it above an assumed level equal to that of the girls.

The age and gender gaps together combine to identify the Year 9 girls as an anomalous group, with a significantly lower mean engagement level than would be anticipated. This finding confirmed a perception previously formed independently by both observers and researcher.

TEACHER ACTIVITY

The observations of teacher activity, also recorded on a minute-by-minute basis for each class, were analysed using spreadsheets to produce the summary shown in Table 8.9. In particular, Table 8.9. shows the percentage of time spent by the teacher-researcher on each type of activity in each class, ranked in terms of the Class D values to form a reference for the simple comparison shown.

	TEACHER TIME (%)		DIFFERENCE
ACTIVITY	CLASS C	CLASS D	CLASS D-CLASS C
Ranging	27.8	29.2	**-1.4**
Management	12.3	16.6	**-4.3**
Talk/Chalk	3.0	12.3	**-9.6**
Gear Organisation	5.9	7.5	**-1.6**
Other	8.4	7.5	**+0.9**
Class Discussion	3.4	7.0	**-3.6**
Writing	1.5	6.5	**-5.0**
Lecturing	4.6	4.1	**+0.5**
Practical Demonstration	0.9	3.9	**-3.0**
Video	2.7	2.9	**-0.2**
Group Discussion	26.8	2.1	**+24.7**
Individual Discussion	1.0	0.3	**+0.7**
Practical Help	1.7	0.1	**+1.6**
Totals (%)	100	100	**0.0**

Table 8.9. Teacher time contrasted under each teaching strategy.

Several features emerge from the analysis shown in Table 8.9.:

1. a considerably greater percentage of teacher time was spent in group discussion in Class C than in Class D.
2. significant reductions of teacher time in Class C occurred in the areas of talk/chalk, management, writing, class discussion and class demonstration compared with that spent in Class D.

These features are displayed in Figure 8.3. (p123) which highlights the major contribution of group discussion to the teacher's activity under the student-managed strategy applying in Class C.

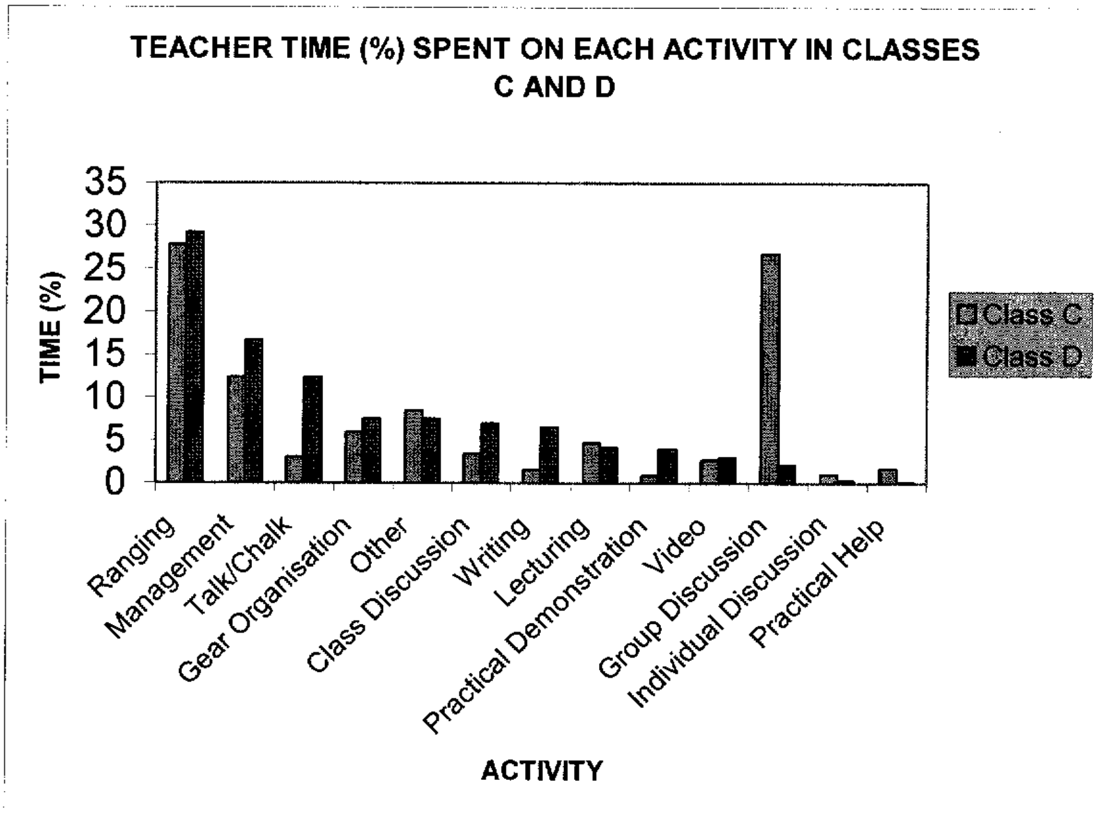


Figure 8.3. The use of teacher time under the contrasting teaching strategies.

The different weightings of the roles of the teacher appear as natural outcomes of the different teaching strategies adopted. In particular, the strategy of student-managed rotated group learning activities adopted for Class C specifically created the situation in which students often worked from pre-written task sheets. With different groups working on different tasks at any given time, whole-class activities were reduced to a minimum – with the teacher time saved re-appearing largely in an increase in teacher/group discussions.

RELATIONSHIPS BETWEEN ENGAGEMENT AND ACTIVITY

Student Activity And Level Of Engagement

The mean level of student engagement for each student activity for the whole module was extracted from the SALTA spreadsheets for each class, and placed in descending order using the Class D results as a reference point. Table 8.10. (p124) shows the results of this ranking. Note that no level of engagement is shown for the activity labelled Class Discussion in Class C since this activity was not a feature of the programme. Similarly, no level is recorded for Group Discussion in Class C since the number of observations was too limited.

	MEAN LEVEL OF ENGAGEMENT	
ACTIVITY	**CLASS C**	**CLASS D**
Video-related	4.48	4.66
Writing	4.04	4.35
Class Discussion	-	4.20
Reading	3.82	4.13
Practical Work	3.74	3.96
Listening	3.62	3.85
Group Task	3.14	3.84
Group Discussion	-	3.27
Other	2.13	3.23

Table 8.10. Inter-class comparison of level of engagement with student activity.

The two key features to emerge from the analysis shown in Table 8.10. are that:

1. the mean level of engagement for Class D for every activity recorded was higher than that for Class C.
2. the ranked order of engagement with class activities was identical for each class in all cases where comparison was possible.

These features are illustrated in Figure 8.4. (p125). The higher level of engagement of Class D in every category of student activity was not unexpected given the earlier finding of its consistently higher level of overall engagement. The difference in level reflects both class characteristics and response to teaching approach. However, the finding that the ranked order of engagement with activity was identical for each class is particularly interesting because it suggests more universal characteristics of these teenage learners. The highest-ranked activity involved two video-related tasks. The first video-related task involved watching short sections of a topical video presented by a host known to be well-received by teenagers, and then in pairs answering questions from a specifically written worksheet. Not only was there an intrinsic interest in the video, but the task itself was strongly focused and relatively short. The second video held more intrinsic appeal, but had no associated worksheet. The high level of engagement for these activities came as no surprise to the researcher.

By contrast, the group tasks had virtually the lowest levels of engagement. These tasks involved significant student responsibility and commitment to a task of long duration. As such, they provided a sustained opportunity for the development of co-operative and self-management skills. In this sense they provided more internal demands on the student than was the case with short, focused activities such as the video-related tasks. Nevertheless, for Class D, the level of engagement with the self-managed group tasks was a surprising 82% of that achieved by the teacher-directed video-related tasks, while for Class C, the corresponding value was just over 70%. The level of engagement may also relate to the novelty of an activity, and the greater fall-off noted in Class C may be a reflection of the greater percentage of time spent on group tasks.

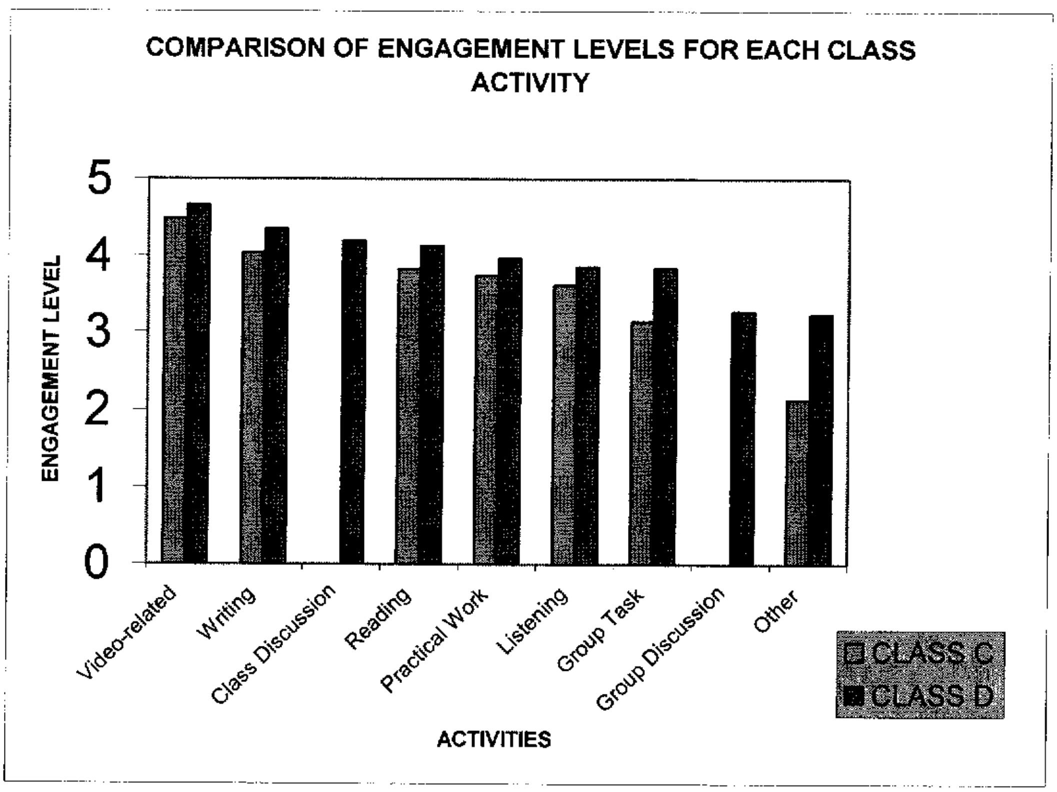


Figure 8.4. The contrasting levels of engagement with class activities for each class.

Teacher Activity And Level Of Student Engagement

The SALTA spreadsheet data for the complete module was analysed to establish the mean level of student engagement occurring in each class for each of the chosen categories of teacher activity. The activities were then ranked in descending level of engagement using the Class D results as a reference point. Table 8.11. displays the results of this analysis, and also indicates the percentage difference between classes. When the activity occurred on a very limited basis (i.e. it was observed less than ten times), no mean level of engagement has been shown.

For clarity, behaviours characteristic of some teacher activities are briefly described. Ranging refers to teacher activities occurring away from the front of the room and of brief duration (i.e. lasting less than one minute). Ranging activities include brief discussion, general assistance to students, and observation of practical activities. Management refers to whole class procedural instruction, for example, giving instructions for a test. Lecturing refers to whole class subject instruction without the use of audio-visual aids, in contrast to the Talk/Chalk category.

	MEAN LEVEL OF ENGAGEMENT		PERCENTAGE DIFFERENCE
ACTIVITY	CLASS C	CLASS D	
Video-related	4.48	4.78	**-6.3**
Class Discussion	4.15	4.22	**-1.7**
Other	3.67	4.17	**-12.0**
Ranging	3.38	4.03	**-16.1**
Writing	3.17	3.98	**-20.4**
Lecturing	4.02	3.97	**+1.3**
Talk/Chalk	3.82	3.94	**-3.0**
Management	3.01	3.84	**-21.6**
Practical Demonstration	4.00	3.83	**+4.4**
Gear Organisation	3.32	3.69	**-10.0**
Individual Discussion	2.80	-	-
Group Discussion	3.06	3.61	**-15.2**
Practical Help	3.5	-	-

Table 8.11. Inter-class comparison of actual level of engagement with teacher activity, and the corresponding percentage differences.

It can be seen from Table 8.11. that:

1. Class C had a lower mean level of engagement than Class D for all teacher activities except Lecturing and Practical Demonstrations, which were slightly higher in percentage terms.
2. the largest percentage differences existing occurred in the three categories of Management, Writing and Ranging respectively, and favoured Class D.
3. the ranked order of engagement with activity varied somewhat between the classes.

The data overall reinforces the view that Class C are less skilled learners than Class D. Their significantly lower level of engagement with the procedures in the Management category, which operated similarly for each class, is an example of this skill difference. Another difference, of similar size and importance, exists in engagement with teacher-directed writing tasks.

However, it is significant that some teacher activities effectively reduced or reversed the gap e.g. the higher level of engagement of Class C in Practical Demonstrations. This may merely be a reflection of the novelty of the situations (which occurred less in the setting of Class C), or, more significantly it may be an indicator of the appeal of such strategies to students with less learning skill. The higher level of engagement of Class C with Lecturing may be similarly interpreted, as may the relatively small gaps in the Talk/Chalk and Class Discussion categories. It is significant to the researcher that such teacher-directed activities appeared to close the gap even more than the highly appealing Video-related activity. Overall, the results suggest that in the student-managed environment, students sensed a greater personal learning advantage in engaging with teacher-directed learning activities than they did in creating their own learning opportunities.

THE RELATIONSHIP BETWEEN ENGAGEMENT AND ACHIEVEMENT

The mean level of engagement over the duration of the module was calculated for each student individually and paired with his or her corresponding achievement. The resulting set of data for each class was plotted on the two scatter diagrams comprising Figures 8.5a-b.

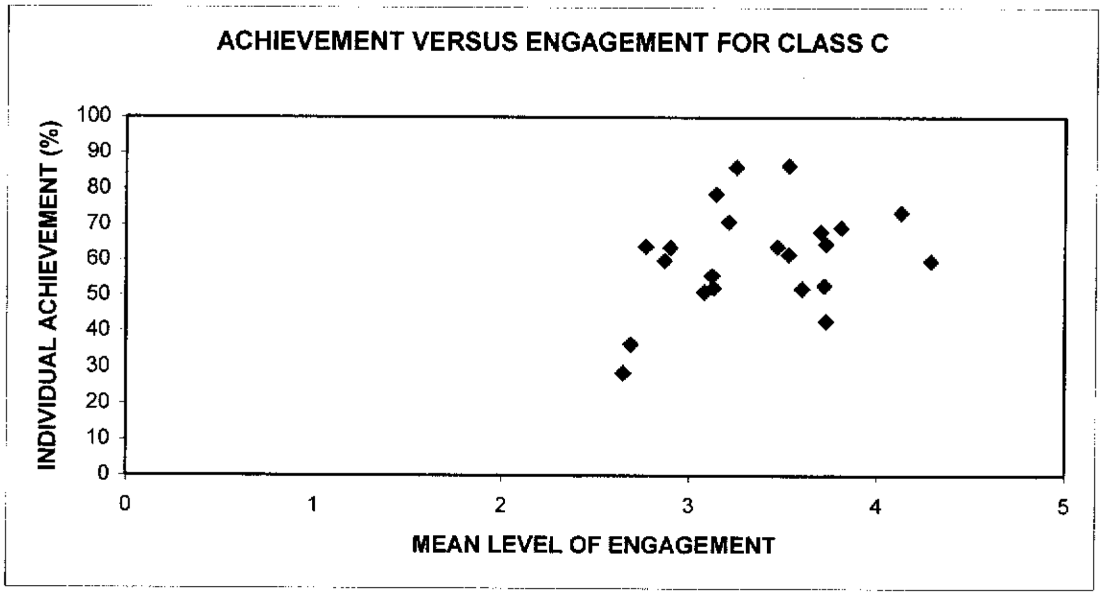


Figure 8.5a. Scatter diagram of achievement and level of engagement for Class C.

Although these scatter diagrams differ significantly, it can be seen that there was a greater correlation between engagement and achievement in Class C than in Class D.

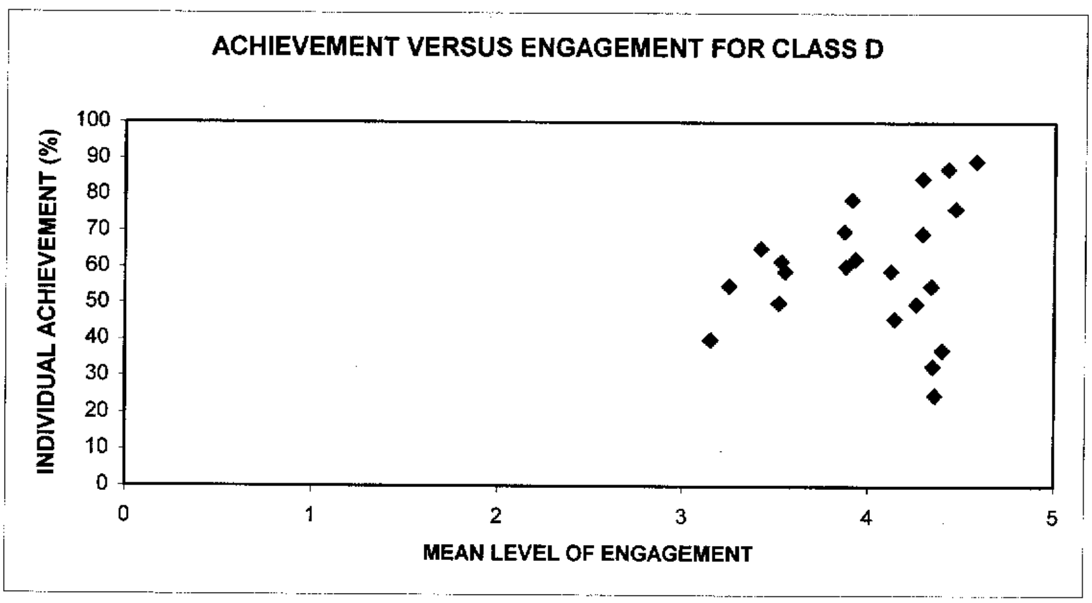


Figure 8.5b. Scatter diagram of achievement and level of engagement for Class D.

It can be seen from Figure 8.5a. that although there is a wide scatter of data points there is some indication of a correlation between increased level of engagement and increased achievement. The highest achievement, however, came from three students with only an average level of engagement. Figure 8.5b. indicates that an even wider scatter of data occurred with Class D, and there is less evidence of correlation. In particular, there was a large range of achievement from those students whose level of engagement was over four.

The equation of the regression line and coefficient of correlation established for each set of data are shown in Table 8.12.

CLASS	REGRESSION EQUATION	CORRELATION
Class C	$y = 10.1x + 27$	0.10
Class D	$y = 7.2x + 31$	0.03

Table 8.12. Analysis of the scatter diagram data.

Table 8.12. confirms that the correlation between engagement and achievement was weak for both classes, and in addition indicates that:

1. the correlation was over three times higher for Class C than for Class D.
2. the gradient was significantly greater for Class C than for Class D.
3. the y-intercepts were close in value.

Interpretation

Even a strong correlation is not evidence of a causal link between variables, and conversely the existence of a weak correlation does not provide evidence that no such causal link exists. In the researcher's experience it is always assumed within teaching practice that students must be engaged with class learning activities in order to make progress. The underlying question is, how can such engagement be assessed?

The y-intercept values indicate the predicted achievement of hypothetical students who had no engagement with the classroom activities, and can therefore be used to indicate the prior knowledge of each class. The similarity of y-intercepts for both classes suggests similar prior knowledge, a point which is explored independently in Chapter Nine. The higher value of the gradient for Class C indicates that an increase in level of engagement in this class is associated with a greater increase in achievement than occurs in Class D. Combined with the significantly increased correlation, this finding suggests that students in the self-managed environment had a greater awareness than those in the teacher-directed environment, that personal achievement was related to personal level of engagement.

However, the low correlations in both classes provide some challenge to the tacit assumption that engagement as perceived by a teacher-observer is related to achievement, and this is particularly evident in the statistics for the traditional teacher-directed environment. Such environments not only provide less opportunity for the apparent level of engagement to fall, but also provide less opportunity for students to relate the effect of personal commitment to subsequent personal achievement.

This situation also indicates a major difficulty in measuring engagement. The perspective of the observers in this research was based on an interpretation of observed student behaviour as has been previously described. Any relation between observable behaviour and within-the-mind engagement of an individual student with the learning intent of activities is of course hidden from a non-interacting observer. Human interaction appears necessary to provide insight into the learner's engagement with the ultimate intent of learning activities – to assist in the emerging understanding of another human being.

Gender Issues

The mean values of engagement and achievement for each class over the entire module were compared on a gender basis as shown in Table 8.13. overleaf.

	CLASS C		CLASS D	
SUB-GROUP	Engagement	Achievement	Engagement	Achievement
Boys	3.57	61.5	4.14	60.4
Girls	3.08	60.1	3.84	58.8

Table 8.13. Engagement and corresponding achievement compared by gender.

It can be seen that, for both classes, the substantially higher level of engagement of boys was associated with only a minor advantage in their comparative achievement. One possible interpretation relates to the comparison being made. The higher overall level of engagement of boys may be simply a reflection of their higher engagement with specific types of activity, for example, practical investigations. Since such activity was not directly assessed in the individual achievement tests, the results of any increased learning would not necessarily be revealed. A supplementary interpretation relates to the weak correlation between level of engagement and achievement previously noted. It may be that the level of engagement as perceived by an independent observer is simply not a reliable indicator of the development of student knowledge and understanding.

SIGNPOST EIGHT

This chapter has examined the SALTA data, commencing with student activity. The percentage of classroom time spent on each student activity in the teacher-directed class has been found to be much more evenly spread, compared to that in the student-managed class, which had a very heavy weighting towards group tasks. Student engagement overall was higher in absolute terms in the teacher-directed class. Falls in engagement level for most sub-groups have been greater in the student-managed class. Within this class, Year 9 students showed a greater fall than Year 10 students. A gender gap favouring boys has been identified, as has an age gap favouring Year 10 students. There is some evidence to suggest that Year 10 girls have better self-management skills than Year 10 boys.

Teacher activity data has indicated the different roles of the teacher in each classroom setting. The reduced time spent in whole-class activities in the student-managed class resulted in increased time spent interacting with groups.

Student activity has been related to level of student engagement. The ranked order of engagement was identical for each class, although the actual levels were always higher for the teacher-directed class. Teacher activity has been related to level of student engagement. The use of teacher-directed activities in the student-managed class was found to be most effective at reducing the gap between the two classes.

A weak correlation was found between level of engagement and achievement, with a possible inference that students in the student-managed environment were more conscious that their progress was related to increased personal engagement. The higher engagement of boys was reflected in marginally increased achievement.

Chapter Nine next discusses issues of validity, and the implications of the findings established in chapters six, seven and eight. Finally, Chapter Ten presents a summary of these findings.

CHAPTER NINE

EVALUATION

The control of variables and the validity of the instrumentation are each discussed to produce an overall evaluation of the research. The prior learning experiences of the classes are compared via an index of common learning. The effects of class composition and other student, teacher and administrative factors are considered. Findings from the ICEQ data, the achievement data and the SALTA data are each considered separately. The appropriateness and strengths of each instrument, and the procedures used to compare data are discussed.

CONTROL OF VARIABLES

The research described took place in a naturalistic situation involving the teaching of scheduled, composite classes. A number of practical as well as theoretical factors had to be considered, and prior effort made wherever possible to control dependent variables arising in the comparative phase. In cases where this was not possible, an awareness of their presence and possible effects was developed. The range of variables, their potential effects, and method of control are discussed supplementing previous discussion.

Prior Learning Experiences

The possibility of different prior learning experiences existing for the two classes was a significant threat to internal validity, and hence establishing the degree of commonality of such formal prior learning was necessary. Most (78%) of the students had joined the school as Year 7 entrants; the remainder had joined at a variety of times, including several in the year of the research. Once at school, all students had undertaken the same modular science course, although taught by different teachers. The 22% of students who joined after Year 7 would have completed only part of this course at this school, but may have encountered many similar learning experiences at their previous schools. Several students had initially joined as Year 7 entrants, later left, and then returned; these are included in the 22% shown above. In each class there were four students who were in their first year at the school. To investigate the magnitude of such differences in formal learning experience between the classes an index of common learning was developed.

Index of common learning.

An index representing years of common learning was established for each class by calculating the weighted average of the number of years each student would have completed in this school at the end of the research year (1998). The mathematical form of this index is:

$$\text{Index of common learning} = \frac{(N_1 \times M_1 + N_2 \times M_2)}{(N_1 + N_2)}$$

where N_1 and N_2 stand for the number of Year 9 and Year 10 students respectively, and M_1 and M_2 stand for the mean number of years of secondary schooling at this school for those Year 9 and Year 10 students respectively. The mean for each sub-group was established by reference to school records. It can be seen in Table 9.1. that, in spite of differences in the way it has occurred, both classes have an identical index of common learning. The effect of individual student absence over these years has not been considered, but is assumed to be similar in both classes.

YEAR LEVEL	MEASURE	CLASS C	CLASS D
10	Number of students	10	13
	Mean time (years) at this school	3.9	3.3
9	Number of students	12	10
	Mean time (years) at this school	2.1	2.4
	Index of common learning	**2.9 yrs**	**2.9 yrs**

Table 9.1. Establishing the index of common learning for the research classes.

Table 9.1. also indicates significant differences in the common learning experiences of the different cohorts of each class. The Year 10 students of Class C had more extensive common learning experience than their counterparts in Class D, while the opposite was the case for the Year 9 students. Within the classroom, responding to such differences is of major importance to learning and the broad-brush measure of the index provides no more than a general indication of comparability of experience.

The background of common learning extends further than just learning in science: it covers all core subjects. One possible threat to this common background arose in mathematics, since classes had been streamed during Years 7/8, and taught to different levels as considered appropriate. However, since Classes C and D were constituted on a mixed-ability basis from students with this range of mathematical backgrounds, it is highly likely that each contained a similar student profile of mathematical skills. Nevertheless, care was taken with each class to ensure that the mathematical aspects of the module were developed carefully from a basic level.

Informal learning.

Quite apart from the strong common background of formal learning between the classes, the content of the module itself was essentially independent of other science modules studied during the year. Each of these factors strengthens the case for attempting valid comparisons. However, students bring more to the classroom than just their prior formal learning, as has been discussed previously. The possibility of significantly different external learning experiences existing between the two classes has been considered and discounted by the researcher. Any effect on learning due to cultural differences in class composition has similarly been considered and discounted. However, there is a possibility of gender-bias in the content of the module favouring male students. The male-female ratio in the classes was very similar (being 1.4 for Class C and 1.3 for Class D), effectively controlling effects of this possible variable.

An unavoidable maturation effect in favour of Class D occurred, Class D having been taught the module immediately after Class C completed it. This maturation effect, which represents six weeks of formal learning in subjects other than science, is considered minor, and masked by end-of-year effects later discussed.

Class Composition Effects

Although the method of creating composite classes ensured an approximately equal range and profile of student academic abilities in all Year 9/10 classes, it was by no means an exact measure. For this reason, various covariate controls were included in the comparative phase in order to establish measures of initial inter-class differences.

The formal learning experiences of the Year 10 students were more extensive than those of Year 9 students in all essential learning areas. Hence, a year-group, rather than a whole-class basis, was used for forming comparisons of individual achievement. Group investigative work, however, was compared on a whole-class basis, since both year groups were, and normally would be, represented in such groups.

Class composition differed in the ratio of Year 10 to Year 9 students present in each class e.g. in Class C this ratio was 0.9, and in Class D it was 1.2. A greater weighting towards Year 10 students in a class can be expected to confer overall learning advantages to the whole class in several ways.

1. The more extensive background knowledge of Year 10 students, particularly in related science modules (as well as mathematics), enables them to provide significant peer assistance to Year 9 students.
2. The greater (average) level of maturity of Year 10 students is likely to exert a positive influence on the overall learning atmosphere of the class.

The first effect of differing year-group ratios initially suggests a comparative learning advantage to the Year 9 students only of Class D; however since such peer assistance is likely to help both individuals involved, such learning advantages are likely to benefit the whole class. Similarly, the second effect is likely to be reflected in learning advantages to the whole class.

The need to consider social factors in creating composite classes may lead, as previously discussed, to classes of significantly different tone. The observers noted a strong difference in tone between the research classes, one later describing them 'as different as chalk from cheese', and commenting that there was a much better social relationship between the students of Class D than there was in Class C. The effect of such a variable in response to different treatment (i.e. teaching approach) cannot be readily measured nor controlled. An equally inaccessible and uncontrollable variable resulting from differences in class tone would be created by random allocation of students to teaching approach. Such differences appear to be an uncontrolled variable implicit in this mode of research.

Student Considerations

Most classes contained an international student for whom English was a second language. This represented a significant learning disadvantage in some cases, particularly when the student was also new to the school. To control such variation, the comparison was restricted to local students. One student in Class D had special learning needs, and was always accompanied and assisted by a teacher aide; this student was necessarily excluded from the comparison. However, neither the presence of the student nor the teacher aide was considered to have exerted measurable influence on the study.

Teacher

Issues relating to the reality of the teacher-researcher presenting identical teaching and learning experiences to both classes must be addressed. Although this was a prerequisite for establishing a fair initial comparison between the classes, it was of course impossible to achieve in practice. The major factors clouding this situation are discussed.

The interactive approach.

In the introductory teacher-directed section common to the two classes a wide range of learning activities was used. These activities, which had been developed and refined over the action-research phase, were intended to focus student interest on specific areas of the module content, and engage them in thinking about key concepts. The activities included many interactive components such as brainstorming, class and group discussion, resolution of discrepant events and hands-on practicals. Such teaching is an inherently interactive process and neither are teachers automatons, nor students, clones. In one class a discussion may develop in a different way than in another. Thus, although the objectives were covered in essentially the same way, to the same depth, in the same time-frame, and using the same learning activities, no more than this can be claimed.

Familiarity with activities.

The many effects of increasing teacher-familiarity with the module are another complex variable. For example, when teaching Class D the teacher-researcher was naturally more familiar with:

- the structure and timing of the intended learning activities of the module.
- likely areas of student difficulties, and their likely solution.

Although these effects were probably small, they may have resulted in a slightly different presentation to Class D. Similarly, any increases in the personal effectiveness of the teacher-researcher over the research period (e.g. improvements in personal knowledge, clarity of purpose, commitment to teaching, commitment to the research) would favour Class D. However, due to the small time-span involved, such effects are likely to be small. Any possible 'uplift' effect on the teaching of the researcher arising from the realisation that Class D was the last research class was probably countered by a similar 'down-swing' of student perceptions as the year drew to a close. Increased familiarity with the contents of the test may also have exerted an unconscious and hence unpredictable effect on the teaching of the researcher, whereas potential bias arising from conscious knowledge of this was at least guarded against.

End-Of-Year Effects

The comparative phase was initially timetabled to occur in semesters four and five; however subsequent timetable constraints resulted in it being rescheduled to semesters five and six. For the semester six class (Class D), the end of the module corresponded with the end of the school year, a time at which traditionally classes expect some relaxation from their normal programmes. Although this was not possible, nevertheless some students definitely showed reduced commitment during the last few periods. There were also some difficulties at this time caused by student absence.

Timetabling

The timetabling arrangements previously discussed provided significant control of the research design. In particular, they ensured:

1. random allocation of classes to either the preliminary or comparative phase.
2. minimal time for time-related learning effects to cloud the comparative phase.
3. zero prior class contact during 1998 between researcher and all research classes.
4. equal class contact time and similar laboratory conditions for all research classes.

Additionally, the two contrasting class settings to be used in the comparative phase had been previously randomly allocated to the classes involved in this phase: student-managed rotated group activities to Class C, and lock-step teacher-directed activities to Class D. This overall randomisation of classes-to-treatment provided strong control.

Although true randomisation of students-to-classes was not considered (both on ethical and practical grounds), the intent of such randomisation in terms of academic variables, was largely met by the method of creating composite classes together with the application of covariate controls. Furthermore, any artificially-imposed short-term randomisation would remove the study from its naturalistic setting introducing additional issues of external validity.

Covariate Controls

Covariate controls were used to establish a fair basis for making comparisons between the research classes or their sub-groups. These controls were applied at the end of the initial section of work immediately before the teaching strategies diverged, and hence ensured students had encountered learning experiences and classroom environments which were as similar as it was possible to provide.

Other Issues

Fair comparison of teaching methods is difficult to achieve. In the practical terms of this research the comparisons were limited to measurable quantities occurring and developing within the time frame of the module itself: namely, the range of classroom activities, the level of student engagement, and the assessment of student knowledge. On this restricted basis, it is argued that it is valid to attempt a comparison and, as far as was possible, conditions were set up to enable this to be done fairly. The input of a variety of perspectives reduced possible bias of the research paradigm, and minimised potential weakness arising from the inexperience of the researcher. Nevertheless, one key element of a scientifically defensible comparison could not be met within the structure of this research, namely, multiplicity of trials across classes. In this regard, the research may best be considered a pilot scheme within its local context. Promising results have been indicated in the reform what was considered the most difficult of modules in which to attempt such reform. Trends across the two classes are on an even stronger footing since the database represents fifty percent of the two year groups involved.

VALIDITY OF INSTRUMENTATION

Classroom Environment

Student perceptions of preferred and actual classroom environment were taken for each class using the short-form of the ICEQ (Fraser, 1990). The questionnaire for assessing the preferred environment was administered to each class at the end of the initial, teacher-directed section of the module. Not only were the learning experiences identical, but also, as far as was possible, the style of delivery. Average differences in preferred classroom environment are therefore most probably a true reflection of differences in class composition. Such differences need to be considered in interpreting the results for the subsequent measure of actual classroom environment. The questionnaire for assessing actual classroom environment was administered to each class at the end of the module, following 15 or 16 hours of quite different classroom settings. If the proviso mentioned above is taken into account, any differences arising are most probably a true reflection of the difference in classroom settings.

The purpose of the questionnaire as forming part of the research was fully discussed with the students, and the administrative procedures recommended by Fraser (1990) were followed. Students gave careful attention to completing them, and the writer considers that the collected data represents a genuine reflection of student perceptions within the limitations of the questionnaire. This particular questionnaire has been validated in thousands of classrooms across international boundaries.

Individual Achievement Data

Individual achievement was measured by the mean performance of each student in the three written tests whose development has been previously described in Chapter Four. The test questions were written by a range of professional science educators and specifically targeted the intended learning objectives. A wide range of types of response was included overall. From the teaching perspective of the researcher, the instrument overall was a valid indicator of differences in individual learning. However, in order to make inter-class comparisons of mean achievement the covariate control described in Chapter Seven had to be applied to the results of the initial test only. The robustness of the findings is therefore directly affected by any weaknesses in the validity of this test. Although the wording of one particular question did cause problems in interpretation, its effect is not considered particularly significant overall.

Both classes sat corresponding tests at the appropriate times in the module and under identical administrative procedures. Tests were marked, and later re-marked together, using annotated model answers and a mark schedule. Minor discrepancies were found and corrected during this process.

Group Achievement Data

The learning intentions of group investigations described in Chapter One indicate the broad nature of the assessment used. Chapter Seven indicates the additional practical difficulties in making fair comparisons in this particular investigation. As a result of this situation, no inferences have been made of learning differences existing between the two classes.

SALTA Observations

The features and operation of the SALTA procedure have been described in Chapter Four, with analysis and interpretation of the resulting data given in Chapter Eight. The strengths of the instrument as an independent data-gathering tool are self-evident, and include both the procedures for random selection of subject, and the long-term duration of the observations. However, since the instrument itself was specifically developed by the researcher for this research, its validity was unknown. While observations of student activity (SA) and teacher activity (TA) appear relatively easy to classify into the specified categories, some practical difficulties in doing so have been previously described. The few anomalies of classification which did occur were resolved by the teamwork of two thoughtful and committed observers, together with occasional input from the researcher. Against the backdrop of around 1000 observations, any unresolved anomalies would have little effect statistically. Within these two low-inference categories, the procedures produced data which appeared self-consistent, reliable and useful from the researcher's perspective. However, the situation is less clear-cut in regard to the observations of level of student engagement (L).

Assessing the level of student engagement with a learning activity involves more than classifying observed behaviour. It also carries a value-laden interpretation of behaviour, and in this regard the SALTA procedures inevitably have an associated inference component. The validity of this aspect of the instrument is therefore considered in terms the relationships found between level of engagement and two other parameters – student activity and individual achievement. The first of these parameters is an aspect of the same instrument and has already been found to yield self-consistent data, while the second is an independent measure.

Two clear points of consistency emerge from data the relating student activity to level of student engagement, namely that the ranking of engagement with activity:

1. agrees with what would have been expected from the teaching perspective

2. is identical for each class.

This consistency offers strong support to the measure. In contrast, the weak relationship between level of engagement and the external measure of individual achievement, previously discussed in Chapter Eight, neither offers nor detracts support.

SIGNPOST NINE

This chapter has evaluated the research in terms of the control of variables and the validity of the instrumentation used. An index of common learning has shown that the classes overall had identical prior formal learning experiences, although there were significant differences when year groups were compared. Efforts were made to control other student-related and teacher-related variables. Academic differences in class composition were effectively controlled. Other effects of class composition, including class tone, were considered as implicit and uncontrolled variables. Comparison of teaching methods within stated restrictions has been considered as valid research. The inability to replicate such trials however, was considered a major limitation.

The independent ICEQ data was considered an appropriate and valid measure of classroom environment. The tests, also containing independent input, were similarly considered an appropriate and valid measure of individual achievement. Analysis of the independent SALTA observations has shown it to produce self-consistent data in line with what a teaching perspective suggests as plausible. This strength has been found to apply to both the classification of classroom activities and the higher-inference assessment of student levels of engagement.

Chapter Ten next summarises the research findings.

CHAPTER TEN

CONCLUSIONS

This chapter presents a summary in descriptive terms of the main findings of the research. Comparisons are made of classroom environmental variables and individual achievement under the student-managed and teacher-directed strategies used. Comparisons are made between classroom activities under each strategy, and the level of student engagement with each activity. The relationship between level of engagement and achievement in each setting is compared. Gender differences in level of engagement and achievement are compared. A personal perspective is given on two local issues, and a conclusion concerning the nature of the balance between teaching strategies is reached.

CLASSROOM ENVIRONMENT

The ICEQ data allowed comparison between student perceptions of the preferred and actual classroom environment in each classroom setting. Students perceived the student-managed environment as being slightly over-personalised, and as differentiating far too much between students. In contrast, they perceived the teacher-directed environment as being slightly under-personalised, and providing slightly more differentiation than preferred. Both classes would have preferred the environment to offer more opportunities for participation. Both classes perceived the environment as offering considerably less independence than preferred, and this was found to relate to the nature of the seating arrangements applied.

Compared with the teacher-directed teaching strategy, the student-managed strategy provided:

1. a more personalised environment
2. identical opportunities for student participation
3. considerably more independence
4. slightly more investigative opportunity
5. considerably more differentiation between students

STUDENT ACHIEVEMENT

Individual Achievement

Controlled pre-testing before the teaching strategies diverged allowed comparison of subsequent test achievement under each strategy during the timeframe of the module. Since the classes were composite, comparisons were made on a year group basis. A small achievement advantage was demonstrated for the Year 10 cohort of the student-managed class, and an equal disadvantage demonstrated for the Year 9 cohort. Intra-class comparisons demonstrated that regardless of teaching strategy used the Year 10 cohort achieved better than their Year 9 counterparts. The disadvantage to the Year 9 cohort was greater within the teacher-directed classroom when raw scores are compared, although the reverse was the case using scaled data. This suggests that each teaching strategy may produce the opposite perception of relative progress in its Year 9 cohort than is actually the case, and holds implications for the development of positive attitudes to future learning.

Group Achievement

The group task involved an extended investigation and was inherently student-managed. It was assessed using broad generic criteria. No advantage was demonstrated to either teaching strategy.

THE SALTA RELATIONSHIPS

Analysis of the SALTA data enabled comparisons of the frequency of classroom activities and level of student engagement to be made. The student-managed class managed about 60% of their own learning, compared with the teacher-directed class which managed about 20%. The Group Task category subsumed other categories making comparisons difficult. The role of whole-class activities was significantly diminished in the student-managed setting with the teacher time saved largely re-appearing in teacher/group discussion. The level of student engagement with activities was assessed throughout the module and found to fall somewhat from its initial value for both classes. Covariate control allowed inter-class comparisons to be made. These showed that the level of engagement fell by twice as much overall in the student-managed setting as in the teacher-directed setting, with the comparative fall being greater among the Year 9 cohort. The level of engagement of boys was found to be significantly higher than that of girls in both year groups of each class.

The ranking of level of engagement with class activity was identical for both classes, with structured video-related tasks rating highest. Focused writing and reading tasks ranked higher than self-managed tasks such as group discussion. The level of engagement with each teacher activity was consistently lower for the student-managed class than for the teacher-directed class. The teacher activities which were found to be most effective in reducing this difference were those involving the whole-class. For example, practical demonstrations, lecturing and whole class discussion were all more effective in closing the inter-class gap than the more-highly ranked video-related tasks.

The relationship between student level of engagement and individual achievement was examined for both classroom settings. The correlation was found to be weak in both cases, although three times higher for the student-managed strategy than for the teacher-directed strategy. There was also a greater increase in achievement associated with a given increase in level of engagement in the student-managed setting compared with the teacher-directed setting. On an intra-class basis, the substantially greater level of engagement of boys overall, was associated with only a minor advantage in achievement compared with girls.

LOCAL IMPLICATIONS

The finding that a cohort penalty applies to Year 9 students under either teaching strategy has academic implications as well as attitudinal ones previously discussed. The philosophical basis assumed by a modular teaching system is the independence of the learning contained within modules. The validity of this basis is eroded when one group of the class has significantly greater prior learning experience than another. In the case of this module, examples of relevant prior learning in mathematics and science have been identified as favouring the Year 10 cohort. Unless such learning gaps are specifically addressed within the context of subsequent modules, the cohort penalty applying to Year 9 students seems likely to be reflected in their subsequent underachievement. Until this issue is resolved, it appears that the combination of composite classes and modular teaching creates the potential for systematic underachievement in at least some aspects of the science course.

Given that there is often a perception that boys underachieve relative to girls, it is significant that differences in achievement and also in level of engagement favoured boys under both teaching strategies. Boys appear to have worked significantly harder than girls, while achieving only modest academic advantages. While the interpretation of this finding is open to question, it certainly does not support any perception of the relative underachievement of boys.

CONCLUSION: FINDING THE BALANCE

The two teaching strategies contrasted in this research each contained aspects of the other when considered over the entire timeframe of the *Energy* module. For example, both strategies started with a teacher-directed section of work, and both ended with a student-managed investigation. The major difference was the ratio in which the contrasting strategies were applied in each environment. Students managed 60% of their overall learning in one environment, and only 20% in the other. No learning advantage in terms of individual or group achievement was demonstrated to favour either extreme when scaled, mean class data was compared. Within these limits it appears that the ratio of student-managed and teacher-directed learning activities is not in itself a significant factor in improving learning when short-term effects alone are considered.

However, when long-term effects are considered, the impact of developing attitudes to learning and the acquisition of generic learning skills become highly significant for future achievement. In this regard, a student-managed environment provides additional advantages. The increased student/teacher discussion observed to take place in a student-managed environment indicates the potential for diagnostic and responsive teaching possible when the role of learning facilitator becomes a significant teacher referent. Major long-term benefits of such interactions include the development of individual and group confidence in the processes of learning, and positive reconsideration of attitudes to learning by some students. Similarly, by reducing mismatch between actual and preferred levels of student independence the structure of this environment provides greater opportunity for such students to maintain positive attitudes. Additionally, it provides the teacher with greater opportunity to turn around negative ones. By providing such avenues for personal and intellectual growth a student-managed learning environment can therefore be considered more effective in fostering meaningful learning than a teacher-directed one.

Further potential for improving learning was noted within each research setting as the teaching strategies intermingled on a micro-scale. The effectiveness of the conceptually-focused learning activities in developing understanding emerged clearly in either setting. The constructivist view of content-matter as context for focused student interaction provides a touchstone for the development of such resources in other science modules. Achieving such interaction requires effective group learning skills. Cooperative learning, with its emphasis on positive interdependence and individual accountability, develops these essential skills and provides strategies for creating successful group involvement. Enhanced learning in science therefore appears possible across a range of teaching environments and modules through the development of specific resources and activities using the strengths of these generic models.

Learning is a dynamic process, and the location of the balance between teacher-directed and student-managed activities can likewise be expected to be always dynamic. The emergence of personal ownership of learning is the hallmark of a true student, and shifting the balance to foster the growth of such independence is perhaps, the key challenge within teaching at this level. It is a challenge which must be approached sensitively as teachers recognise and respond to the needs of the individual. While the balance between teacher-directed and student-managed learning may not be critical, the direction in which it is moving for each individual certainly is. Learning partnerships develop as the strategies intermingle and the distinction between formal roles becomes blurred. In such partnership-centred learning the balance is found.

SIGNPOST TEN

This chapter has summarised the main findings of the research. The classroom environmental data established that the student-managed environment provided students with considerably more independence and task differentiation. The achievement data demonstrated no consistent short-term learning advantage to either teaching strategy in either individual or group achievement. A cohort penalty applied to the Year 9 cohort under either strategy. The SALTA data showed that students managed 60% of their learning in the student-managed environment, and only 20% in the other. The ranking of level of engagement with student activity was identical under either strategy.

The correlation between level of engagement and individual achievement, although weak, was three times greater in the student-managed environment than in the teacher-directed. The relationship between these variables was also considerably stronger in the student-managed environment. The achievement of boys was only slightly higher than girls although their level of engagement was considerably higher.

Two local implications of the findings were considered. The features of composite classes and modular teaching were together considered to create the potential for systematic underachievement of the Year 9 cohort in some aspects of science. Any perception of the relative underachievement of boys was not supported.

The effects of the contrasting teaching strategies were considered in terms of both short-term and long-term learning, with a student-managed environment considered more effective in promoting meaningful learning. Potential for improving learning was noted in both teaching environments through the development of conceptually-focused resources and cooperative group learning strategies. The balance was considered dynamic and always directed to the achievement of partnership-centred learning.

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APPENDIX ONE: ASSESSMENT CRITERIA FOR SCIENCE

ASSESSMENT IN SCIENCE

Learning in Science has been divided into six aspects, three of which are normally assessed each semester.
The six aspects and the criteria for each grade follow. They show that the student:

CONTENT KNOWLEDGE
(What you have shown you know about the topic in tests and assignments)
1. Attempts to recall and use ideas.
2. Recalls and uses a limited range of ideas.
3. Recalls and uses a wide range of ideas.
4. Applies a wide range of ideas to produce explanations.
5. Applies a wide range of ideas to produce correct and detailed explanations

PLANNING AN INVESTIGATION
(Identifying possible solutions to problems and designing fair tests)
1. Presents some ideas.
2. Presents a plan.
3. Presents a plan which is capable of being investigated.
4. Presents a plan which could lead to a sound investigation.
5. Presents a plan which would lead to a valid conclusion.

GATHERING EXPERIMENTAL INFORMATION
(Your practical and recording skills)
1. Needs considerable assistance to use equipment and/or record data.
2. Uses equipment with some assistance and records some data.
3. Uses equipment correctly,with limited assistance and records a suitable range of data.
4. Uses equipment correctly, with minimal assistance, and accurately collects a suitable range of data.
5. Uses equipment effectively to systematically and accurately collect and record a wide range of data.

PROCESSING AND INTERPRETING
(Finding patterns in results, and using them to answer questions)
1. Attempts to process and interpret information.
2. Processes and interprets some information.
3. Processes and interprets information.
4. Interprets and partly explains information.
5. Interprets and fully explains information.

RESEARCHING AND/OR REPORTING
(Reporting results of practical investigations, written research etc)
1. Researches and/or reports some information.
2. Researches and/or reports some relevant information.
3. Researches and/or reports a range of relevant information.
4. Researches and/or reports a range of relevant information in own style.
5. Researches and/or reports all relevant information carefully and originally.

CARRYING OUT AN INVESTIGATION
(Demonstrating all four skills above in a complete investigation)
1. Carries out some activities in an investigation.
2. Carries out most activities in an investigation.
3. Completes an investigation.
4. Completes an investigation skillfully.
5. Completes an investigation skillfully and thoroughly.

APPENDIX TWO: LEARNING OUTCOMES FOR THE *ENERGY* MODULE

On successfully completing this module the student should be able to:

ENERGY TRANSFORMATIONS (6 periods)

With reference to the energy classifications: potential (gravitational, chemical, elastic), kinetic, electrical, light, nuclear, magnetic, heat; and to frictional forces:
1. Recall and distinguish between the energy types.
2. Carry out physical energy conversion experiments, and identify the energy changes and system losses.
3. Define work and energy, and measure these for a variety of situations.
4. Interpret situations and solve problems involving energy transformations/losses with given formulae.

MOVEMENT (5 periods)

1. Classify motion into constant speed, acceleration or deceleration, and recall their units.
2. Recall the speed triangle, and use it to solve problems involving simple calculations with a variety of units.
3. Plot and interpret distance/time and speed/time graphs.
4. Interpret the motion of a toy car/trolley by producing and analysing a ticker tape of its movement

FORCE AND WORK (7 periods)

1. Use spring balances to measure forces, and establish earth's gravitational field strength as approximately 10N/kg.
2. Investigate hypotheses concerning the origin of the gravitational force.
3. Recall 3 effects of forces, and explain static and dynamic equilibrium in terms of balanced forces.
4. Measure the amount of work done in a variety of situations, and relate the work done to energy changes.

INVESTIGATING (4 periods)

Plan, carry out fair tests, analyse results and report findings into an investigation of any one of:
1. The effect of parachute area on the landing speed of a parachute.
2. The effect of different levels of friction on the speed a radio-controlled car.
3. The effect of changing the shape of a boat hull on its speed.
4. The nose cone shape needed to produce maximum height from a water rocket.
5. The distance a duster will travel when propelled with different tensions of elastic.
6. The range of a paper pellet when flicked at different angles.
7. Another negotiated project.

APPENDIX THREE: SALTA OBSERVATION PROFORMA

CLASS:	TEACHER:	TOPIC:	DATE:	PERIOD:	OBSERVER 1:
					OBSERVER 2:

	TIME SLOT 1			TIME SLOT 2			TIME SLOT 3			TIME SLOT 4			TIME SLOT 5		
NAME	S. A	LEVEL	T.A	S. A	LEVEL	T.A	S. A	LEVEL	T.A	S. A	LEVEL	T.A	S. A	LEVEL	T.A
AV															

APPENDIX FOUR: SALTA OBSERVER NOTATION

STUDENT ACTIVITY		LEVEL OF INVOLVEMENT IN MINUTE			TEACHER ACTIVITY	
LISTENING	L	DESCRIPTION	TIME (S)	LEVEL	MANAGEMENT	M
READING	R	FULLY	51 -60	5	LECTURING	L
WRITING	W	VERY	41 -50	4	WRITING	W
CLASS DISCUSSION	CD	GENERALLY	21 -40	3	TALK/CHALK	T/C
GROUP DISCUSSION	GD	SOME	11 -20	2	CLASS DISCUSSION	CD
GROUP TASK	GT	LIMITED	0 - 10	1	GROUP DISCUSSION	GD
PRAC WORK	PW				INDIV DISCUSSION	ID
VIDEO	V				PRAC DEMO	PD
OTHER	O				GEAR ORG	GO
					PRAC HELP	PH
					RANGING	R
					OTHER	O
					NOT RELEVANT	NR

APPENDIX FIVE: THE TEST USED FOR THE ENERGY TRANSFORMATIONS SECTION

LAKESIDE COLLEGE SCIENCE DEPARTMENT

LEVEL 5 ENERGY TEST

NAME:____________________

1. Match up the terms with definitions. Record the matching letter alongside the numbers.

1. energy	a) chocolate contains lots of this	1
2. nuclear energy	b) possessed by all moving objects	2
3. energy transformation	c) waves produced by vibrating objects	3
4. elastic energy	d) energy stored in the nucleus of an atom	4
5. radiant energy	e) causes particles of matter to move faster and more freely	5
6. sound energy	f) energy possessed by objects which are high up	6
7. kinetic energy	g) energy stored in squashed or stretched objects	7
8. heat energy	h) required to make things happen	8
9. gravitational energy	i) one way in which energy can travel	9
10. chemical energy	j) a change from one energy type to another	10

2. Indicate whether the following statements are true or false.

a) Energy is measured in units called James.

b) Energy is always required to make things happen or change.

c) Potential energy types include chemical, gravitational and elastic.

d) Potential energy can be transformed into types of active energy.

e) Gravitational potential energy depends not just on height, but also on mass and shape.

f) It is not possible to transform active forms of energy into stored types.

g) Light and sound waves from an explosion will reach an observer at the same time.

h) As you lift an object up it has kinetic energy and also gains gravitational potential energy.

i) When an object falls it loses gravitational energy and gains kinetic energy.

a
b
c
d
e
f
g
h
i

3. Identify and match the objects which carry out the energy transformations listed. Make the best match possible.

1) electrical energy to sound energy	a. torch	1
2) electrical energy to heat energy	b. stove element	2
3) electrical energy to light energy	c. battery charger	3
4) electrical energy to kinetic energy	d. blender	4
5) elastic energy to kinetic energy	e. spotlight	5
6) chemical energy to light energy	f. remote control	6
7) electrical energy to chemical energy	g. CD player	7
8) electrical energy to infra-red radiant energy	h. wind-up toy	8

4. State the main energy transformations occurring in <u>any four</u> of the following events.

eg dynamite exploding: from kinetic to solar. (This answer may be wrong!)

a) falling rain e) lightning flash b) thunder clap f) waterfall

c) dynamite exploding g) tree burning d) you are parachuting h) going up in a lift

5. Complete <u>any two</u> of the following stories.

a) When your car is moving it has ___ energy. This energy comes from the burning of petrol in the motor.

The petrol contains stored ___ ___ energy. This petrol was refined from oil.

The chemicals in oil were originally produced by microscopic plants which lived in the sea. These plants obtained their energy from ___ energy coming from the sun. The source of the sun's radiation is ___ energy.

b) When we have finished exercising in the gym, our bodies are hot because of the ___ energy transformed from the ____ energy associated with moving.

The energy to make our muscles move comes from the ___ ___ energy stored in food.

The energy in food originally came from plants (or animals which ate plants). The plants obtained their energy from ____ energy.

c) When you play a CD, ___ energy reaches your ears. This energy came from ____ energy which flowed to your house from a hydroelectric station.

The electricity was generated from ___ energy as water raced down the pipes from the top of the dam where it had lots of ___ ___ energy originally.

d) ______ is useful between car tyres and the road, because it produces a force for braking or _____. Friction between the air and the car is not wanted because it makes the car burn more ____. This can be partly overcome by making the car more ____ in shape. When braking, the car's kinetic energy is transformed int o ___ energy.

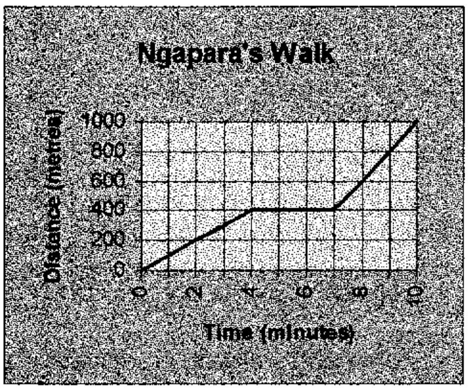
APPENDIX SIX: THE TEST USED FOR THE MOVEMENT SECTION

LAKESIDE COLLEGE SCIENCE DEPARTMENT

LEVEL 5 INTERPRETING MOVEMENT.

NAME____________________

1. While Ngapara was walking her Jack Russell terrier, she recorded the total distance they had travelled each minute. Later, she drew a graph as shown. Use the graph to answer the following questions. **Make sure your answers are complete, and have correct units.** Express speeds in metres per minute



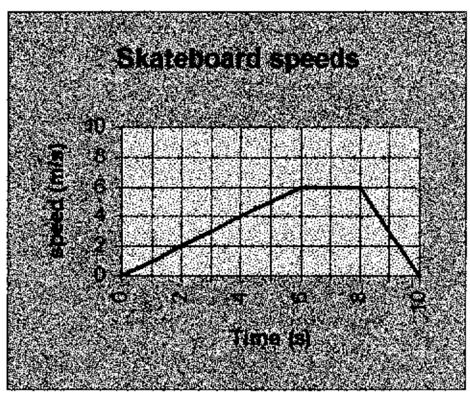
1. How far had she walked after two minutes? ________________
2. When did she stop, and how long for? ________________________
3. What was her speed during the first two minutes? __________________________
4. What was her speed during the last three minutes? __________________________
5. What was her average speed over the whole time? __________________________
6. Convert her average speed into $km.h^{-1}$ __________________________

$(m.\ min^{-1})$

12 marks

2. Sam is skateboarding down a slope, across flat, smooth concrete, and then up another slope. His movement was videoed, and then a graph drawn.

1. How fast is he going after 7 seconds? __________________________
2. What is his maximum speed, and how long does he keep it up for? __________________________
3. Fully describe his type of movement during the first 6 seconds.__________________________
4. How far does he go between 6 and 8 seconds? __________________________
5. What makes you think that the up-slope was steeper than the down-slope?__________________________
6. What indicates that the concrete was smooth? __________________________



12 marks

3. Complete the speed triangle. Then complete the Table below. **(8 marks)**

SYMBOL	UNIT	ABBREVIATION
d		
	metres per second	m s^{-1}

4. Solve these problems using your speed triangle to help you. Remember to include units!

a) I sprint 100 m in 12 s. Find my average speed. ____________________________

b) A snail moves 90 cm in 2 hours. What is its average speed? ___________________

c) Harry bikes to school at 4 m s^{-1}, taking 3 minutes to get here.

How many seconds in 3 minutes? _________ How far away was he from school?_________________

d) Renee travels 4km on her rollerblades at a speed of 16 km h^{-1}.

How long does this take (in minutes) ________________________ **(8 marks)**

5.

For the tape shown above answer True /False for each question below. **(5 marks)**

a) The speed is faster in Section A than in Section B _________

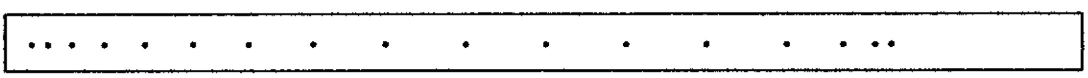
b) The trolley was slowing down in Section C __________

c) The speed was constant in Section A and Section C. __________

d) The trolley was probably going uphill in Section C __________

e) If a ticker timer makes 50 dots per second, each 5 dots represent a time of 0.2 s. __________

6.



The tape has recorded the movement of a toy car. Study it carefully and then complete the Table.

(6 marks)

SECTION	DESCRIBE MOTION	POSSIBLE REASON
A		
B		
C		

APPENDIX SEVEN: THE TEST USED FOR THE FORCES AND WORK SECTION

LAKESIDE COLLEGE SCIENCE DEPARTMENT

LEVEL 5 FORCES, and WORK.

NAME____________________ **Mark /35**

1. A tyre company measured the stopping distance of a Toyota car under icy, wet, and dry road conditions. The trials were carried out on a special test track . The speed of the car and all other important factors were kept the same for each trial.

(a) Which line in the Table most likely shows the data recorded by the tyre factory?
(1m)

	ICY ROAD	WET ROAD	DRY ROAD
A	30 m	40 m	50 m
B	100 m	70 m	40 m
C	30 m	70 m	40 m
D	100 m	40 m	50 m
E	100 m	100 m	100 m

(b) Explain your choice of answer above.____

____

____(2m)

(c) Which of these factors would <u>not</u> need to be kept the same each time? (1m)

A	B	C	D	E
The mass of the car and load	The air pressure in the tyres	The brand of petrol used	The condition of the tyres	The force used to put on the brakes

(d) When the car is being stopped, its kinetic energy is converted to __________ energy in the brake pads. This is because of the _____________ between the pads and the steel they push on. The more kinetic energy the car has the _______________ the brakes will become in a quick stop. (3m)

(e) The kinetic energy depends on two factors. What are they?

__________________________and ______________________________ (2m)

2. Following a visit to the local marae, the students in Mr. Hegan's class made their own poi. When they used their poi during a waiata (song), they noticed that the poi were all swinging at different speeds.

Hine thought that the length of the poi string was one thing that affected the swing. Her group decided to plan a "fair test" to see if she was correct.

a) What idea are they testing?

____(1m)

b) What would they need to change to test this idea?

____(1m)

c) What are two things they would need to keep the same?

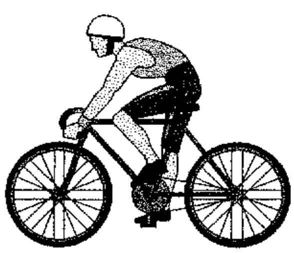
i)____(1m)

ii)____(1m)

d) In fair tests, why is it important to do repeat trials?

____

____(2m)



3. A group of students on camp were racing down a hill on identical mountain bikes. The rules were that you could not pedal and the race began from a standing start. Paul wanted to beat Aroha to the bottom of the hill.

a) Without doing anything to the bike, what could Paul do to try to travel faster than Aroha?

____(1m)

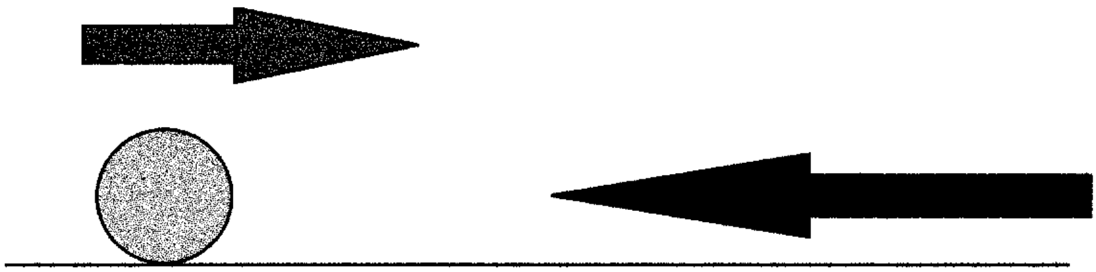
b) Explain how this would help Paul go faster.

____(1m)

c) Aroha decided to make some changes to her bike to go faster. What could she do? (State one factor)

____(1m)

4.(a) In a game of air-soccer the ball is moving steadily to the right, when a strong stream of air is blown onto it in the opposite direction as shown. The ball will most likely: (1m)



A	B	C	D	E
Carry on to the right unaffected	Accelerate to the right	Slow down, stop, and then go left	Go left, then slow down and stop	Stop, and stay stopped

5. True/False Section (4m)

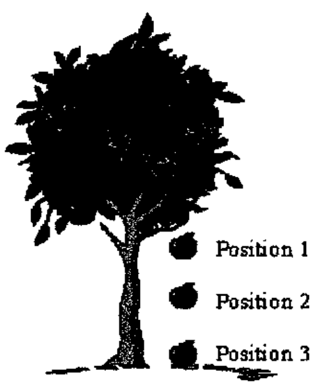
(a) When a parachutist is coming down at a steady speed, the upwards and downwards forces must be balanced.

(b) The upwards force on a boat in the water is called drag.

(c) When a motorbike is accelerating the force produced by the motor must be more than the frictional forces.

(d) If a floor didn't bend and push back on us enough to support our weight, we would fall through.

a
b
c
d



6. The drawing shows an apple falling to the ground.

(a) In which of the three positions shown does gravity act on the apple? (1m)

A	2 only
B	1 and 2
C	1 and 3
D	1, 2 and 3
E	3 only

(b) The apples on the tree all have gravitational potential energy. The amount of this energy they have depends on various factors. They are: (1m)

A	B	C	D	E
Mass and Height	Height only	Mass, Height and Gravitational pull	Mass and Gravitational pull	Height and Gravitational pull

7. A skydiver jumped from a plane, and soon reached a speed of about 200kmh^{-1}. After that the speed did not increase even though the parachute had not yet been opened. What term do we give to the maximum speed that the skydiver reached? (1m)

A	B	C	D	E
Freefall	Acceleration	Gravity	Terminal velocity	Kinetic energy

8. The force of gravity is caused by the earth's: (1m)

A	B	C	D	E
Mass	Spin	Atmosphere	Magnetic Field	None of these

9. A student holds a force-meter with an unknown mass tied to it. The meter reads 8 newtons.

(a) The size of the upwards force the student needs to support the weight must be ____________newtons.

(b) The force of gravity pulling down on the mass must be ______________newtons.

(c) The unknown mass must be _____________grams which is ____________kilograms.

(d) The force needed to lift the mass slowly and steadily would be ____________newtons. (5m)

10. A group of students have been dragging a rock along the ground, and want to measure the amount of work they have done. They know that the formula for calculating work is **WORK = FORCE X DISTANCE**. They measure the force needed to pull the rock, and find it is 600 N, while the distance they dragged it was 5 m. How much work have they done? (1m)

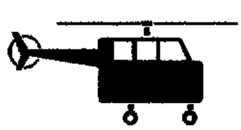
A	B	C	D	E
300 m	300 j	300 J	120 J	300 W

11. On earth the gravitational field strength is $10Nkg^{-1}$, but on Jupiter it is $25\ Nkg^{-1}$, which is 2.5 times as much. Which column of the Table shows correct information about mass and weight on each planet? (1m)

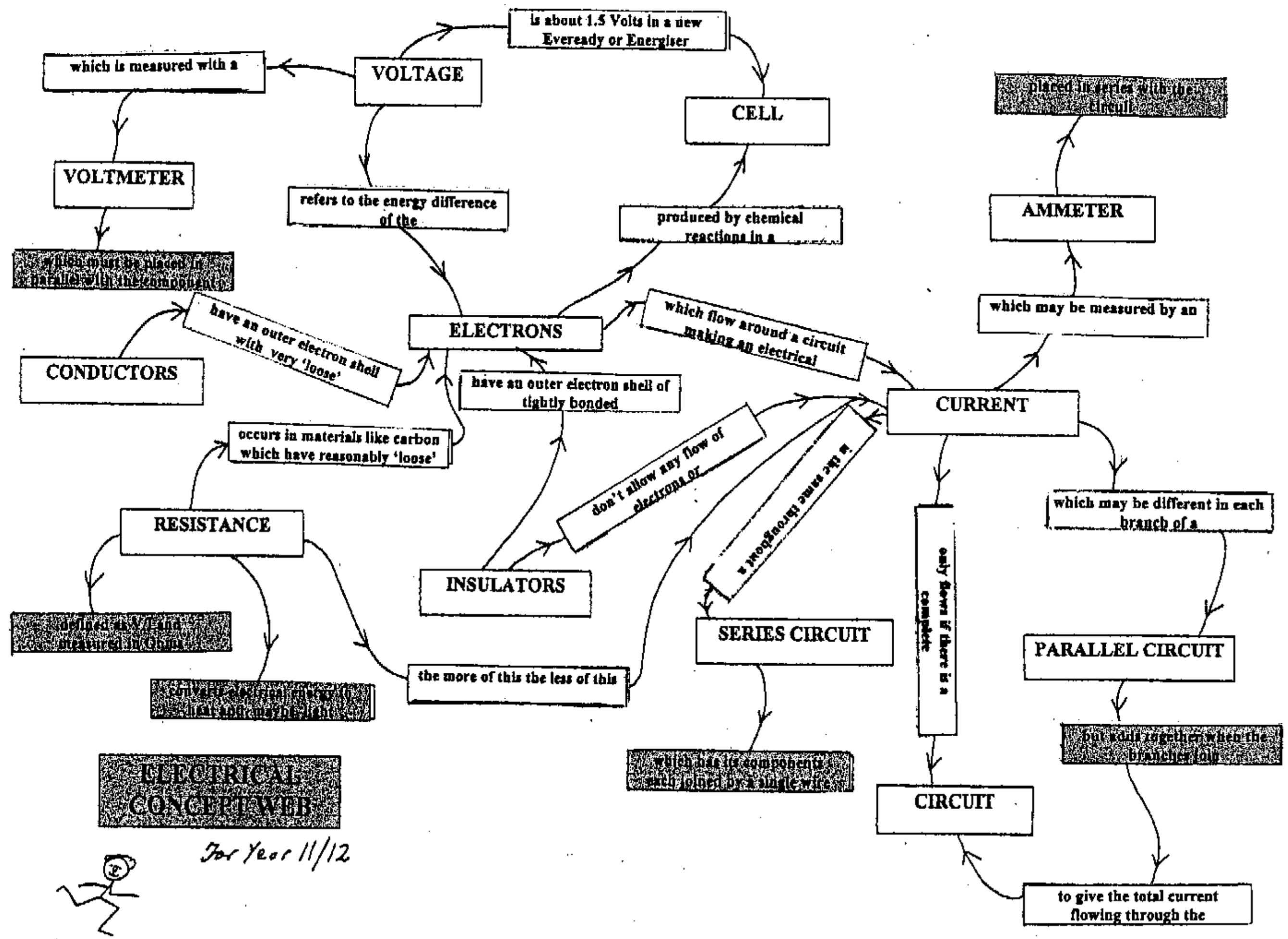
	A	B	C	D	E
MASS	STAYS CONSTANT	LESS ON EARTH	STAYS CONSTANT	STAYS CONSTANT	MORE ON EARTH
WEIGHT	MORE ON EARTH	MORE ON JUPITER	STAYS CONSTANT	MORE ON JUPITER	STAYS CONSTANT

12. If a car travels at $100kmh^{-1}$, it will have more kinetic energy than if it travels at $50kmh^{-1}$. How much more? (1m)

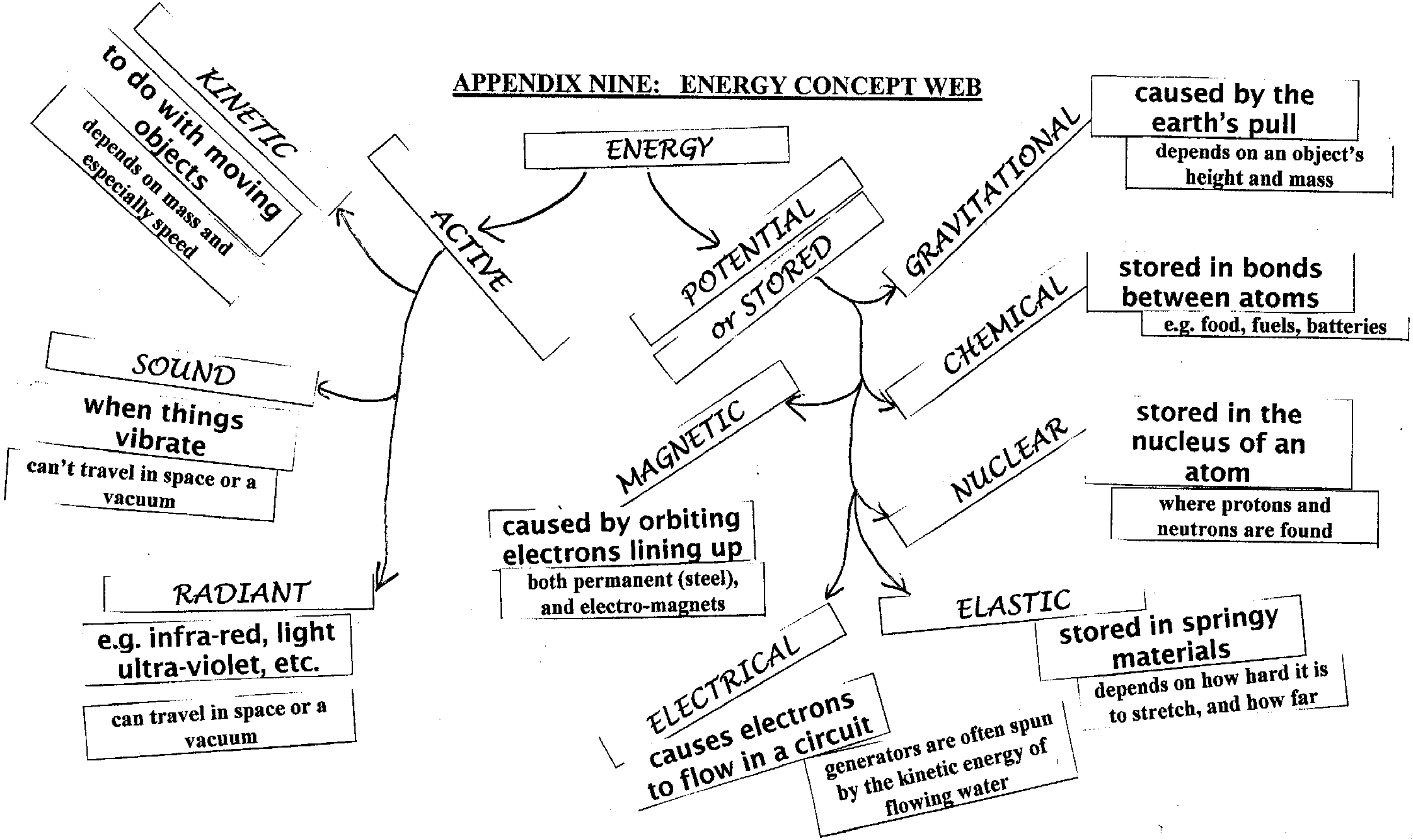
A	B	C	D	E
Need more information	Not correct. It has the same amount	Only a little bit more	Twice as much as originally	Four times as much as originally



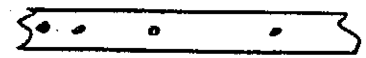
APPENDIX EIGHT: ELECTRICAL CONCEPT WEB



APPENDIX NINE: ENERGY CONCEPT WEB



APPENDIX TEN: MIXED-UP MOVEMENT STATEMENTS

SPEED IS DEFINED	as distance divided by time	written as v = d/t
COMMON UNITS FOR SPEED	are kilometres per hour and metres per second	written as km h^{-1} and m s^{-1}
TYPICAL WALKING SPEEDS	are about 1 m s^{-1}	which is 3.6 km h^{-1}
YOU CAN USE THE SPEED TRIANGLE TO FIND OUT HOW LONG A TRIP TAKES	 by covering up t 	we find t = d / v
IF I KEPT RIDING MY BIKE AT 8 m s^{-1}	in 1 hour I would travel 8 X 60 X 60 m	which is exactly 28800 m, or 28.8 km
TICKER TIMERS LEAVE A TRAIL OF DOTS	on a ticker tape. The closer the dots	the slower the object must be travelling
WHEN A TROLLEY ACCELERATES, ITS SPEED	keeps getting faster and faster and the dots on a ticker tape	would look like 
AT A STEADY SPEED	you would travel the same distance	in equal amounts of time
A NEGATIVE ACCELERATION	is usually called a deceleration	and means to slow down

APPENDIX 11: SPECIMEN TEAM TASK INVESTIGATION

LEVEL 5 SCIENCE

ENERGY INVESTIGATIONS

TEAM TASK 1

ROLE	NAME
Manager	
Recorder/Checker	
Practical Coordinator	

You are designing a toy car which must be able to travel across a wide variety of terrain e.g. sand, earth, gravel, lawn, asphalt, concrete - as well as vinyl and carpet.

Your hypothesis is that, for a given starting speed, the car will travel further on surfaces with less friction.

Tasks.

1. Plan and carry out an investigation to compare the friction between any 5 of the surfaces mentioned. Write it up as you do it.

Equipment available: Spring balance, cart, brick, string.

Hint: Make sure your tests are fair.

2. Now plan and carry out an investigation to test your hypothesis. Write it up.

Equipment available: Cart, brick, ramp, metre rule, stopwatch.

Hint: Devise a way of giving the car the same starting speed for every trial.

Assessment.

Since this is a group task, only one piece of work is to be handed in for the group. All members of the group will receive the same grade, and should be involved in checking that the final work represents the best standard of the group.

Checklist for each task:

heading

aim

labeled diagram

description of what you did

the testing is fair

results clearly presented

clear discussion of what the results mean in terms of the hypothesis.

APPENDIX 12: ICEQ (LONG FORM) DATA FOR CLASS A

STUDENT		PREFERRED CLASSROOM ENVIRONMENT					ACTUAL CLASSROOM ENVIRONMENT				
CODE	YEAR	Pe	Pa	Id	Iv	D	Pe	Pa	Id	Iv	D
A01	10	38	36	31	32	26	Ab	Ab	Ab	Ab	Ab
A02	10	27	29	34	30	30	20	24	36	29	33
A03	10	39	37	28	40	28	31	38	24	38	26
A04	10	44	39	18	37	20	47	42	23	34	26
A05	10	32	36	36	33	28	35	29	23	31	26
A06	10	45	46	29	35	28	32	37	29	39	22
A07	10	32	31	25	33	24	34	35	20	37	28
A08	10	30	34	33	30	30	30	30	29	25	32
A09	10	29	24	22	29	27	Ab	Ab	Ab	Ab	Ab
A10	10	41	41	28	35	27	Ab	Ab	Ab	Ab	Ab
A11	10	39	35	21	34	28	38	37	20	38	30
A12	9	30	33	28	34	32	28	29	28	24	25
A13	9	23	30	32	30	30	23	28	31	30	27
A14	9	34	34	39	29	34	34	34	38	29	35
A15	9	39	38	28	35	27	36	37	28	35	25
A16	9	41	31	29	29	30	32	28	30	30	25
A17	9	37	30	29	38	29	26	27	32	33	29
A18	9	29	35	33	29	31	25	26	39	24	31
A19	9	36	36	26	34	34	Ab	Ab	Ab	Ab	Ab
A20	9	41	37	34	32	31	26	33	38	33	32
A21	9	38	43	29	37	29	N/A	N/A	N/A	N/A	N/A
A22	9	33	27	37	28	36	12	24	34	27	30
A23	9	39	38	28	36	31	35	39	34	32	37
MEANS											
YR 10		36	35.3	27.7	33.5	26.9	33.4	34	25.5	33.9	27.9
YR 9		35	34.3	31	32.6	31.2	27.7	30.5	33.2	29.7	29.6
OVERALL		35.5	34.8	29.4	33	29.1	30.2	32.1	29.8	31.6	28.8

APPENDIX 13: ICEQ (SHORT FORM) DATA FOR CLASS B

STUDENT		PREFERRED CLASSROOM ENVIRONMENT					ACTUAL CLASSROOM ENVIRONMENT				
CODE	YEAR	Pe	Pa	Id	Iv	D	Pe	Pa	Id	Iv	D
B01	10	24	21	18	21	14	17	18	19	19	11
B02	10	23	23	21	22	14	17	17	11	17	11
B03	10	12	12	25	11	19	7	14	16	11	12
B04	10	18	16	17	15	10	17	15	17	14	12
B05	10	21	25	21	12	20	17	21	15	13	9
B06	10	20	21	19	21	12	15	18	20	20	10
B07	10	20	22	19	15	17	21	18	15	15	12
B08	10	13	10	25	9	7	19	18	10	17	10
B09	10	17	15	16	17	14	15	14	12	15	10
B10	10	22	20	19	23	14	16	19	14	17	12
B11	10	19	21	19	15	13	N/A	N/A	N/A	N/A	N/A
B12	9	19	19	15	19	10	12	13	10	13	14
B13	9	19	17	19	15	15	13	13	17	13	12
B14	9	16	17	18	14	17	12	14	9	14	12
B15	9	22	25	16	17	7	22	19	16	17	7
B16	9	20	22	22	21	13	15	13	16	9	15
B17	9	19	14	17	16	18	15	12	13	13	21
B18	9	16	15	14	13	14	19	16	14	17	10
B19	9	19	19	21	16	10	12	10	18	13	13
B20	9	13	12	24	17	12	Ab	Ab	Ab	Ab	Ab
B21	9	19	18	19	16	14	14	11	20	16	13
B22	9	17	12	11	17	15	16	16	14	19	16
MEANS											
YR 10		19	18.7	19.9	16.5	14	16.1	17.2	14.9	15.8	10.9
YR 9		18.1	17.3	17.8	16.5	13.2	15	13.7	14.7	14.4	13.3
OVERALL		**18.5**	**18**	**18.9**	**16.5**	**13.6**	**15.6**	**15.5**	**14.8**	**15.1**	**12.1**

APPENDIX 14: ICEQ (SHORT FORM) DATA FOR CLASS C

STUDENT		PREFERRED CLASSROOM ENVIRONMENT					ACTUAL CLASSROOM ENVIRONMENT				
CODE	YEAR	Pe	Pa	Id	Iv	D	Pe	Pa	Id	Iv	D
C01	10	17	23	11	23	17	21	19	5	21	20
C02	10	21	15	19	23	14	21	13	17	21	19
C03	10	Ab	Ab	Ab	Ab	Ab	16	13	12	14	21
C04	10	16	15	21	15	14	14	14	18	14	13
C05	10	18	14	22	13	14	20	17	7	16	14
C06	10	20	19	12	15	10	16	13	16	17	21
C07	10	13	18	10	20	6	20	16	14	20	12
C08	10	17	20	14	19	9	18	15	13	17	9
C09	10	21	22	14	21	13	19	21	12	17	14
C10	10	14	17	24	12	14	11	11	14	15	18
C11	9	12	18	20	21	14	16	18	12	15	17
C12	9	14	18	25	17	5	18	19	12	19	12
C13	9	Ab	Ab	Ab	Ab	Ab	19	21	17	20	18
C14	9	19	21	12	17	8	18	17	10	15	12
C15	9	14	17	17	15	12	19	18	9	16	13
C16	9	19	23	16	19	15	Ab	Ab	Ab	Ab	Ab
C17	9	17	21	16	13	13	17	17	10	16	13
C18	9	14	17	15	16	18	17	15	18	15	18
C19	9	15	19	25	22	14	Ab	Ab	Ab	Ab	Ab
C20	9	17	25	20	23	11	18	17	9	20	17
C21	9	20	18	22	19	10	20	17	8	12	19
C22	9	15	17	16	12	17	19	21	12	17	17
MEANS											
YR 10		17.4	18.1	16.3	17.9	12.3	17.6	15.2	12.8	17.2	16.1
YR 9		16	19.5	18.5	17.6	12.5	18.1	18	11.7	16.5	15.6
OVERALL		**16.7**	**18.9**	**17.6**	**17.8**	**12.4**	**17.9**	**16.6**	**12.3**	**16.9**	**15.9**

APPENDIX 15: ICEQ (SHORT FORM) DATA FOR CLASS D

STUDENT		PREFERRED CLASSROOM ENVIRONMENT					ACTUAL CLASSROOM ENVIRONMENT				
CODE	YEAR	Pe	Pa	Id	Iv	D	Pe	Pa	Id	Iv	D
D1	10	19	21	20	22	12	19	21	9	11	11
D2	10	18	16	19	15	15	19	21	11	15	11
D3	10	21	17	24	18	16	16	15	12	20	14
D4	10	17	17	23	17	14	11	11	9	13	15
D5	10	19	18	20	15	15	5	5	5	9	11
D6	10	17	20	20	20	12	13	16	10	15	10
D7	10	21	17	21	15	15	20	17	8	18	13
D8	10	Ab	Ab	Ab	Ab	Ab	21	23	7	20	18
D9	10	20	22	21	19	17	15	20	11	14	6
D10	10	19	19	15	19	10	Ab	Ab	Ab	Ab	Ab
D11	10	21	23	22	15	9	14	14	12	14	11
D12	10	17	20	23	17	16	17	18	11	16	15
D13	10	23	10	16	20	15	Ab	Ab	Ab	Ab	Ab
D14	9	21	20	9	19	10	17	17	9	20	14
D15	9	18	10	25	12	10	16	16	7	18	14
D16	9	22	24	23	14	15	13	13	11	15	15
D17	9	17	23	25	16	11	Ab	Ab	Ab	Ab	Ab
D18	9	17	15	14	12	12	23	15	10	17	18
D19	9	15	17	21	17	7	14	11	9	14	16
D20	9	16	19	21	13	13	18	16	14	14	17
D21	9	11	19	21	17	11	15	15	9	14	17
D22	9	19	21	16	19	9	21	23	13	17	12
MEANS											
YR 10		19.3	18.3	20.3	17.7	13.8	15.5	16.5	9.5	15	12.3
YR 9		17.3	18.7	19.4	15.4	10.9	17.1	15.8	10.3	16.1	15.4
OVERALL		**18.5**	**18.5**	**20**	**16.7**	**12.6**	**16.2**	**16.2**	**9.8**	**15.5**	**13.6**

APPENDIX 16: INDIVIDUAL ACHIEVEMENT DATA FOR CLASSES C AND D

STUDENT		TEST RESULTS (%)				STUDENT		TEST RESULTS (%)			
CODE	**YEAR**	**ENERGY**	**MOVE**	**F/WK**	**MEAN**	**CODE**	**YEAR**	**ENERGY**	**MOVE**	**F/WK**	**MEAN**
C01	10	75.6	72.5	55.9	68	**D01**	10	86.7	88.2	61.8	78.9
C02	10	73.3	47.1	38.2	52.9	**D02**	10	57.8	51	55.9	54.9
C03	10	N/A	80.4	47.1	63.8	**D03**	10	68.9	60.8	47.1	58.9
C04	10	77.8	72.5	41.2	63.8	**D04**	10	73.3	80.4	55.9	69.9
C05	10	80	82.4	50	70.8	**D05**	10	73.3	39.2	38.2	50.2
C06	10	73.3	47.1	58.8	59.7	**D06**	10	N/A	58.8	58.8	58.8
C07	10	77.8	56.9	50	61.6	**D07**	10	84.4	76.5	67.6	76.2
C08	10	82.2	60.8	64.7	69.2	**D08**	10	N/A	23.5	26.5	25
C09	10	91.1	92.2	76.5	86.6	**D09**	10	88.9	96.1	76.5	87.2
C10	10	57.8	62.7	58.8	59.8	**D10**	10	97.8	94.1	61.8	84.6
C11	9	86.7	62.7	70.6	73.3	**D11**	10	82.2	54.9	58.8	65.3
C12	9	62.2	60.8	44.1	55.7	**D12**	10	88.9	56.9	41.2	62.3
C13	9	N/A	54.9	47.1	51	**D13**	10	86.7	92.2	N/A	89.5
C14	9	88.9	43.1	61.8	64.6	**D14**	9	35.6	39.2	23.5	32.8
C15	9	40	25.5	44.1	36.5	**D15**	9	75.6	82.4	50	69.3
C16	9	71.1	33.3	N/A	52.2	**D16**	9	77.8	74.5	32.4	61.6
C17	9	88.9	76.5	70.6	78.7	**D17**	9	53.3	68.6	58.8	60.2
C18	9	35.6	29.4	20.6	28.5	**D18**	9	33.3	60.8	17.6	37.2
C19	9	80	N/A	47.1	63.6	**D19**	9	55.6	58.8	35.3	49.9
C20	9	91.1	88.2	79.4	86.2	**D20**	9	64.4	37.3	35.3	45.7
C21	9	55.6	47.1	52.9	51.9	**D21**	9	64.4	64.7	35.3	54.8
C22	9	57.8	35.3	35.3	42.8	**D22**	9	62.2	31.4	26.5	40
MEANS						**MEANS**					
YR 10		**76.5**	**67.5**	**54.1**	**66**	**YR 10**		**80.8**	**67.1**	**54.2**	**67.4**
YR 9		**68.9**	**50.6**	**52.1**	**57.2**	**YR 9**		**58**	**57.5**	**35**	**50.2**
OVERALL		72.3	58.6	53.1	61.3	**OVERALL**		70.6	63.2	45.9	59.9

APPENDIX 17: GROUP ACHIEVEMENT DATA FOR CLASSES C AND D

STUDENT		INVEST	STUDENT		INVEST
CODE	YEAR	GRADE	CODE	YEAR	GRADE
C01	10	4	**D01**	10	5
C02	10	5	**D02**	10	3
C03	10	3	**D03**	10	5
C04	10	3	**D04**	10	5
C05	10	5	**D05**	10	3
C06	10	4	**D06**	10	3
C07	10	5	**D07**	10	3
C08	10	4	**D08**	10	2
C09	10	5	**D09**	10	5
C10	10	4	**D10**	10	5
C11	9	4	**D11**	10	3
C12	9	4	**D12**	10	4
C13	9	4	**D13**	10	ab
C14	9	4	**D14**	9	3
C15	9	3	**D15**	9	5
C16	9	4	**D16**	9	5
C17	9	5	**D17**	9	5
C18	9	3	**D18**	9	3
C19	9	5	**D19**	9	5
C20	9	4	**D20**	9	3
C21	9	4	**D21**	9	ab
C22	9	4	**D22**	9	5
OVERALL MEANS		4.1			4

APPENDIX 18: SALTA OBSERVATIONS FOR CLASS C

LESSONS 1-5

LESSON 1					LESSON 2					LESSON 3					LESSON 4					LESSON 5				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
C09	1		5	M	C07	1		4			1			M	C17	1	L	4	M	C05	1	L	3	M
C17	2		4	M	C18	2		4			2			M	C15	2	L	3	LC	C06	2	W	4	LC
C06	3		5	M	C08	3		3			3			M	C08	3	L	4	LC	C11	3	W	3	TC
C16	4		3	M	C15	4		3			4			M	C18	4	L	4	LC	C09	4	W	3	W
C22	5		3	M	C05	5		3			5			M	C07	5	GT	5	GO	C22	5	W	3	W
C02	6		4	M	C20	6		4			6			LC	C20	6	GT	5	GO	C02	6	O	1	RG
C04	7		4	M	C12	7		4			7			PD	C12	7	GT	5	RG	C04	7	O	1	NR
C03	8		4	M	C21	8		5			8			PD	C21	8	GT	4	GO	C03	8	L	3	NR
C14	9		5	M	C01	9		5			9			PD	C01	9	L	5	TC	C14	9	L	3	TC
C10	10		4	M	C19	10		5			10			PD	C19	10	L	4	TC	C10	10	L	3	CD
C22	11		4	RG		11			CD	C22	11	L	3		C17	11	L	4	CD	C05	11	L	5	TC
C09	12		3	RG		12			CD	C09	12	PW	5		C15	12	O	1	TC	C06	12	L	5	TC
C16	13		5	GD		13			LC	C11	13	PW	5		C08	13	L	4	TC	C11	13	L	5	TC
C06	14		5	CD		14			LC	C06	14	PW	5		C18	14	L	2	GO	C09	14	W	5	TC
C17	15		4	CD		15			W	C17	15	PW	5		C07	15	L	5	CD	C22	15	L	5	RG
C02	16		5	CD		16			TC	C02	16	PW	5		C20	16	PW	2	PH	C02	16	L	4	CD
C04	17		5	CD		17			TC	C04	17	PW	4		C12	17	PW	4	LC	C04	17	V	5	V
C03	18		4	GO		18			W	C03	18	PW	4		C21	18	PW	5	GO	C03	18	V	4	V
C13	19		5	GO		19			TC	C14	19	PW	4		C01	19	PW	5	RG	C14	19	L	5	CD
C10	20		3	PD		20			CD	C10	20	W	4		C19	20	PW	3	RG	C10	20	L	5	CD
C09	21		5	PD	C07	21		5			21			RG	C17	21	PW	5	RG	C05	21	V	5	V
C17	22		5	W	C18	22		3			22			O	C15	22	PW	0	RG	C06	22	V	5	V
C06	23		4	LC	C08	23		3			23			PH	C08	23	PW	1	RG	C11	23	V	5	V
C16	24		5	CD	C15	24		3			24			PH	C18	24	PW	4	CD	C09	24	V	5	V
C22	25		5	CD	C05	25		4			25			PH	C07	25	PW	5	RG	C22	25	V	5	V
C02	26		5	CD	C20	26		3			26			RG	C20	26	PW	4	RG	C02	26	L	5	CD
C04	27		3	CD	C12	27		3			27			O	C12	27	PW	3	RG	C04	27	V	4	V
C03	28		3	CD	C21	28		1			28			RG	C21	28	PW	5	RG	C03	28	V	4	V
C14	29		3	PH	C01	29		1			29			PH	C01	29	PW	5	RG	C14	29	L	5	LC
C10	30		3	RG	C19	30		1			30			O	C19	30	L	4	CD	C10	30	L	5	LC
C22	31		4	ID		31			RG	C22	31	PW	5		C17	31	PW	5	TC	C05	31	V	5	V
C09	32		5	TC		32			RG	C09	32	PW	4		C15	32	PW	4	PH	C06	32	V	5	V
C16	33		2	RG		33			CD	C11	33	PW	5		C08	33	PW	3	PH	C11	33	V	5	V
C06	34		4	O		34			TC	C06	34	L	5		C18	34	PW	3	PH	C09	34	V	5	V
C17	35		2	ID		35			TC	C17	35	L	3		C07	35	PW	4	PH	C22	35	L	5	CD
C02	36		4	TC		36			CD	C02	36	L	5		C20	36	PW	5	PH	C02	36	L	4	CD
C04	37		4	TC		37			TC	C04	37	W	5		C12	37	PW	3	PH	C04	37	GT	4	CD
C03	38		3	TC		38			TC	C03	38	L	3		C21	38	PW	5	PH	C03	38	R	4	GO
C13	39		3	TC		39			W	C14	39	L	5		C01	39	PW	5	LC	C14	39	RW	5	W
C10	40		1	W		40			TC	C10	40	L	5		C19	40	PW	3	PH	C10	40	GT	1	W
					C07	41		4			41			PD	C17	41	PW	1	RG	C05	41	RW	4	RG
					C18	42		4			42			PH	C15	42	PW	0	RG	C06	42	L	4	CD
					C08	43		3			43			PD	C08	43	PW	5	RG	C11	43	L	3	CD
					C15	44		3			44			O	C18	44	PW	0	RG	C09	44	RW	5	RG
					C05	45		5			45			O	C07	45	PW	4	ID	C22	45	RW	3	RG
					C20	46		1			46			RG	C20	46	PW	1	RG	C02	46	RW	5	RG
					C12	47		5			47				C12	47	O	5	CD	C04	47	RW	3	RG
					C21	48		5			48			CD	C21	48	O	5	RG	C03	48	RW	2	RG
					C01	49		1			49			CD	C01	49	L	3	RG	C14	49	L	4	CD
					C19	50		5							C19	50	L	2	CD	C10	50	L	2	CD
			3.9					3.4					4.5					3.6					4	

APPENDIX 18: SALTA OBSERVATIONS FOR CLASS C

LESSONS 6-10

LESSON 6					LESSON 7					LESSON 8					LESSON 9					LESSON 10				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
C07	1	R		M	C17	1	L	4	M	C17	1	L	2	M	C05	1	L	4	M	C06	1	L	5	M
C18	2	W		M	C06	2	L	4	M	C06	2	GT	5	GD	C15	2	L	4	M	C16	2	L	2	M
C08	3	R		M	C11	3	L	5	M	C08	3	GT	4	M	C11	3	GT	4	ID	C09	3	GT	4	GD
C15	4	W		M	C09	4	GT	1	M	C13	4	GT	1	GO	C18	4	GT	1	RG	C20	4	GT	5	GD
C05	5	R		O	C22	5	GT	3	GD	C07	5	GT	4	GO	C02	5	GT	4	RG	C07	5	GT	1	GD
C19	6	W		O	C02	6	GT	2	RG	C20	6	GT	4	GO	C22	6	GT	5	RG	C21	6	GT	2	GD
C01	7	R		O	C04	7	GT	3	GD	C12	7	GT	2	GD	C03	7	GT	5	RG	C01	7	GT	5	RG
C21	8	W		O	C03	8	GT	3	GD	C21	8	GT	5	RG	C04	8	GT	5	RG	C13	8	GT	2	GD
C12	9	R		O	C13	9	GT	1	GD	C01	9	GT	5	RG	C10	9	GT	1	RG	C12	9	GT	2	RG
C20	10	W		O	C10	10	GT	1	GD	C19	10	GT	5	RG	C14	10	GT	4	RG	C17	10	GT	1	ID
C07	11	R	3	M	C17	11	GT	5	GD	C17	11	GT	5	O	C05	11	GT	4	GO	C06	11	R	5	GD
C18	12	W	4	M	C06	12	GT	5	GD	C06	12	GT	5	GD	C15	12	GT	3	GD	C16	12	R	3	GD
C08	13	L	5	LC	C11	13	GT	4	GD	C08	13	GT	4	PH	C11	13	GT	5	GD	C09	13	R	3	GD
C15	14	L	5	LC	C09	14	GT	2	GD	C13	14	GT	1	GD	C18	14	GT	2	GD	C20	14	O	4	M
C05	15	L	5	LC	C22	15	GT	1	GD	C07	15	GT	5	GD	C02	15	GT	3	GD	C07	15	R	4	O
C19	16	R	5	RG	C02	16	GT	5	GD	C20	16	GT	4	RG	C22	16	GT	3	GD	C21	16	R	2	RG
C01	17	W	5	RG	C04	17	GT	3	GD	C12	17	GT	3	PH	C03	17	GT	2	O	C01	17	R	1	O
C21	18	R	5	RG	C03	18	GT	1	GD	C21	18	GT	3	RG	C04	18	GT	5	RG	C13	18	O	4	RG
C12	19	W	5	RG	C13	19	GT	2	GD	C01	19	GT	4	RG	C10	19	GT	4	GD	C12	19	O	1	M
C20	20	R	5	RG	C10	20	GT	2	GD	C19	20	GT	1	RG	C14	20	GT	4	RG	C17	20	L	4	M
C07	21	W	5	RG	C17	21	GT	2	GD	C17	21	GT	4	RG	C05	21	GT	4	GD	C06	21	L	5	LC
C18	22	R	5	RG	C06	22	GT	5	RG	C06	22	GT	5	GD	C15	22	GT	4	GD	C16	22	L	3	O
C08	23	W	5	RG	C11	23	L	5	M	C08	23	GT	5	RG	C11	23	GT	5	GD	C09	23	T	5	O
C15	24	R	5	RG	C09	24	L	4	M	C13	24	GT	1	RG	C18	24	GT	2	GD	C20	24	T	5	O
C05	25	W	5	RG	C22	25	L	3	M	C07	25	GT	3	RG	C02	25	GT	5	GD	C07	25	T	5	O
C19	26	R	5	RG	C02	26	GT	5	RG	C20	26	GT	3	RG	C22	26	GT	4	GD	C21	26	T	5	O
C01	27	W	5	RG	C04	27	GT	3	RG	C12	27	GT	1	RG	C03	27	GT	5	GD	C01	27	T	5	O
C21	28	R	5	RG	C03	28	GT	1	RG	C21	28	GT	3	O	C04	28	GT	3	GD	C13	28	T	4	O
C12	29	W	5	RG	C13	29	GT	1	GD	C01	29	GT	5	O	C10	29	GT	1	GD	C12	29	T	5	O
C20	30	R	5	RG	C10	30	GT	3	GD	C19	30	GT	2	RG	C14	30	GT	2	GD	C17	30	T	5	O
C07	31	W	5	RG	C17	31	GT	5	GD	C17	31	GT	5	GD	C05	31	GT	3	RG	C06	31	T	5	O
C18	32	R	5	RG	C06	32	GT	5	GD	C06	32	GT	5	GD	C15	32	GT	2	GD	C16	32	T	4	O
C08	33	O	1	RG	C11	33	GT	4	GD	C08	33	GT	5	GD	C11	33	GT	2	RG	C09	33	T	5	O
C15	34	R	4	RG	C09	34	GT	5	GD	C13	34	GT	1	RG	C18	34	GT	3	M	C20	34	T	5	RG
C05	35	O	1	M	C22	35	GT	5	GD	C07	35	GT	4	GD	C02	35	GT	5	GD	C07	35	T	5	O
C19	36	O	1	M	C02	36	GT	5	O	C20	36	GT	1	RG	C22	36	GT	4	RG	C21	36	T	5	O
C01	37	O	1	M	C04	37	GT	3	RG	C12	37	GT	1	RG	C03	37	GT	3	RG	C01	37	T	1	O
C21	38	L	4	M	C03	38	GT	3	RG	C21	38	L	3	RG	C04	38	GT	4	RG	C13	38	T	5	O
C12	39	O	2	M	C13	39	GT	4	GD	C01	39	L	5	LC	C10	39	GT	1	RG	C12	39	T	5	O
C20	40	O	2	M	C10	40	GT	1	GD	C19	40	GT	1	LC	C14	40	GT	4	RG	C17	40	T	1	O
C07	41	W	1	M	C17	41	GT	1	GD	C17	41	GT	4	GO	C05	41	GT	4	GD	C06	41	T	5	O
C18	42	W	4	O	C06	42	GT	4	GD	C06	42	GT	5	RG	C15	42	GT	4	GD	C16	42	T	2	O
C08	43	W	5	O	C11	43	GT	3	O	C08	43	GT	5	GD	C11	43	GT	5	GD	C09	43	T	1	O
C15	44	W	5	RG	C09	44	GT	2	O	C13	44	GT	4	RG	C18	44	GT	4	O	C20	44	T	5	O
C05	45	W	4	RG	C22	45	L	1	M	C07	45	GT	3	RG	C02	45	GT	3	O	C07	45	T	5	O
C19	46	W	2	O	C02	46	GT	2	M	C20	46	GT	5	GD	C22	46	GT	5	O	C21	46	O	1	M
C01	47	O	1	M	C04	47	GT	2	GD	C12	47	GT	3	GD	C03	47	GT	5	O	C01	47	L	2	M
C21	48	O	1	O	C03	48	GT	1	GD	C21	48	GT	2	RG	C04	48	GT	5	RG	C13	48	O	1	M
C12	49	L	3	M	C13	49	GT	1	GD	C01	49	GT	5	GO	C10	49	GT	1	O	C12	49	R	2	M
C20	50	L	3	M	C10	50	GT	1	GD	C19	50	L	3	M	C14	50	GT	1	O	C17	50	R	4	M
			3.8					2.9					3.5					3.5					3.5	

APPENDIX 18: SALTA OBSERVATIONS FOR CLASS C

LESSONS 11-15

LESSON 11					LESSON 12					LESSON 13					LESSON 14					LESSON 15				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
C10	1	L	3	M	C06	1	GT	2	RG	C08	1	L	3	M	C16	1	L	4	M	C02	1	LC	3	M
C14	2	L	3	M	C11	2	GT	2	RG	C15	2	L	2	M	C06	2	L	4	M	C15	2	LC	2	M
C03	3	L	3	M	C09	3	GT	2	M	C02	3	L	3	M	C20	3	L	4	LC	C09	3	LC	2	M
C04	4	L	3	M	C20	4	L	2	M	C18	4	GT	2	RG	C12	4	R	4	LC	C04	4	LC	3	M
C15	5	L	3	M	C07	5	L	4	M	C03	5	GT	1	GO	C21	5	L	5	LC	C03	5	LC	3	M
C02	6	O	2	O	C21	6	O	3	M	C22	6	GT	4	GD	C07	6	R	5	LC	C05	6	GT	1	O
C05	7	GD	1	RG	C14	7	GT	1	RG	C05	7	GT	1	GD	C17	7	L	3	LC	C13	7	GT	2	RG
C18	8	GT	2	GD	C19	8	GT	4	GD	C13	8	GT	1	GD	C01	8	R	5	LC	C14	8	GT	3	GD
C22	9	GT	4	GD	C12	9	GT	2	GD	C10	9	GT	3	GD	C19	9	L	4	LC	C10	9	GT	3	GD
C08	10	GT	4	GD	C17	10	GT	1	GD	C04	10	GT	3	GD	C22	10	R	4	LC	C18	10	GT	2	GD
C10	11	GT	2	GD	C06	11	GT	3	GD	C08	11	GT	2	GD	C16	11	L	4	LC	C02	11	GT	5	GD
C14	12	GT	2	O	C11	12	GT	2	GD	C15	12	GT	4	GD	C06	12	RG	4	LC	C15	12	GT	2	GD
C03	13	GT	1	RG	C09	13	GT	2	ID	C02	13	GT	2	GD	C20	13	L	4	RG	C09	13	GT	4	GD
C04	14	GT	3	RG	C20	14	GT	2	RG	C18	14	GT	1	RG	C12	14	RG	3	TC	C04	14	GT	1	GD
C15	15	GT	1	RG	C07	15	GT	3	GD	C03	15	GT	2	GO	C21	15	L	4	TC	C03	15	GT	2	GD
C02	16	GT	4	GD	C21	16	GT	3	GD	C22	16	GT	3	GD	C07	16	RG	4	TC	C05	16	GT	2	GO
C05	17	GT	1	RG	C14	17	GT	3	GD	C05	17	GT	2	GD	C17	17	L	3	TC	C13	17	GT	2	GD
C18	18	GT	3	M	C19	18	GT	2	GD	C13	18	GT	3	RG	C01	18	RG	4	M	C14	18	GT	3	GD
C22	19	GT	4	RG	C12	19	GT	3	RG	C10	19	GT	3	GD	C19	19	L	4	TC	C10	19	GT	3	GD
C08	20	GT	3	GD	C17	20	GT	1	GD	C04	20	GT	3	GD	C22	20	RG	3	RG	C18	20	GT	2	GD
C10	21	GT	2	GD	C06	21	GT	5	GD	C08	21	GT	3	RG	C16	21	RG	1	M	C02	21	GT	1	RG
C14	22	GT	2	GD	C11	22	GT	5	GD	C15	22	GT	1	GD	C06	22	RG	2	M	C15	22	GT	1	GD
C03	23	GT	2	GD	C09	23	GT	4	GD	C02	23	GT	3	GO	C20	23	RG	1	M	C09	23	GT	1	RG
C04	24	GT	4	GD	C20	24	GT	5	GD	C18	24	GT	2	GO	C12	24	L	4	GO	C04	24	GT	2	GD
C15	25	GT	1	GD	C07	25	GT	5	GO	C03	25	GT	1	GO	C21	25	O	4	RG	C03	25	GT	4	GD
C02	26	GT	4	GD	C21	26	GT	4	RG	C22	26	GT	3	GO	C07	26	GT	1	RG	C05	26	GT	2	GD
C05	27	GT	3	GD	C14	27	GT	5	GD	C05	27	O	3	GO	C17	27	GT	2	RG	C13	27	GT	1	GD
C18	28	GT	3	GD	C19	28	GT	5	RG	C13	28	L	3	GO	C01	28	GT	2	GD	C14	28	GT	2	GD
C22	29	GT	4	GD	C12	29	GT	5	GD	C10	29	L	5	O	C19	29	GT	1	GD	C10	29	GT	1	GD
C08	30	GT	4	GD	C17	30	GT	1	GD	C04	30	L	4	O	C22	30	GT	2	GD	C18	30	GT	2	GO

LESSON 11					LESSON 12					LESSON 13					LESSON 14					LESSON 15				
C10	31	GT	4	GD	C06	31	GT	2	GD	C08	31	V	5	V	C16	31	GT	3	RG	C02	31	GT	5	GO
C14	32	GT	4	GD	C11	32	GT	2	GD	C15	32	V	5	V	C06	32	GT	5	GD	C15	32	GT	1	GO
C03	33	GT	1	GD	C09	33	GT	1	GO	C02	33	V	5	V	C20	33	GT	4	ID	C09	33	GT	4	GD
C04	34	GT	2	GD	C20	34	GT	2	RG	C18	34	V	2	V	C12	34	GT	2	GD	C04	34	GT	2	GD
C15	35	GT	3	GD	C07	35	GT	1	GD	C03	35	V	1	V	C21	35	GT	3	GO	C03	35	GT	1	GD
C02	36	GT	3	GD	C21	36	GT	3	GD	C22	36	V	5	V	C07	36	GT	3	GD	C05	36	GT	2	GD
C05	37	GT	3	GD	C14	37	GT	4	PD	C05	37	V	5	V	C17	37	GT	4	GD	C13	37	GT	1	GD
C18	38	GT	2	GD	C19	38	GT	3	GO	C13	38	V	5	V	C01	38	GT	4	GD	C14	38	GT	4	GD
C22	39	GT	3	GD	C12	39	GT	2	GD	C10	39	V	5	V	C19	39	GT	4	GD	C10	39	GT	1	GD
C08	40	GT	5	GD	C17	40	GT	1	RG	C04	40	V	5	V	C22	40	GT	2	GD	C18	40	GT	2	GD
C10	41	GT	1	GD	C06	41	GT	5	RG	C08	41	V	5	V	C16	41	GT	3	GO	C02	41	GT	3	GD
C14	42	GT	4	GD	C11	42	GT	2	RG	C15	42	V	5	V	C06	42	GT	2	GD	C15	42	GT	2	GD
C03	43	GT	2	GD	C09	43	GT	5	RG	C02	43	V	5	V	C20	43	GT	2	GD	C09	43	GT	2	GD
C04	44	GT	4	GD	C20	44	GT	4	RG	C18	44	V	1	V	C12	44	GT	1	GD	C04	44	LC	3	M
C15	45	GT	2	GD	C07	45	GT	2	GD						C21	45	GT	1	GD	C03	45	GT	3	O
C02	46	L	3	M	C21	46	GT	5	RG						C07	46	GT	2	GD	C05	46	GT	1	O
					C14	47	GT	2	RG						C17	47	GT	1	GD	C13	47	LC	4	M
					C19	48	GT	2	RG						C01	48	GT	5	GD	C14	48	LC	4	M
					C12	49	GT	1	RG						C19	49	GT	2	GD	C10	49	LC	3	M
					C17	50	GT	1	GD						C22	50	GT	3	GD					
			2.8					2.8					3.1					3.1					2.3	

APPENDIX 18: SALTA OBSERVATIONS FOR CLASS C

LESSONS 16-20

LESSON 16					LESSON 17					LESSON 18					LESSON 19					LESSON 20				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
C06	1	L	4	M	C09	1	L	3	M	C06	1	L	4	M	C02	1	L	3	M	C18	1	GT	3	GO
C20	2	GT	1	M	C15	2	L	4	LC	C20	2	R	3	M	C04	2	L	4	LC	C15	2	GT	3	GO
C12	3	GT	1	GO	C02	3	L	4	LC	C12	3	L	2	LC	C21	3	L	4	LC	C04	3	GT	4	GO
C21	4	GT	2	GD	C04	4	L	4	LC	C21	4	R	5	LC	C18	4	L	4	LC	C20	4	GT	5	GO
C07	5	GT	2	GD	C03	5	L	4	M	C07	5	L	3	LC	C05	5	L	5	LC	C01	5	GT	3	GO
C17	6	GT	3	GO	C18	6	L	3	M	C17	6	R	3	LC	C13	6	L	3	M	C12	6	GT	5	GO
C22	7	GT	1	O	C05	7	L	3	M	C22	7	L	3	LC	C10	7	GT	2	RG	C11	7	GT	5	RG
C01	8	GT	4	GD	C14	8	GT	4	RG	C01	8	R	5	LC	C16	8	GT	4	RG	C22	8	GT	5	RG
C19	9	GT	4	GD	C10	9	GT	1	RG	C19	9	L	2	LC	C09	9	GT	5	RG	C13	9	GT	5	RG
C16	10	GT	3	M	C11	10	GT	3	GD	C14	10	R	4	LC	C11	10	GT	5	GO	C14	10	GT	5	RG
C06	11	GT	4	M	C09	11	GT	5	GD	C06	11	L	2	M	C02	11	GT	4	GO	C18	11	GT	3	RG
C20	12	GT	1	GD	C15	12	GT	3	GD	C20	12	GT	2	RG	C04	12	GT	4	GO	C15	12	GT	3	RG
C12	13	GT	5	RG	C02	13	GT	5	GD	C12	13	GT	1	RG	C21	13	GT	3	GD	C04	13	GT	2	RG
C21	14	GT	3	GD	C04	14	GT	5	GD	C21	14	GT	2	GD	C18	14	GT	4	RG	C20	14	GT	2	RG
C07	15	GT	3	RG	C03	15	GT	3	GD	C07	15	GT	1	GD	C05	15	GT	4	RG	C01	15	GT	4	RG
C17	16	GT	2	RG	C18	16	GT	5	GD	C17	16	GT	1	GD	C13	16	GT	5	RG	C12	16	GT	5	RG
C22	17	GT	5	RG	C05	17	GT	5	GD	C22	17	GT	1	GD	C10	17	GT	5	GD	C11	17	GT	5	RG
C01	18	GT	5	RG	C14	18	GT	3	GD	C01	18	GT	5	GD	C16	18	GT	3	GO	C22	18	GT	5	RG
C19	19	GT	5	RG	C10	19	GT	4	RG	C19	19	GT	2	M	C09	19	GT	4	GO	C13	19	GT	5	RG
C16	20	GT	1	RG	C11	20	GT	5	RG	C14	20	GT	3	GD	C11	20	GT	5	RG	C14	20	GT	5	RG
C06	21	GT	5	RG	C09	21	GT	3	GD	C06	21	GT	5	RG	C02	21	GT	4	RG	C18	21	GT	1	RG
C20	22	GT	4	RG	C15	22	GT	1	GD	C20	22	GT	2	RG	C04	22	GT	5	RG	C15	22	GT	1	RG
C12	23	GT	5	RG	C02	23	GT	1	GD	C12	23	GT	1	RG	C21	23	GT	5	RG	C04	23	GT	1	RG
C21	24	GT	1	RG	C04	24	GT	4	GD	C21	24	GT	3	RG	C18	24	GT	4	RG	C20	24	GT	4	RG
C07	25	GT	2	RG	C03	25	GT	2	RG	C07	25	GT	4	GD	C05	25	GT	1	GO	C01	25	GT	3	RG
C17	26	GT	1	RG	C18	26	GT	2	RG	C17	26	GT	4	GD	C13	26	GT	5	RG	C12	26	GT	5	RG
C22	27	GT	2	RG	C05	27	GT	3	RG	C22	27	GT	5	GD	C10	27	GT	5	RG	C11	27	GT	5	RG
C01	28	GT	5	RG	C14	28	GT	5	RG	C01	28	GT	4	GD	C16	28	GT	5	GD	C22	28	GT	5	RG
C19	29	GT	5	RG	C10	29	GT	2	RG	C19	29	GT	2	RG	C09	29	GT	5	RG	C13	29	GT	5	RG
C16	30	GT	5	GD	C11	30	GT	5	GD	C14	30	GT	3	GO	C11	30	GT	4	GO	C14	30	GT	5	RG
C06	31	GT	5	GD	C09	31	GT	1	GO	C06	31	GT	1	GD	C02	31	GT	5	GO	C18	31	GT	1	RG
C20	32	GT	3	GD	C15	32	GT	2	GD	C20	32	GT	1	GD	C04	32	GT	3	GD	C15	32	GT	1	RG
C12	33	GT	5	GD	C02	33	GT	5	GD	C12	33	GT	1	GD	C21	33	GT	4	GO	C04	33	GT	1	RG
C21	34	GT	4	GD	C04	34	GT	5	GD	C21	34	GT	4	GD	C18	34	GT	1	RG	C20	34	GT	4	RG
C07	35	GT	5	GD	C03	35	GT	4	GD	C07	35	GT	3	GD	C05	35	GT	2	ID	C01	35	GT	4	RG
C17	36	GT	3	RG	C18	36	GT	5	GD	C17	36	GT	1	RG	C13	36	GT	5	RG	C12	36	GT	2	RG
C22	37	GT	3	RG	C05	37	GT	4	GD	C22	37	GT	2	GD	C10	37	GT	5	RG	C11	37	GT	4	RG
C01	38	GT	1	RG	C14	38	GT	4	GD	C01	38	GT	5	GD	C16	38	GT	1	RG	C22	38	GT	5	RG
C19	39	GT	1	RG	C10	39	GT	5	GD	C19	39	GT	1	RG	C09	39	GT	1	RG	C13	39	GT	4	RG
C16	40	GT	3	GD	C11	40	GT	4	GD	C14	40	GT	3	RG	C11	40	GT	2	RG	C14	40	GT	5	RG
C06	41	GT	4	GD	C09	41	GT	1	GD	C06	41	GT	5	GD	C02	41	L	3	M	C18	41	GT	1	RG
C20	42	GT	3	GD	C15	42	GT	4	GD	C20	42	GT	5	RG	C04	42	L	4	M	C15	42	GT	3	RG
C12	43	GT	5	GD	C02	43	GT	3	GD	C12	43	GT	1	GD	C21	43	L	4	M	C04	43	GT	4	RG
C21	44	GT	2	GD	C04	44	GT	3	GD	C21	44	GT	5	RG	C18	44	L	4	M	C20	44	GT	3	RG
C07	45	GT	2	GD	C03	45	GT	2	RG	C07	45	GT	3	GD	C05	45	L	4	M	C01	45	GT	3	RG
C17	46	GT	3	M	C18	46	GT	1	RG	C17	46	GT	4	GD						C12	46	GT	3	RG
C22	47	GT	4	RG	C05	47	GT	1	RG	C22	47	GT	5	GD						C11	47	GT	5	RG
C01	48	O	1	M	C14	48	GT	4	RG	C01	48	GT	5	RG						C22	48	GT	5	RG
C19	49	L	2	M	C10	49	GT	4	GD	C19	49	GT	3	ID						C13	49	GT	5	RG
C16	50	L	3	M	C11	50	O	4	RG	C14	50	GT	2	ID						C14	50	GT	5	RG
			3.1					3.4					2.9					3.8					3.7	

APPENDIX 18: SALTA OBSERVATIONS FOR CLASS C

LESSONS 21-22

	LESSON 21					LESSON 22			
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
C01	1	L	3	M	C02	1	L	2	M
C20	2	L	4	LC	C04	2	L	1	M
C19	3	L	3	LC	C03	3	L	1	M
C06	4	L	4	LC	C18	4	R	1	RG
C12	5	GT	2	GO	C05	5	R	1	M
C14	6	GT	3	GO	C13	6	L	5	M
C17	7	GT	5	RG	C10	7	R	5	RG
C07	8	GT	3	GO	C22	8	W	5	RG
C21	9	GT	2	GO	C09	9	R	5	O
C22	10	GT	5	GO	C11	10	W	5	O
C01	11	GT	4	RG	C02	11	R	5	O
C20	12	GT	3	RG	C04	12	W	5	O
C19	13	GT	5	GD	C03	13	R	4	RG
C06	14	GT	5	GD	C18	14	W	3	O
C12	15	GT	5	O	C05	15	R	5	O
C14	16	GT	5	RG	C13	16	W	5	O
C17	17	GT	5	W	C10	17	R	5	RG
C07	18	GT	3	W	C22	18	W	5	O
C21	19	GT	5	GD	C09	19	R	5	O
C22	20	GT	5	W	C11	20	W	5	O
C01	21	GT	3	W	C02	21	R	1	O
C20	22	GT	2	W	C04	22	W	5	O
C19	23	GT	2	TC	C03	23	R	5	O
C06	24	GT	4	RG	C18	24	W	1	O
C12	25	GT	2	GD	C05	25	R	5	O
C14	26	GT	5	GD	C13	26	W	2	RG
C17	27	GT	5	RG	C10	27	R	1	RG
C07	28	GT	5	GO	C22	28	W	1	RG
C21	29	GT	5	RG	C09	29	R	5	RG
C22	30	GT	5	GO	C11	30	L	4	M
C01	31	GT	5	RG	C02	31	PW	4	RG
C20	32	GT	5	RG					
C19	33	GT	1	RG					
C06	34	GT	4	RG					
C12	35	GT	5	RG					
C14	36	GT	5	RG					
C17	37	GT	5	O					
C07	38	GT	3	GO					
C21	39	GT	4	O					
C22	40	GT	4	O					
C01	41	GT	2	W					
C20	42	GT	1	GD					
C19	43	GT	1	O					
C06	44	GT	5	M					
C12	45	GT	2	M					
C14	46	GT	5	M					
C17	47			M					
C07	48	L	5	M					
C21	49	L	4	M					
			3.8					3.6	

APPENDIX 19: SALTA OBSERVATIONS FOR CLASS D

LESSONS 1-5

LESSON 1					LESSON 2					LESSON 3					LESSON 4					LESSON 5				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
D20	1	L	3	M	D12	1	L	5	M	D08	1	L	3	M	D22	1	L	4	GO	D01	1	L	4	M
D05	2	L	4	M	IS	2	L		M	D05	2	L	3	PD	D23	2	L	3	M	D05	2	CD	5	CD
D19	3	L	3	M	D10	3	W	5	TC	D19	3	L	5	PD	D13	3	L	4	M	D19	3	CD	4	CD
D15	4	L	4	M	D11	4	L	5	TC	D15	4	L	4	PD	D02	4	L	4	M	D15	4	CD	5	CD
D16	5	L	4	M	D09	5	W	5	TC	D07	5	L	5	PD	D16	5	GT	4	GO	D07	5	CD	5	CD
D14	6	L	5	M	D16	6	L	5	TC	D04	6	L	5	PD	D09	6	GT	5	RG	D22	6	CD	3	CD
D07	7	L	4	M	D02	7	CD	5	CD	D17	7	L	5	PD	D11	7	GT	5	RG	D03	7	CD	4	CD
D06	8	GD	4	M	D13	8	CD	5	CD	D10	8	L	5	PD	D06	8	GT	5	TC	D10	8	CD	4	CD
D03	9	GD	2	M	D05	9	W	5	O	D21	9	L	5	M	IS	9	GT		TC	D17	9	L	4	L
D22	10	GD	4	M	D01	10	W	5	W	D22	10	L	5	RG	D12	10	GT	4	TC	D14	10	W	4	M
D20	11	CD	4	TC	D12	11	W	5	RG	D08	11	GT	5	RG	D22	11	GT	3	TC	D01	11	GD	4	M
D05	12	CD	4	CD	IS	12	W		RG	D05	12	GT	5	RG	D23	12	GT	3	TC	D05	12	W	4	M
D19	13	CD	4	CD	D10	13	W	5	RG	D19	13	GT	5	RG	D13	13	GT	4	TC	D19	13	GD	4	M
D15	14	RW	4	TC	D11	14	L	5	TC	D15	14	GT	5	M	D02	14	GT	4	RG	D15	14	R	4	M
D16	15	RW	2	TC	D09	15	L	4	TC	D07	15	GT	5	M	D16	15	GT	4	RG	D07	15	W	5	M
D14	16	RW	4	TC	D16	16	L	5	TC	D04	16	GT	5	RG	D09	16	GT	5	RG	D22	16	R	1	GO
D07	17	RW	4	TC	D02	17	W	5	TC	D17	17	GT	5	RG	D11	17	GT	3	O	D03	17	W	4	GO
D06	18	RW	3	TC	D13	18	L	5	TC	D10	18	GT	5	RG	D06	18	GT	5	RG	D10	18	R	4	GO
D03	19	RW	3	TC	D05	19	W	3	RG	D21	19	GT	5	RG	IS	19	GT		RG	D17	19	V	3	V
D22	20	CD	4	CD	D01	20	O		O	D22	20	GT	5	RG	D12	20	GT	4	M	D14	20	V		V
D20	21	L	5	CD	D12	21	O		L	D08	21	PW	5	RG	D22	21	GT	3	O	D01	21	V	3	V
D05	22	L	4	TC	IS	22	L	4	CD	D05	22	PW	5	RG	D23	22	GT	2	RG	D05	22	V	4	V
D19	23	R	2	W	D10	23	L	5	CD	D19	23	PW	5	RG	D13	23	GT	5	RG	D19	23	V	5	V
D15	24	L	5	CD	D11	24	CD	5	TC	D15	24	PW	5	RG	D02	24	GT	5	RG	D15	24	V	5	V
D16	25	W	2	L	D09	25	CD	3	TC	D07	25	PW	5	RG	D16	25	GT	5	RG	D07	25	V	5	V
D14	26	W	5	L	D16	26	L	3	L	D04	26	PW	5	RG	D09	26	GT	5	M	D22	26	V	5	V
D07	27	L	4	CD	D02	27	L	5	CD	D17	27	PW	5	RG	D11	27	GT	5	RG	D03	27	V	5	V
D06	28	L	5	PD	D13	28	CD	5	CD	D10	28	PW	5	RG	D06	28	GT	3	RG	D10	28	V	5	V
D03	29	L	5	PD	D05	29	W	3	W	D21	29	PW	5	RG	IS	29	GT		RG	D17	29	V	5	V
D22	30	L	3	PD	D01	30	W	4	W	D22	30	PW	5	RG	D12	30	GT	5	GD	D14	30	V	5	V
D20	31	CD	4	L	D12	31	W	3	W	D08	31	GT	3	RG	D22	31	GT	4	RG	D01	31	V	5	V
D05	32	GT	4	RG	IS	32	W		W	D05	32	GT	5	RG	D23	32	GT	2	RG	D05	32	V	5	V
D19	33	GT	4	RG	D10	33	W	5	M	D19	33	GT	5	RG	D13	33	GT	5	RG	D19	33	V	5	V
D15	34	GT	2	RG	D11	34	GT	1	RG	D15	34	GT	5	RG	D02	34	GT	5	RG	D15	34	V	5	V
D16	35	L	3	CD	D09	35	GT	4	RG	D07	35	GT	5	RG	D16	35	GT	4	RG	D07	35	V	5	V
D14	36	L	3	CD	D16	36	CD	5	TC	D04	36	GT	5	RG	D09	36	GT	5	GD	D22	36	V	4	V
D07	37	L	3	CD	D02	37	L	3	W	D17	37	GT	5	M	D11	37	GT	4	GD	D03	37	CD	4	CD
D06	38	L	3	CD	D13	38	W	4	TC	D10	38	GT	5	CD	D06	38	GT	3	RG	D10	38	PW	5	M
D03	39	L	3	CD	D05	39	L	4	TC	D21	39	CD	5	CD	IS	39	GT		RG	D17	39	L	2	M
D22	40	W	4	M	D01	40	W	5	TC	D22	40	CD	5	CD	D12	40	GT	5	RG	D14	40	R	4	M
D20	41	W	5	RG	D12	41	CD	3	TC	D08	41	W	5	LC	D22	41	GT	2	GD	D01	41	L	5	L
D05	42	R	5	RG						D05	42	L	5	LC	D23	42	GT	1	GD	D05	42	R	1	GO
D19	43	GD	5	W						D19	43	L	5	LV	D13	43	GT	5	M	D19	43	W	5	GO
D15	44	CD	5	CD						D15	44	L	4	LC	D02	44	O	4	O	D15	44	R	5	RG
D16	45	CD	5	CD						D07	45	L	5	LC	D16	45	O	4	O	D07	45	W	5	M
										D04	46	L	5	LC	D09	46	CD	5	CD	D22	46	O	3	M
										D17	47	L	5	LC	D11	47	GT	5	CD	D03	47	O	3	M
										D10	48	L	5	LC	D06	48	GT	1	RG					
															IS	49	O		RG					
															D12	50	O	2	M					
			3.8					4.3					4.8					3.9					4.2	

APPENDIX 19: SALTA OBSERVATIONS FOR CLASS D

LESSONS 6-10

LESSON 6					LESSON 7					LESSON 8					LESSON 9					LESSON 10				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
D20	1	L	3	M	D08	1	L	4	M	D20	1	L	3	M	D22	1	L	3	LC	D12	1	O	3	O
D23	2	L	2	M	D05	2	L	3	M	D23	2	L	2	TC	IS	2	L	5	LC	D03	2	L	4	M
D13	3	L	5	M	D19	3	L	3	RG	D13	3	L	5	TC	D10	3	L	5	LC	D06	3	R	2	TC
D02	4	L	5	M	D15	4	GT	1	RG	D02	4	L	3	TC	D17	4	L	3	LC	D04	4	W	4	TC
D16	5	R	1	RG	D07	5	GT	2	O	D16	5	L	5	TC	D04	5	R	1	O	D14	5	L	5	TC
D12	6	R	5	RG	D04	6	GT	2	CD	D09	6	L	5	TC	D07	6	L	2	M	D16	6	W	5	TC
D21	7	R	1	RG	D17	7	CD	3	GO	D11	7	L	3	TC	D15	7	L	5	GO	D02	7	L	5	TC
D06	8	R	5	RG	D06	8	L	3	GO	D06	8	L	1	TC	D19	8	L	2	M	D13	8	W	5	TC
D11	9	R	4	GO	D21	9	PW	5	GO	IS	9	L	5	TC	D05	9	L	4	GO	D23	9	L	4	TC
D04	10	R	4	GO	D22	10	PW	5	RG	D12	10	W	2	W	D08	10	L	5	GO	D20	10	W	5	TC
D20	11	L	4	M	D08	11	PW	5	RG	D20	11	W	5	RG	D22	11	PW	1	RG	D12	11	L	5	TC
D23	12	L	4	M	D05	12	PW	5	GO	D23	12	W	1	RG	IS	12	PW	5	RG	D03	12	PW	3	TC
D13	13	L	4	M	D19	13	PW	5	GO	D13	13	W	4	TC	D10	13	PW	5	GO	D06	13	PW	3	W
D02	14	R	5	RG	D15	14	PW	5	RG	D02	14	L	5	TC	D17	14	PW	5	M	D04	14	PW	5	TC
D16	15	W	5	O	D07	15	PW	5	RG	D16	15	L	1	TC	D04	15	L	3	M	D14	15	W	5	TC
D12	16	R	5	O	D04	16	PW	5	RG	D09	16	W	5	W	D07	16	L	5	M	D16	16	W	5	W
D21	17	W	5	O	D17	17	PW	5	RG	D11	17	L	3	TC	D15	17	L	5	M	D02	17	W	5	W
D06	18	R	5	O	D06	18	PW	5	M	D06	18	L	1	TC	D19	18	L	5	M	D13	18	W	5	TC
D11	19	O		O	D21	19	PW	5	M	IS	19	W	5	W	D05	19	PW	2	GO	D23	19	W	4	RG
D04	20	W	5	O	D22	20	PW	5	RG	D12	20	W	5	W	D08	20	PW	5	GO	D20	20	W	5	RG
D20	21	R	5	O	D08	21	GT	3	RG	D20	21	W	5	TC	D22	21	PW	2	GO	D12	21	L	4	TC
D23	22	W	5	O	D05	22	GT	3	RG	D23	22	L	5	TC	IS	22	PW	5	GO	D03	22	W	3	TC
D13	23	R	5	O	D19	23	GT	5	RG	D13	23	W	3	LC	D10	23	PW	5	RG	D06	23	PW	4	TC
D02	24	W	5	O	D15	24	GT	4	RG	D02	24	R	5	LC	D17	24	PW	5	RG	D04	24	PW	4	RG
D16	25	R	5	O	D07	25	GT	5	RG	D16	25	L	3	LC	D04	25	PW	5	RG	D14	25	PW	5	RG
D12	26	W	5	O	D04	26	GT	4	RG	D09	26	W	5	W	D07	26	PW	5	RG	D16	26	PW	5	RG
D21	27	R	5	O	D17	27	GT	4	RG	D11	27	W	3	O	D15	27	PW	5	RG	D02	27	PW	4	RG
D06	28	W	5	O	D06	28	GT	4	RG	D06	28	W	1	O	D19	28	L	5	M	D13	28	PW	5	TC
D11	29	R	5	O	D21	29	GT	5	M	IS	29	W	5	W	D05	29	L	1	M	D23	29	L	4	TC
D04	30	W	5	O	D22	30	GT	3	RG	D12	30	W	5	O	D08	30	L	5	RG	D20	30	L	4	RG
D20	31	R	5	O	D08	31	O	1	M	D20	31	W	3	O	D22	31	PW	2	GO	D12	31	PW	3	W
D23	32	W	4	O	D05	32	O	1	TC	D23	32	W	2	O	IS	32	PW	5	RG	D03	32	L	4	TC
D13	33	O	3	O	D19	33	R	5	TC	D13	33	W	1	W	D10	33	PW	5	RG	D06	33	L	3	RG
D02	34	O	3	GO	D15	34	L	4	TC	D02	34	L	3	TC	D17	34	PW	5	GO	D04	34	PW	4	RG
D16	35	V	4	M	D07	35	L	5	TC	D16	35	W	4	TC	D04	35	PW	5	GO	D14	35	PW	3	ID
D12	36	V	2	RG	D04	36	GT	4	RG	D09	36	W	5	RG	D07	36	PW	5	GO	D16	36	PW	1	RG
D21	37	V	5	V	D17	37	GT	4	M	D11	37	W	5	RG	D15	37	PW	5	GO	D02	37	PW	5	RG
D06	38	V	5	V	D06	38	GT	5	GO	D06	38	L	3	TC	D19	38	PW	5	RG	D13	38	PW	5	W
D11	39	V	5	V	D21	39	GT	4	RG	IS	39	L	5	TC	D05	39	PW	1	RG	D23	39	PW	3	RG
D04	40	V	5	V	D22	40	GT	4	RG	D12	40	L	4	TC	D08	40	PW	5	RG	D20	40	L	5	LC
D20	41	V	5	V	D08	41	GT	5	RG	D20	41	L	5	TC	D22	41	PW	3	RG	D12	41	PW	5	TC
D23	42	V	5	V	D05	42	GT	5	RG	D23	42	W	5	W	IS	42	PW	3	RG	D03	42	PW	2	RG
D13	43	V	5	V	D19	43	GT	5	RG	D13	43	W	5	W	D10	43	PW	5	RG	D06	43	PW	2	RG
D02	44	V	5	V	D15	44	L	5	RG	D02	44	W	5	W	D17	44	L	5	M	D04	44	PW	3	RG
D16	45	V	5	V	D07	45	GT	4	M	D16	45	W	5	W	D04	45	L	5	M	D14	45	PW	4	TC
D12	46	V	5	V	D04	46	PW	1	M	D09	46	W	5	RG	D07	46	PW	4	RG	D16	46	PW	4	RG
					D17	47	CD	4	PD	D11	47	L	2	TC	D15	47			RG	D02	47	PW	5	RG
					D06	48	R	5	M	D06	48	L	4	TC	D19	48	L	5	LC	D13	48			RG
					D21	49	CD	5	W	IS	49	W	5	RG	D05	49	L	2	LC	D23	49	PW	4	RG
					D22	50	CD	4	M	D12	50	W	5	RG						D20	50			M
			4.4					4					3.8					4					4	

APPENDIX 19: SALTA OBSERVATIONS FOR CLASS D

LESSONS 11-15

LESSON 11					LESSON 12					LESSON 13					LESSON 14					LESSON 15				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
D09	1	L	4	M	D14	1	L	5	M	D09	1	L	4	TC	D14	1	L	5	M	D04	1	L	3	LC
D17	2	L	3	M	D11	2	L	4	M	D17	2	L	4	CD	D11	2	L	5	M	D17	2	L	3	LC
D10	3	L	4	TC	D06	3	L	5	M	D10	3	L	3	CD	D06	3	L	4	TC	D10	3	L	4	LC
D21	4	CD	3	CD	IS	4	L	5	M	D21	4	GD	1	M	D03	4	L	5	TC	D21	4	L	3	LC
D22	5	CD	4	CD	D12	5	O	5	GO	D22	5	GD	1	RG	D12	5	L	5	CD	D22	5	L	4	LC
D01	6	CD	4	CD	D08	6	R	4	GO	D01	6	GD	3	M	D20	6	L	5	CD	D08	6	L	4	TC
D05	7	CD	4	CD	D23	7	R	2	RG	D05	7	GD	3	CD	D23	7	W	5	CD	D05	7	L	2	TC
D19	8	CD	4	CD	D13	8	R	5	RG	D19	8	GD	5	LC	D13	8	L	5	CD	D19	8	L	4	TC
D15	9	PW	5	W	D02	9	R	1	O	D15	9	CD	4	CD	D02	9	W	5	CD	D15	9	L	4	TC
D07	10	PW	5	W	D16	10	R	1	O	D16	10	CD	4	CD	D07	10	L	5	CD	D07	10	W	5	RG
D09	11	PW	5	W	D14	11	R	3	ID	D09	11	L	5	M	D14	11	CD	4	CD	D04	11	W	4	TC
D17	12	PW	5	W	D11	12	R	3	M	D17	12	L	3	GO	D11	12	L	4	M	D17	12	W	4	RG
D10	13	PW	5	W	D06	13	R	4	M	D10	13	PW	5	GO	D06	13	GT	5	M	D10	13	W	1	RG
D21	14	PW	4	W	IS	14	L	5	M	D21	14	PW	5	RG	D03	14	GT	3	W	D21	14	W	5	TC
D22	15	PW	4	W	D12	15	R	5	RG	D22	15	PW	4	RG	D12	15	GT	1	W	D22	15	W	5	TC
D01	16	PW	3	M	D08	16	W	5	RG	D01	16	PW	4	W	D20	16	GT	3	W	D08	16	W	5	TC
D05	17	PW	3	RG	D23	17	R	5	O	D05	17	PW	5	W	D23	17	GT	2	M	D05	17	W	3	RG
D19	18	PW	3	RG	D13	18	W	5	O	D19	18	L	3	GO	D13	18	GT	5	GD	D19	18	W	5	M
D15	19	PW	3	RG	D02	19	R	5	O	D15	19	L	5	GO	D02	19	GT	5	RG	D15	19	W	5	M
D07	20	PW	5	RG	D16	20	W	5	RG	D16	20	L	5	M	D07	20	GT	3	RG	D07	20	W	5	RG
D09	21	PW	5	RG	D14	21	R	5	RG	D09	21	R	5	W	D14	21	PW	2	W	D04	21	W	5	RG
D17	22	PW	1	RG	D11	22	W	5	O	D17	22	W	5	W	D11	22	PW	5	TC	D17	22	W	4	RG
D10	23	PW	1	W	D06	23	R	5	O	D10	23	R	5	TC	D06	23	PW	5	RG	D10	23	W	4	W
D21	24	PW	1	W	IS	24	W	5	O	D21	24	W	5	TC	D03	24	PW	5	M	D21	24	W	5	LC
D22	25	CD	5	CD	D12	25	R	5	O	D22	25	R	4	TC	D12	25	PW	1	RG	D22	25	L	4	M
D01	26	CD	3	CD	D08	26	W	5	O	D01	26	W	4	TC	D20	26	PW	3	RG	D08	26	L	4	M
D05	27	PW	2	W	D23	27	R	4	O	D05	27	R	3	TC	D23	27	PW	5	RG	D05	27	R	5	M
D19	28	PW	4	W	D13	28	W	5	O	D19	28	W	4	TC	D13	28	PW	5	RG	D19	28	W	5	RG
D15	29	PW	4	W	D02	29	R	5	O	D15	29	R	4	TC	D02	29	PW	5	RG	D15	29	R	5	RG
D07	30	PW	5	W	D16	30	W	5	O	D16	30	W	5	TC	D07	30	PW	5	RG	D07	30	W	5	RG
D09	31	PW	5	W	D14	31	R	5	O	D09	31	W	5	W	D14	31	GT	4	RG	D04	31	W	5	RG
D17	32	PW	3	W	D11	32	W	3	RG	D17	32	W	5	W	D11	32	GT	1	RG	D17	32	W	5	RG
D10	33	PW	4	W	D06	33	R	3	RG	D10	33	W	5	W	D06	33	GT	2	M	D10	33	L	5	CD
D21	34	PW	1	RG	IS	34	W	3	RG	D21	34	W	5	TC	D03	34	L	4	M	D21	34	L	5	CD
D22	35	PW	1	RG	D12	35	R	5	RG	D22	35	W	5	W	D12	35	L	2	TC	D22	35	L	4	CD
D01	36	PW	3	RG	D08	36	O	5	RG	D01	36	W	4	RG	D20	36	L	4	LC	D08	36	L	5	M
D05	37	PW	1	W	D23	37	O	5	O	D05	37	W	5	CD	D23	37	L	3	LC	D05	37	L	2	M
D19	38	L	4	TC	D13	38	L	5	O	D19	38	W	5	PD	D13	38	O	4	O	D19	38	PW	5	O
D15	39	CD	4	CD	D02	39	L	4	M	D15	39	L	5	PD	D02	39	O	3	O	D15	39	PW	5	ID
D07	40	CD	5	CD	D16	40	L	3	M	D16	40	PW	5	GO	D07	40	O	4	M	D07	40	PW	5	RG
D09	41	PW	5	RG	D14	41	R	5	M	D09	41	GT	5	GO	D14	41	L	5	CD	D04	41	GT	3	RG
D17	42	L	2	TC	D11	42	R	4	M	D17	42	GT	5	GO	D11	42	L	2	TC	D17	42	GT	4	PD
D10	43	L	3	TC	D06	43	L	1	M	D10	43	GT	5	GO	D06	43	L	5	TC	D10	43	GT	5	PD
D21	44	L	2	TC	IS	44	R	1	M	D21	44	GT	5	GO	D03	44	R	3	M	D21	44	GT	5	RG
D22	45	L	1	TC	D12	45	L	5	M	D22	45	GT	4	GO	D12	45	L	2	M	D22	45	GT	4	RG
D01	46	L	4	PD	D08	46	R	5	M	D01	46	GT	5	RG	D20	46	R	5	M	D08	46	GT	5	RG
D05	47	L	3	PD	D23	47	L	1	M	D05	47	GT	5	W	D23	47	L	3	M	D05	47	GT	4	RG
D19	48	L	5	M	D13	48	O	5	M	D19	48	CD	5	RG	D13	48	R	5	M	D19	48	GT	5	W
D15	49	L	4	M	D02	49	O	5	M	D15	49	CD	3	CD	D02	49	L	5	M	D15	49	W	5	TC
					D16	50	O	5	M	D16	50	CD	3	M	D07	50	R	5	M	D07	50	W	5	TC
			3.5					4.2					4.3					3.9					4.3	

APPENDIX 19: SALTA OBSERVATIONS FOR CLASS D

LESSONS 16-20

LESSON 16					LESSON 17					LESSON 18					LESSON 19					LESSON 20				
STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A	STU	TM	ACT	LVL	T.A
D07	1	L		PD	D16	1	L	3	M	D03	1	O	3	M	D20	1	L	4	M	D14	1	L	4	M
D02	2	L		PD	D02	2	L	4	M	D23	2	O	2	M	D04	2	L	3	M	D11	2	L	4	PD
D08	3	L		PD	D19	3	L	5	M	D04	3	O	3	LC	D15	3	L	3	M	D19	3	L	4	PD
D23	4	CD		PD	D22	4	L	2	M	D15	4	L	4	LC	D07	4	PW	4	M	D03	4	L	4	PD
D01	5	O		PD	D01	5	L	4	M	D16	5	L	2	LC	D17	5	PW	4	GO	D21	5	L	4	PD
D17	6	O		PD	D11	6	L	3	TC	D12	6	L	3	W	IS	6	PW		GO	D09	6	L	4	M
D11	7	O		PD	D14	7	L	4	TC	D21	7	L	4	W	D12	7	PW	5	M	D02	7	L	4	M
D06	8	O		PD	D07	8	L	4	TC	D10	8	L	4	W	D09	8	PW	5	GO	D01	8	O	3	GO
IS	9	O		M	IS	9	L		W	D22	9	L	4	W	D16	9	PW	2	GO	D22	9	O	3	M
D21	10	O		M	D03	10	GT	5	RG	D09	10	L	5	LC	D10	10	PW	5	RG	D08	10	O	3	M
D07	11	O	2	PD	D16	11	GT	2	RG	D03	11	L	5	M	D20	11	PW	5	RG	D14	11	PW	3	M
D02	12	O	4	PD	D02	12	GT	4	RG	D23	12	L	5	M	D04	12	PW	3	RG	D11	12	PW	1	GO
D08	13	O	2	PD	D19	13	W	4	RG	D04	13	L	5	M	D15	13	PW	5	RG	D19	13	T	5	GO
D23	14	O	1	PD	D22	14	W	2	RG	D15	14	GT	5	RG	D07	14	O	4	O	D03	14	GT	5	RG
D01	15	O	4	PD	D01	15	W	5	RG	D16	15	GT	2	RG	D17	15	PW	4	RG	D21	15	GT	5	RG
D17	16	L	3	CD	D11	16	W	2	M	D12	16	GT	3	RG	IS	16	PW	5	RG	D09	16	GT	5	RG
D11	17	L	4	CD	D14	17	W	5	RG	D21	17	GT	4	RG	D12	17	PW	5	RG	D02	17	T	5	RG
D06	18	L	3	CD	D07	18	W	5	CD	D10	18	GT	4	RG	D09	18	PW	5	GO	D01	18	T	5	RG
IS	19	L		TC	IS	19	L		CD	D22	19	GT	4	GO	D16	19	PW	3	M	D22	19	GT	4	GD
D21	20	L	3	TC	D03	20	L	5	CD	D09	20	GT	4	GO	D10	20	R	4	M	D08	20	T	5	GO
D07	21	W	5	TC	D16	21	L	5	TC	D03	21	GT	5	GO	D20	21	T	5	O	D14	21	GT	4	RG
D02	22	W	4	TC	D02	22	W	5	CD	D23	22	GT	2	GO	D04	22	T	5	O	D11	22			RG
D08	23	W	4	GO	D19	23	L	3	CD	D04	23	GT	1	GO	D15	23	T	5	O	D19	23	T	5	RG
D23	24	L	3	PD	D22	24	L	2	PD	D15	24	GT	1	GO	D07	24	T	5	O	D03	24	GT	3	RG
D01	25	PW	1	M	D01	25	L	4	GO	D16	25	GT	1	GO	D17	25	T	5	O	D21	25	GT	4	RG
D17	26	PW	1	M	D11	26	GT	5	GO	D12	26	GT	1	GO	IS	26	T	5	O	D09	26	GT	4	RG
D11	27	PW	2	PH	D14	27	GT	5	RG	D21	27	GT	4	GO	D12	27	T	5	O	D02	27	GT	5	RG
D06	28	PW	5	RG	D07	28	GT	5	RG	D10	28	GT	5	RG	D09	28	T	5	O	D01	28	T	5	RG
IS	29	PW		RG	IS	29	GT		GO	D22	29	GT	1	RG	D16	29	T	2	O	D22	29	GT	5	RG
D21	30	PW	4	RG	D03	30	GT	5	RG	D09	30	GT	1	RG	D10	30	T	5	O	D08	30	T	5	RG
D07	31	PW	5	GD	D16	31	L	2	M	D03	31	GT	5	RG	D20	31	T	5	O	D14	31	GT		RG
D02	32	PW	5	W	D02	32	L	3	TC	D23	32	GT	1	RG	D04	32	T	4	O	D11	32			RG
D08	33	PW	5	W	D19	33	GT	5	M	D04	33	GT	2	GD	D15	33	T	5	O	D19	33	T	5	RG
D23	34	PW	1	RG	D22	34	GT	1	RG	D15	34	GT	4	GD	D07	34	T	5	O	D03	34	GT	5	RG
D01	35	PW	2	RG	D01	35	GT	5	RG	D16	35	GT	1	RG	D17	35	T	3	O	D21	35	GT	5	RG
D17	36	PW	2	CD	D11	36	GT	4	RG	D12	36	GT	3	RG	IS	36	T	5	O	D09	36	GT	4	RG
D11	37	W	4	TC	D14	37	GT	5	RG	D21	37	GT	5	GO	D12	37	T	5	O	D02	37	GT	5	RG
D06	38	W	2	W	D07	38	GT	2	GD	D10	38	L	1	GO	D09	38	T	3	O	D01	38	GT	2	RG
IS	39	W		W	IS	39	GT		GD	D22	39	L	1	M	D16	39	T	1	O	D22	39	GT	5	RG
D21	40	W	3	RG	D03	40	GT	5	RG	D09	40	L	4	LC	D10	40	T	3	O	D08	40	GT	4	RG
D07	41	W	4	RG	D16	41	GT	5	RG	D03	41	GT	5	LC						D14	41	GT	5	RG
D02	42	W	5	W	D02	42	GT	5	RG	D23	42	L	2	LC						D11	42			GD
D08	43	L	5	TC	D19	43	GT	4	RG	D04	43	L	2	M						D19	43	GT	2	GD
D23	44	W	1	TC	D22	44	GT	1	RG	D15	44	L	3	M						D03	44	GT	5	GD
D01	45	O	4	TC	D01	45	GT	5	RG	D16	45	GT	3	RG						D21	45	GT	5	GD
D17	46	O	2	GO	D11	46	GT	1	RG	D12	46	GT	2	O						D09	46	GT		GD
D11	47	O	2	GO	D14	47	GT	5	M	D21	47	GT	5	O						D02	47	GT	5	RG
D06	48	O	2	PD	D07	48	GT	2	M	D10	48	GT	2	RG						D01	48	GT	4	GD
IS	49	O		PD	IS	49	GT		CD	D22	49	GT	1	RG						D22	49	GT	5	GD
D21	50	O	4	PD	D03	50	L	5	CD	D09	50	GT	1	GD						D08	50	GT	4	GD
			3.1					3.8					3					4.2					4.2	

APPENDIX 19: SALTA OBSERVATIONS FOR CLASS D

LESSON 21

	LESSON 21			
STU	TM	ACT	LVL	T.A
D07	1	L	5	M
IS	2	W		M
D02	3	W	5	M
D17	4	W	5	W
D20	5	W	5	M
D08	6	W	5	M
D11	7	W	5	M
D23	8	W	3	M
D16	9	W	4	M
D12	10	W	5	M
D07	11	GT	5	GO
IS	12	GT		GO
D02	13	GT	2	GO
D17	14			GO
D20	15	GT	5	GO
D08	16			GO
D11	17	GT	1	GO
D23	18	GT	2	GO
D16	19	GT	2	GO
D12	20	GT	5	GO
D07	21	PW	5	RG
IS	22			RG
D02	23	PW	2	RG
D17	24			RG
D20	25	PW	5	RG
D08	26	PW		RG
D11	27	PW	3	RG
D23	28	PW	4	RG
D16	29	PW		RG
D12	30	PW		RG
D07	31	GT	5	RG
IS	32			RG
D02	33	GT	4	RG
D17	34			RG
D20	35	GT	5	RG
D08	36	GT	4	RG
D11	37	GT	1	RG
D23	38	GT	2	RG
D16	39			RG
D12	40			RG
D07	41	PW	5	RG
IS	42			RG
D02	43	PW	3	RG
D17	44			RG
D20	45			RG
D08	46	PW	5	RG
D11	47	PW	1	RG
D23	48			RG
D16	49			RG
D12	50			RG
			3.8	