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# **The learning and transfer of science process skills in New Zealand secondary school distance education**

A thesis presented in partial fulfilment of the  
requirements for the degree  
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## Abstract

This study investigates whether the science process skills of processing and interpreting scientific information, carrying out an investigation, communicating information and using information can be transferred across the strands of the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b). The data were collected during the 1995 school year and was from a level 6 science course developed by the Correspondence School. Measurements of student performance were taken from moderated teacher-marked activities and were analysed using group means comparisons of each science process skill taught and pair-wise comparisons of students' performance. A representative population sample, chosen by using stratified random sampling, was surveyed on how they viewed the skills offered in the level 6 science course. The fulltime teachers who marked the level 6 science course in 1995, were also surveyed about the success of the course. The broad method used to conduct this research was illuminative evaluation. Results indicate, that while whole process skills such as carrying out an investigation may be transferable, other science process skills are more context bound and less likely to be transferred.

# The Correspondence School

Wellington New Zealand



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# 1 Introduction

This thesis investigates the learning and transfer of science skills of investigation and the science process skills entailed, in a distance education setting. In this study the term 'science skills' embraces both routines of low cognitive content learnt by repeated rehearsal and those of high cognitive content such as communicating, classifying or predicting, while the term 'science process skills' is reserved for the coming together of the science skills to solve practical problems. Processes and methods are also linked. A method is understood by the researcher to be a collection of processes, while a process is a collection of skills that are used together. Processes are usually represented as a cycle or loop which in science learning and teaching goes through hypothesizing, experimenting, designing, evaluating, recording, interpreting and communicating but a skill is a capacity or a competence, the ability to successfully perform a task of some kind whether intellectual or manual. Watts (1991) prefers to classify science skills into specific and general skills. General skills are identified in clusters, for example, social skills, and degrees of skillfulness are recognized. These definitions hold true for both distance as well as face-to-face education.

The Correspondence School, Wellington, provides distance education for New Zealand citizens of compulsory school age, who are unable to attend conventional face-to-face schools in New Zealand. Some adults who wish to study at the post-primary level also study with the Correspondence School, as do some Home Schoolers who do not wish to attend conventional schools. Another group of students that use the Correspondence School courses are the secondary school students who are unable to study subjects at their own schools due to absence of teachers in that subject or because there are too few students to qualify for teacher time.

In 1995 the Correspondence School offered a skill-based, level 6 science course for the first time to cover the requirements of *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the new School Certificate Science Prescription (1994). The course is intended for year 11 students who are preparing for the external School Certificate Science Examination. *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) is one of the curriculum documents of *The New Zealand Curriculum Framework* (Ministry of Education 1993a) which presents the policy for

learning and assessment in all New Zealand schools, including the distance education situation of the Correspondence School. There was no national policy for distance education in 1995, the year of the present study, with the distinction between the two separate modes of face-to face and distance learning and teaching not evident in the curriculum and Ministry of Education documents. The documents gave guidance of what every student should be taught in each subject, but it was up to each school and teacher to choose the exact contexts, learning experiences and assessment tasks. This influenced what teachers included or did not include in their courses and could affect what children learn in different parts of the country. Due to individual circumstances, many students spend only a short time studying with the Correspondence School before returning to the classrooms of conventional schools. It is thought they may be disadvantaged by having to repeat work already completed, or by missing chunks of work previously done in their new school's programme.

This research highlights the issues encountered providing distance education courses to promote science skills and science process skills. It also has the potential to provide information on the learning and transfer of practical science skills in New Zealand post-primary distance education and indicate ways future development of other skill-based, distance education science courses could proceed or be revised. The research also gave the opportunity to see how the performance of different groups of students compared, while using a single science course for learning science process skills.

The reason for under taking this study was to find out if:

- (a) skills and science process skills can be successfully taught by a distance education course so that transfer from one science context to another can occur
- (b) a single distance education course, at a particular curriculum level, could accommodate several different groups of the student population.

### ***The structure of the thesis***

Following the introduction, the literature review (chapter 2) describes recent research in skill development and learning. The current view of science education presents science as a hierarchy of science skills and processes. It believes science skills can be taught, improved and then used in different

situations, however there are debates over whether such skill-learning is permanent and whether skill-learning should be isolated from the contexts in which the skills are used. This chapter continues with a review of the theories of teaching and learning science skills and the relationship between skill development and teaching practice. This is followed by a look at the factors that influence the learning and transfer of skills, especially student characteristics, teaching contexts, approach to learning tasks and assessment of skills and learning outcomes.

In chapter 3 the methodology chosen to investigate the research questions is described. The method used in this study come under illuminative evaluation umbrella and covers document analysis, student performance and perception of the level 6 Correspondence School science course. Teacher perceptions were also looked at as their opinions may have a flow on effect to the students, along with data gathered from student logsheets, the computerized Student Information System and questionnaires.

The next four chapters report on the data obtained from document analysis, student performance and the student and teacher perceptions of the level 6 Correspondence School science course. The data collected include grades recorded by teachers and what students and teachers think about the course and how they respond to the questionnaires.

In the discussion (chapter 8) the researcher attempts to pull all the threads of the research together to form an overview of how science skill learning and teaching at a distance affects student performance and progress through the school system and later in the work force.

In the last chapter (chapter nine) the findings of the study are brought together and recommendations are made for future skill based courses and research.



## 2 Literature Review

This chapter begins with a discussion of the meaning of the term 'skill'. It traces the way the term has been used over time and how skills have been classified. It continues with an outline of the current theoretical perspectives on the teaching and learning of skills and the contribution these theories have made to understanding the processes of skill learning and transfer. The debate on whether skills can be transferred from one situation to another is discussed and the research into the transfer of skills is reviewed. Several factors that may affect or influence the learning and transfer of science skills are identified. Evidence is taken from general education literature with a focus on science education literature.

### 2.1 *The meaning of 'skill'*

The usage of the term 'skill' has evolved over a period of time. It was used to describe something relatively routine, low in cognitive content and learned through rehearsal. Now the term is used to embrace a broad cognitive view as described in expressions such as problem-solving skills, management skills or interpersonal skills. Philosophers of 30 years ago, such as Peters (1966) have described skill training as the antithesis of education. In the 1990s however, the language of skills embraces activities with a relatively low, though significant, level of cognitive content (drilling a hole in a metal plate), and activities with a high level of cognitive content, (chairing a discussion, negotiating a contract). Fairbrother (1993) describes skills as things that students do. He says the term 'skills' must embrace broad actions as well as specific ones, macro-skills and micro-skills and should not be confined just to practical work. He emphasizes that skills are not only visible things you can see people doing but also invisible things such as thinking that must be inferred from some other action. Bridges (1993) takes the expanded view of skill and considers a well-balanced education should contain both the acquisition of knowledge and the ability to undertake and complete tasks of everyday life in co-operation with other people.

#### 2.1.1 **Science process skills**

In science education the term 'practical work' and the activity to which it relates, has been central to science programmes for many years. In some science texts, terms such as 'experimental work' 'laboratory work' and more recently 'process skills' have become interchangeable with the term 'practical work'. Other texts use the terms 'practical work', 'experimental work' and

'laboratory work' for the 'actual doing' of science activities such as observing, inferring, measuring, communicating, classifying and predicting. The term 'process skills' is then reserved for the coming together of those activities to solve practical problems, by using students' ability to make hypotheses, identify and control variables, interpret data and carry out investigations and this is the understanding to be used in this study. Jenkins (1989) said the recent emphasis on the process approach is due to the different meanings of 'process' used in science education literature as well as the rhetoric of official documents. Watts (1991) said it was not always clear where skills end and process starts. Often, the terms for different types of process skills have been interchanged and there is a problem in distinguishing between them. Ideally in schools, 'doing science' is seen as providing learning situations where students can use skills and apply processes to solve real life problems. Watts and Pope (1989, cited in Wellington, 1989) viewed this 'doing' of science as a pedagogic shift towards a strong child-centered constructivist model of participative group learning and away from traditional didactic methods.

The term 'process skills' has been used in several recent western curricular documents such as *Warwick Process Science* (Screen 1986) and the *Suffolk Co-ordinated Science Development* (Dobson 1987). These documents and others published since, for example, *Science in the New Zealand Curriculum* (1993b) have divided science process skills into generic, essential, core skills, transferable and cross-curricular skills. These are all general science skills as referred to by Watts (1991), because they could be applied across different cognitive domains or subject areas and across a variety of social and employment situations.

## **2.2 Theoretical perspectives on skill teaching and learning**

Theoretical perspectives on learning which are significant for learning in science in New Zealand through the Correspondence School are the behavioural and the cognitive traditions. These traditions will be outlined to show their relevance to the present study. Transfer theories of skill learning in particular are discussed.

### **2.2.1 Theoretical perspectives on learning**

Ryba (1990) suggests that learning may be looked on as a continuum between two traditions, behavioural and cognitive, and, depending on the

task, learning programmes can use the strategies from either side the dichotomy as shown in figure 2.1.

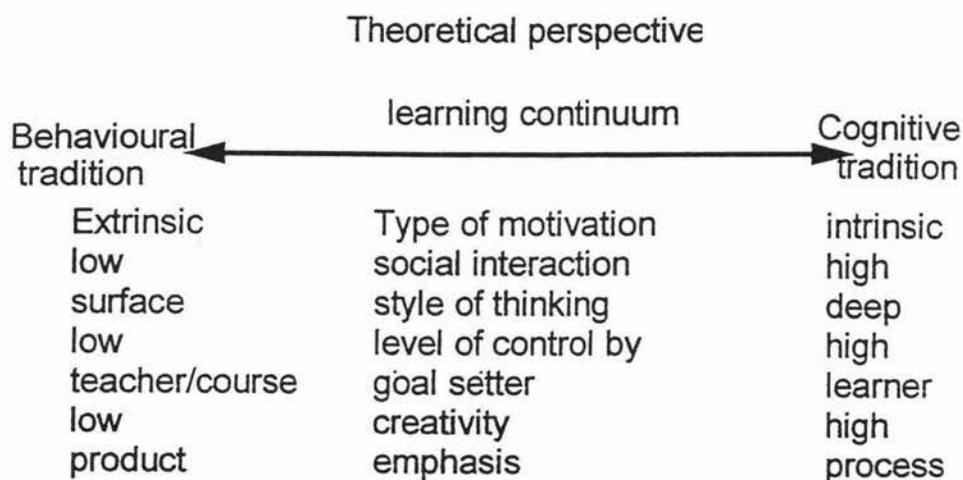


Fig. 2.1 Showing the dichotomy of learning theories. From Ryba (1990).

#### (i) Behavioural Tradition

The behavioural tradition is concerned mostly with behaviour and its modification rather than with mental processes. There is a strong emphasis on control and manipulation of stimuli and appropriate sequencing of learning material. The learning material is structured so that small learning steps are provided, along with positive reinforcement when the student gets it right. These small steps then have to be linked in chains to give mastery of complex material. The behavioural tradition began as control of sequenced subject material so that learning was maximized. It stressed the relationship between learning opportunities and the need to make the teaching process more efficient. Skinner (1954), using his principles of Operant Conditioning developed this tradition with the use of teaching machines. Behavioural theories such as Skinner's are based on reinforcement and correction in guiding student responses towards a prescribed goal. This matches the design of many self-instructional materials used in distance education.

#### (ii) Humanistic tradition

Between the behavioural and the cognitive perspectives is the humanistic tradition. Over the years humanistic theories have influenced New Zealand

education. These theories described each individual as having an inner drive to fulfil the best of their potential. Maslow (1968) theorized that once basic survival needs were met, people then express their growth needs for love, esteem and self-actualization. While Rogers (1966) pointed out, that to become fully functional, people must receive unconditional positive regard from significant others in their lives. Beyond this unconditional regard, critics of humanism say there is a need for social reform and constructive guidance.

### (iii) Cognitive tradition

The cognitive tradition is concerned with the processes of thinking and learning. Ausubel (1968) said that material is more readily learned when it is meaningful than when it is not, (the material should be made comprehensible to the learner by relating it to their current state of knowledge). Advance organizers were used to link previous knowledge to new learning.

The cognitive tradition emphasizes existing cognitive structure and the prior knowledge of the learner and how this impacts on what is learnt. It assumes that each learner brings special and unique prior learning and perceptions to the learning situation that will influence whether new learning occurs. All these factors combine to affect the way a particular learner responds and completes a learning task. There are several perspectives (see figure 2.2) of the cognitive tradition each with their distinct features but all have similar assumptions about the learning process. These will be discussed in turn.

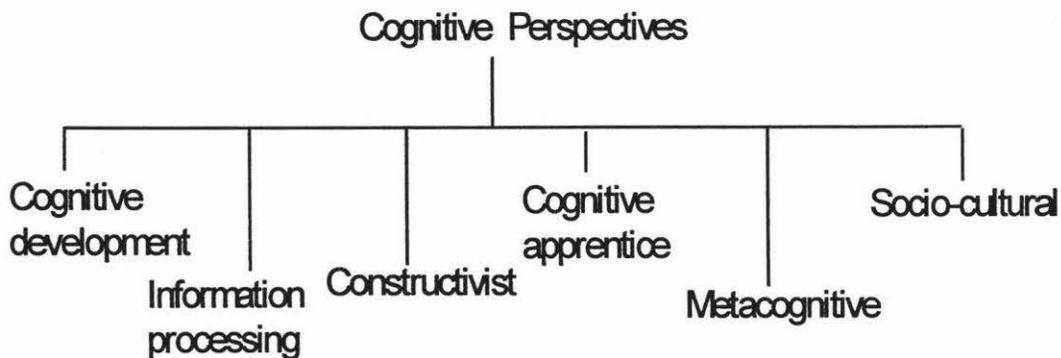


Fig 2.2 The major cognitive perspectives

### Cognitive development

The cognitive developmental tradition stresses the Piagetian age-related restrictions on what level of learning could be expected of a child at a certain age. It proposes that certain curriculum topics requiring higher order thinking should be deferred until students have reached an appropriate stage of development. Piaget (1896 - 1980) inferred levels of the cognitive development of people from their performance on a set of interview tasks. If a person successfully completed the tasks, he inferred they were able to handle advanced propositions of logic and therefore were capable of learning advanced subject matter. Piaget described them as rational, logical thinkers who used formal, abstract operations. By using these types of tasks researchers have found many secondary students and adults do not reach abstract or formal levels of logic. It is inferred that these students fail to understand science because they simply have not attained a high enough level of rational thinking. Usually in everyday life, we would assume that the person did not understand what was required, not that they lacked logic.

### Information processing

The key to successful learning from the information processing point of view lies in the quality of the processing. The cognitive processes such as information acquisition, retention and retrieval are thought to act similarly to processes in a computer (McInerney and McInerney 1994). This belief has led to the direct teaching of cognitive strategies so that students trained in them can use them to help their learning. In distance education cognitive strategies are modeled or talked through even though the conversation is one way, from the teacher to the student, until the student has an opportunity to use the strategies and reply with their work.

### Constructivist views

Constructivist views of learning see learning as the active process of making sense of experiences by relating the new experiences to prior knowledge (Jones and Mercer 1993). This learning was originally considered to occur on a personal basis and later in the social context of the learner.

In the personal constructivist's view the students learn by processing new information on the basis of what they already know and they then construct their new knowledge. Driver and Bell (1986) had described learning as a process in which the learner is actively engaged in constructing meanings from text, dialogue and experimentation. As students encountered the

formal ideas of science, conflict occurred with their prior knowledge. Research showed a possible outcome of this conflict could be students storing aspects of the scientist's viewpoint in their memory even though it was not the way they think about it.

In the social constructivist's view the individual learner and their social environment are two parts of a whole system, each a balancing opposing force which constantly interact. Crain (1992) describes how Vygotsky (1978) adapted the idea of dialectical process to form one of his main concepts of internalisation of interpersonal processes. From this students are said firstly to learn from their social environment and then individually learn and internalise what is unique to them.

Constructivism is important to this study because it underpins *Science in the New Zealand Curriculum* (1993b).

#### Cognitive apprenticeship

The role of the teacher plays a prominent part in the cognitive apprenticeship view of learning as it is seen as helping the students gain domain specific knowledge. This view is based on the idea that expert learners have more knowledge than novices do. The teacher is expected to provide scaffolded instruction during which control is gradually faded to the student (Resnick, 1987). Scaffolding is seen as a strategy in the early stages of learning that provides the student with help and support, but as the student becomes more confident, the support is gradually withdrawn. Borkowski (1985, cited in Biggs 1991) thought, as Vygotsky (1978) had earlier, that this process was important in learning how to transfer. It is believed that students should gain knowledge and skills in contexts where they will have to apply their knowledge in the future.

#### Metacognitive view

Metacognitive skills are higher order thinking skills which students use to regulate their own learning. These skills are significant because they are thought to be responsible for the ability of learning to learn (Flavell 1976). This description of thinking and regulation of one's thinking was followed by many studies of learning processes such as those in reading (Brown, 1978, Paris, Cross and Lipson, 1984; Wittrock, 1986). The main thrust of the metacognitive view is to encourage learners to become reflective

thinkers and self-directed learners (Ryba and Anderson, 1990), and this is also the intention of distance education.

### Socio-cultural view

The socio-cultural view is related to social constructivism. It considers learning as a social activity within culture rather than a set of cognitive processes existing inside the head. Crook (1994) suggests through analysis and thinking people interact with their environment. This theory puts forward Vygotsky's and Luria's work of the 1930s as three main ideas of socio-cultural learning, which are:

- importance of culture

- central role of language

- zone of proximal development (ZPD) which underpins Bruners's scaffolding(1973).

Vygotsky sees human development as a process that occurs as a result of the interactions between the internal or biological heritage and the external environment. The external environment with which humans interact includes psychological tools and signs, such as language, writing and mathematics, which are present during their time in history and in their culture. This also includes attitudes, values and beliefs of the culture, which are transmitted through social interaction and eventually internalised. Vygotsky brought the two lines of thought of the internal and external environments together into the concept of 'internalisation of interpersonal processes' (Vygotsky 1978, p57) as described under social constructivism.

The second idea of language being at the centre of human culture has long been recognized (Moll 1990). Language is seen as the organizer of thought and as a tool that helps individuals to think and communicate in new ways (Jones and Mercer 1993). Students use speech and actions together in the development of metacognitive processes and in problem solving. This socio-cultural view implies that language provides the environment for teaching and learning. Therefore effective language development should allow students the opportunity to learn more efficiently.

The third idea, the zone of proximal development, is important to this study as it refers to the distance between actual development as determined by independent problem-solving and the level of potential achievement as determined through problem-solving under adult guidance or with more

capable peers (Vygotsky 1978). In this type of environment teachers provide scaffolding for better learning. This view has in many ways been responsible for the development of group work among students. Group work among distance education students is not always possible and the interactions between students in a group are enacted with the distance teacher mainly through the print media with the parents and siblings taking on a greater role.

Distance education needs a recognized view of learning in which all learning theories can contribute to give the lone distance student appropriate learning opportunities. Osborne and Wittrock (1985) put forward an inclusive view in the form of the Generative Learning Theory that incorporated aspects of both the constructivist and information processing traditions. It stressed the importance of identifying children's ideas and exploring further strategies that students use to learn. It was suggested this generative learning theory was a useful theoretical framework for teaching, learning and curriculum development in science. Previous to this the different learning theories had competed against each other to produce curricula and teaching situations that favoured one theory over another.

### **2.2.2 Theoretical perspectives on skill learning**

Two theoretical perspectives have dominated the way in which skills are believed to develop. These perspectives belong to either the behavioural tradition or from the cognitive tradition. The behavioural tradition assumes the acquisition of skills is by a gradual accumulation of learned behaviour and rules and that skill development is a result of conditioning. This Skinnerian theory indicated that skilled performance resulted from the chaining of numerous stimulus-response (S-R) units so that a long orderly sequence of behaviour is formed. Kitchener and Fischer (1990) argued against the assumptions made with this approach, saying it was not sufficient and that an interactional theory was required to understand the development of skills. They suggested a skill theory involving the idea of levels of development and a range of variations in those levels normally shown by each student. This cognitive perspective was provided an internal programme similar to a programme in a computer.

Piaget, when developing his ideas on cognitive development, had defined four basic sequential stages in the development of logical thinking skills,

concrete through to formal. His research suggested that concrete thinkers could not use abstract reasoning abilities to solve problems whereas formal thinkers could. He did not consider the onset of the various stages important, but these stages were to be important to education. Educators often generalize about appropriate teaching methods and materials for various year levels for school-aged children and use this developmental tradition to emphasize the age-related restrictions on what level of learning can be expected of a child at a certain age. Educators propose that curriculum topics requiring higher order thinking skills should be deferred until the students had reached an appropriate Piagetian stage of development.

Science education research into Piaget's formal operations has focused on two questions. Firstly, how do the lack of formal abilities affect the acquisition of scientific concepts, and secondly, under what circumstances a student can be taught to use formal modes of reasoning. Walkoz and Yeany, (1984) conducted research that indicated the amount of learning accomplished was determined by the level of the student's formal reasoning ability. Other factors that affect the performance of a skill are the teaching strategies used when a skill is taught. Other researchers, (Case and Fry, 1973, Howe and Mierzwa, 1977 and Wollman and Lawson, 1977, all cited in Yeany, Yap and Padiila 1986) found these reasoning abilities could be learnt but retention and transfer was usually limited. Students could learn to apply the principles to problems similar to those used in their training, but in most cases the skills disappeared over time and did not transfer to problems of a different nature.

A theory in which they discussed the control and construction of hierarchies of skills was further developed by Fischer & Pipp (1984) to show there were two types of processes taking place in the development of a skill. Firstly, the process of optimal levels, which explains the large changes people can show over a long period of time, and secondly, the process of skill acquisition, which describes how people learn specific skills and how they move from a particular skill in one context to a more complex skill. Figure 2.3 shows the growth curves for skill development at the possible optimal level and the more realistic functional level. According to Fischer and Pipp (1984) skills are hard to learn and sustain so that students' functional performances are often below the optimal level and most classroom

behaviour involves skill performance at functional levels far below optimal levels.

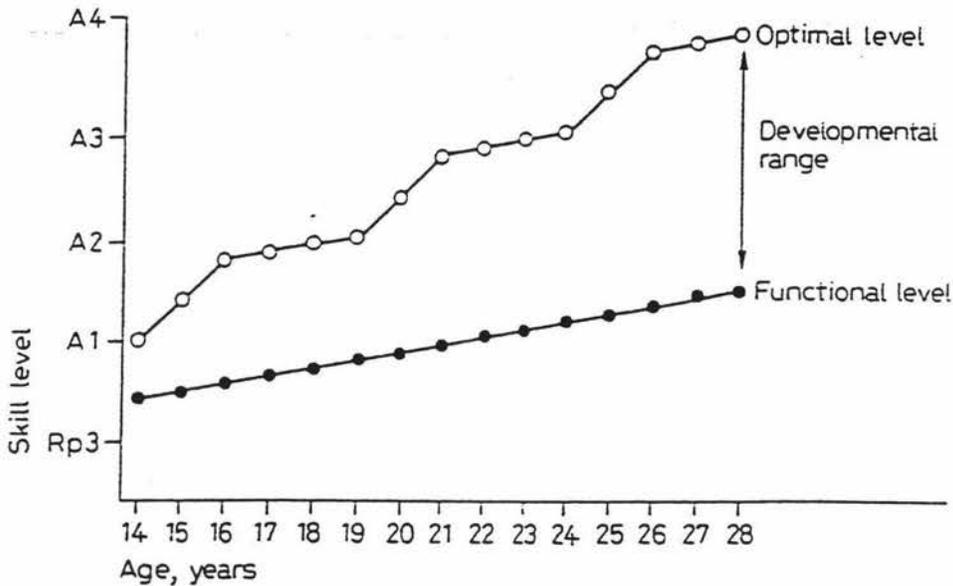


Fig. 2.3 Idealized growth curves for developmental range in adolescence and early adulthood. Fischer and Pipp (1984).

### 2.2.3 Hierarchies of 'skills'

Learning hierarchies form another theory and approach to skills learning. Gagne (1970) had evidence from his research of learning hierarchies that showed the relationships of subordinate skills to higher intellectual skills and how subordinate skills had to be mastered before higher skills could be attained. Shulman (1976) described this approach as atomistic because it tried to identify the simplest units of learning; associationist because it showed how these units of learning could be linked, giving a 'vertical transfer' (the student learns subordinate skills in order to build higher level skills); and inductivist by indicating the general, which could be understood as a construction of the particular. However, this did not take into account the nature of the subject content and the relationships between its parts.

Yeany et al. (1986) continued the search for a learning hierarchy among skills comprising formal operations and the integrated science processes. According to Yeany et al. (1986), the terms critical thinking, problem solving, scientific thinking, logical thinking abilities and science process skills have all been used to describe students' reasoning abilities. They recognized two sets of reasoning abilities and called them formal operational reasoning abilities and integrated science process skills as each came from a different

theoretical perspective. The theoretical perspective of developmental psychology of Piaget (1896-1980) recognized formal operational reasoning abilities and included the abilities to identify and control variables. On the other hand, theoretical perspectives taken by science education literature on scientific method include a broader range of skills such as identifying variables, hypothesizing, operational defining, designing experiments and graphing and interpreting data. These skills were grouped together in some later science education literature as the integrated science process skills. Writings about science education and especially about science process skills, still use terms that change in meaning according to the context or background and need defining in each case.

The Yeany et al. (1986) hierarchy of learning is in the form of linear and branching relationships. This form of hierarchy appears to have support of some educationalists in New Zealand as it has influenced curriculum development and classroom practices in recent years. The relationship in this hierarchy of skills appears to be entangled with the Piagetian modes of reasoning, such as students may not be able to acquire certain scientific process abilities until the prerequisite cognitive skills are in place. This research by Yeany et al. (1986) suggested that any process skill-based curriculum must develop and present a structure that considers the relationships of skills to each other as shown in fig 2.4. It also suggested that the entry level, as well as the progress of students' skill acquisition, must be measured in order to determine what instruction is needed to develop prerequisite skills.

Duschl (1989) agreed with these research findings and also pointed out that Resnick's work (1983) on the organization of the learner's knowledge base into declarative knowledge and procedural knowledge supported this. Nevertheless, the position of 'designing experiments' in the hierarchy concerned Duschl (1989) as he argued that the ability of identifying variables is a prerequisite for design of experiments. He believed the problem of this placement in the hierarchy was due to the experimental design of the research. If identifying variables and designing experiments were skills within a science process then they could be part of a cycle or loop of skills as suggested by the researcher in the introduction and then either could be the prerequisite of the other. Duschl (1989) suggested the lack of uniformity of the language used by science education researchers to describe, analyze and evaluate how learning takes place in science had

contributed to the problem of skill placement. He continued to say, that in order for communication to succeed among science education researchers, the language used must relate to a common set of terms. If alternative interpretations were to be tolerated researchers must also be aware which set of terms were in use.

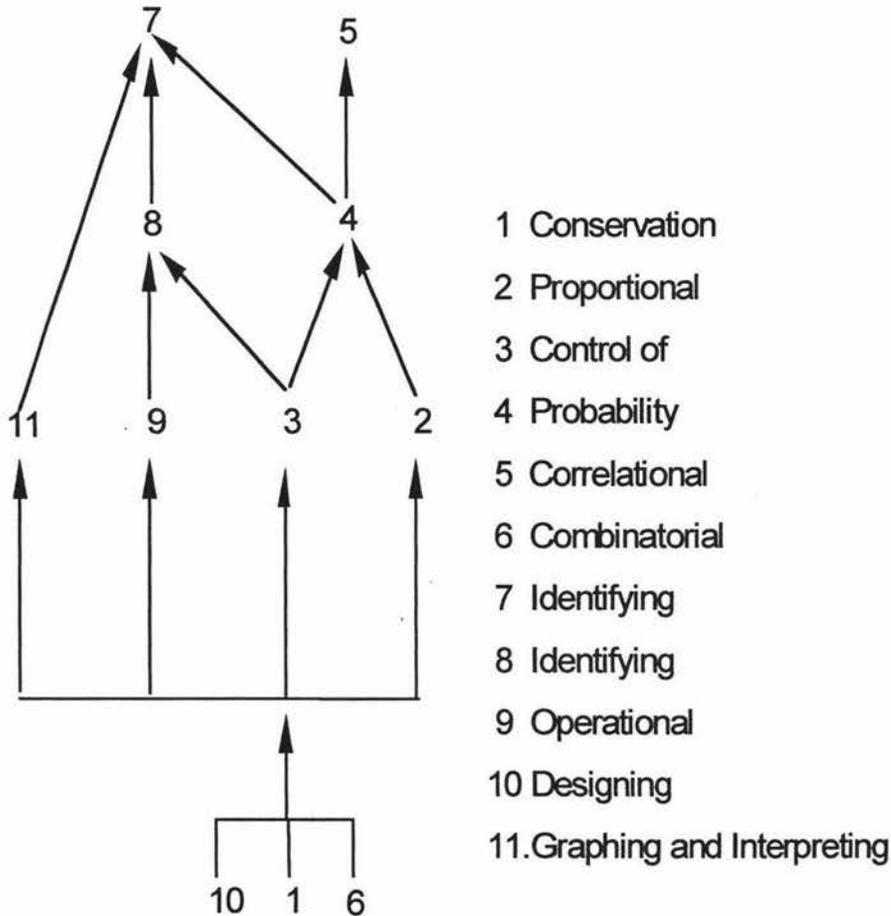


Fig.2.4 The hierarchical relationships of reasoning and science process skills according to Yeany, Yap and Padilla (1986).

However, the theoretical perspectives taken by researchers often determined the interpretation given to the terms.

Views of science education as seen in *Science in the New Zealand Curriculum* (1993b) present the method of science as a hierarchy of science skills and processes. Students are taught the science skills and processes which are then assessed. This means the science skills and processes are not just providing a means of doing science but are also the end products. Millar (1989, cited in Wellington, 1989) points out that the 'processes' of science are really part of general cognition and that they are used by people without instruction. He suggests the 'processes' (inferring or hypothesizing)

are not specifically linked to science, as people in other fields of endeavour use them to carry out their work. (The New Zealand Curriculum Framework implies this is so). Millar then says specific science skills, on the other hand, can be taught and improved. They may then be used in different situations, for example, reading a thermometer remains the same skill wherever it is being done. This example brings with it the idea of transferability.

Whichever view is taken, behavioural or cognitive, a skill can only be retained if it had been previously learned and can only be transferred to new situation if the student retains it. With reference to education in general, Singley and Anderson (1989) developed a theory of transfer based on a linear system in that transfer of learning refers to cognitive events occurring subsequent to learning so that learning is seen as a state prior to and a prerequisite for transfer. According to Singley and Anderson (1989) skills are acquired in a linear fashion. Three main stages have been recognized, the acquisition of the skill, maintenance of the skill and transfer to another situation. The success of skill transfer is affected by (1) Time; length of time since training and rate at which the skill is used. (2) Independence; from support of the text, teacher or peers. (3) Extension; to different settings from the one in which training took place, taking into consideration task content and task structure. (4) Dispositional state of the student. Perkins and Salomon (1989) described various studies in which the transfer of learning skills does take place like this, but Brown and Palincsar's research (1989) showed that transfer could also occur when learners were shown how problems resemble each other by having the same structures in the old problem and in the new. Transfer could also occur when the learners knew the work well and did not need help, or when the it took place in a social context even after a period of time, without retraining.

Science education literature has described many different designs to assess the transfer of skills making comparisons among the studies difficult. In one study, Fairbrother (1986, cited in Wellington, 1989) said the measurement of performance in a skill depends on the view held on how skills develop. Some people take the developmental view in which students are situated on a continuum of increasing competence in the skill. Others take a dichotomous view in which students either have the skill or do not have the skill. They take a point on the continuum as the reference point (the criterion) for making judgements. To do this, the path of progress and

whether it is a straight path, have to be determined first.

In general the term transferable skills is usually used when people are talking about the application of skills across different social contexts such as interpersonal skills, management skills or collaborative skills as used by doctors or managers. In science the term transferable skills is used to identify those skills that can be used in different science contexts. One definition of transferable skills is that they are generic capabilities that allow people to succeed in a wide range of different tasks and jobs. This is an example of interlocking definitions as described by Halliday and Martin (1994) where different descriptive terms used to distinguish different types of skills are used to describe each other.

There is opposition to this idea of transferability. Referring to general education literature Hirst (1974), McPeck (1987) and Barrow (1987, cited in Bridges, 1993) all say that success in one area of learning is not enough to enable a student to transfer the ability (skill) to another. Andrew (1990, cited in Bridges, 1993) states that a Theory of Domains of Knowledge is needed to sustain this idea. This indicates the teaching and assessment of core or generic skills should be embedded in the contexts in which they are taught then emphasizing what is common in the skills required for different contexts. In science education literature, Wolf (1991, cited in Bridges, 1993) discussed the relation of skills to cognitive context and said core skills are inseparable from the context in which they were developed. Kok-Auntoch and Woolnough (1994) indicated the evidence for transferability of science process skills was still questionable but education and training should still aim for the transferability of skills rather than just the knowledge of facts.

A study by Lock (1990) into the relationships between the component skills such as observing, planning, interpreting, reporting and self-management, involved practical science assessment, reported the skills of interpretation and self-management to be transferable across tasks. However, Sheldrick, (1991) reported of the British Assessment of Performance Unit, that student performance was low when students were asked to apply science skills in contexts other than the one in which it was taught. He felt this indicated that there was a barrier to overcome when there was a shift of contexts.

Contrary to Watts' (1991) view that it is not clear where skills end and

processes begin, it is generally assumed that the practical science skills of planning, performing and interpreting are transferable (generalizable) in the classroom. Kok-Auntoh and Woolnough (1994) say the collective evidence is still inconclusive but that assessment schemes tend to assume that these skills are transferable. Nevertheless, Tamir (1989) says there is some evidence for successful transfer of skills but it is said to be dependent on two conditions being met. These two conditions are: (a) distance between the context in which the learning takes place and the new context of the next application which must not be too wide, and (b) transfer is explicitly taught by the teacher. The Warwick Process Science programme (Screen 1986) supports these two conditions and shows the transfer of skills is possible when the new context is closely related to the first, making sure the distance between the two contexts is not too wide. This is a horizontal application of specific skills, for example reading a thermometer to prepare the way for more global skills when reading a thermometer is part of a larger investigation. Students can then be assessed on their recognition of the need to measure temperature, how to measure it, when to measure it and how many times, to give an accurate mean value of their skill. This skill then becomes part of planning, performing, interpreting and communication in other situations.

Previously, Solomon (1983) said the 'distance' between contexts increased when the shift was from school based, symbolic knowledge associated with school life to everyday life. This meant skills were less likely to be transferred. This result has also been recorded in works by Murphy and Schofield, (1984); Solomon, (1985); and Clough and Driver, (1986 cited in Kok-Auntoh and Woolnough, 1994).

When the teacher specifically teaches the transfer of a particular skill most studies would agree that this would probably be successful. Wellington, (1989) says this is especially true when the idea behind the skill is taught. Screen (1986) agrees but says the skill must be reinforced by repetition. Studies by Rowell (1984, Controlling Variables, and Poulter and Wright (1990, hypothesis generation, cited in Kok-Auntoh and Woolnough, 1994) showed successful transfer in these skills when students were specifically instructed on a particular aspect of investigation. However, Kok-Auntoh and Woolnough (1994) say you cannot assume that students have understood the process of acquiring a skill even when they are taught it.

There is continuing controversy over the implicit or explicit nature of skill learning, skill teaching and whether hierarchies of skills should be developed across or within skills. When teachers assess students on their skill ability they usually depend on some hierarchical structure by which they can rank student achievement. The debate is whether skills should be in a rank order so that the lower ones are achievable by everyone but the higher ones are achievable only by the best students; or whether all students should develop all the skills but develop the easier ones to a greater extent. This depends on the philosophy the teachers hold as it influences the way assessment takes place. Many science teachers in New Zealand hold a developmental view in which students are positioned along a continuum of increasing competence in a skill (Fairbrother, 1986). This is the position taken by *Science in the New Zealand Curriculum* (1993 b) as students pass from one level of achievement to a higher one. However, the New Zealand Qualification Authority takes the other view in the assessment of unit standards, in which students either possess the skill or do not possess it, therefore, the view of teachers is not really considered important as they have to work with both systems. As the level 6 science Correspondence School course was written to be compliant to the *Science in the New Zealand Curriculum* (1993 b) document the developmental view was dominant and multiple measurements of the same skill were taken. This was seen to increase reliability of the skill assessment compared with a single measurement, increase the validity of the assessment tasks and show progression in student achievement. However, the big question is whether learned skills in one context can be achieved in another. It is the opinion of the researcher that transfer of skills can occur if the skills are very general or simple, discrete in nature and are repeatedly used. More complex skills in science are context bound and are less likely to show transferability. The students have to change and adapt the skills to each new circumstance before completing the tasks.

### **2.3 *Factors that influence the learning and transfer of skills***

The learning and transfer of skills is affected by various factors that can be grouped into three main areas: student characteristics, teaching context and assessment.

### **2.3.1 Student characteristics**

In this section selected student characteristics are discussed in relation to learning and skill development. The term 'student characteristics' is used to mean those characteristics that the student brings to the learning situation. In this study, characteristics such as prior knowledge, language ability and other general abilities are considered.

#### (i) Student prior knowledge

Learning is the cumulative attainment of knowledge from one level of knowledge to a higher one and is dependent on an environment that acknowledges prior learning as a starting point. To learn something new, the learning environment should be structured so that each new piece of information is related to previous experience. In recent years the acknowledgment that the most important factor influencing learning is what the learner already knows has been emphasized by constructivist theories. Freyberg and Osborne (1981) support this point of view of constructivism. Later, Cobern, (1995) said knowledge is a meaningful interpretation of people's experiences of reality and that learning is the active process of constructing a conceptual framework so that one does not learn by transmission, but by making sense of what is experienced. If students have prior knowledge of a topic area then finding out how to use that knowledge is made easier. The same applies to the skills needed to carry out the tasks within that learning. If students have prior knowledge of the required skills then applying them is also easier.

#### (ii) The effect of student language abilities on skill learning

Most instructions are language based, being spoken or written and the level of language ability of students has a bearing on their ability to learn and maintain skills. In classroom situations instructions are mainly spoken and this is where most of the research has taken place, while in distance education instructions are usually given in the written form. In New Zealand multicultural classrooms research indicates that science education leans heavily upon the use of language to explore different meanings of words. New Zealand teachers recognize the value of group work discussions in helping students form new understanding and build on what they already know (prior knowledge). This negotiated social interaction is part of the idea behind the 'strong hypothesis' of Benjamin Whorf (1956, cited in Halliday and Martin, 1994). However, it is considered that his 'weak hypothesis' is more useful in the present time because it says language is significant in

that it determines what we attend to. Vygotsky (1978) had a similar view which has been discussed previously. He described the development of children's language as 'turning inward' to become the basis of inner speech and then of thought itself. In distance education this negotiated meaning through social interaction is difficult to build into the courses but it is attempted by using a guided didactic conversation (Holmberg 1989) between the teacher, through the printed word, and the student. Student difficulties with science language are explored in more detail in 2.4, the Distance Education section of this chapter.

(iii) The effect of general ability on students' learning and skill performance

Students' general ability is an important factor that influences the learning and performance of skills. General ability is a term that refers to the over-all intelligence of a child whose relative level of ability is compared with other children of the same age. The unit used in measuring this comparison is known as the intelligence quotient, IQ.

Lock (1990) suggests that the usual assumed links between ability and skill performance should be questioned. Findings from his research indicate that students of a mixed ability range could plan adequately if the task was set in a familiar context. Lock presented students with a problem to solve using equipment and materials provided. The students were involved in skills such as planning, performing and interpreting the data they collected in order to solve the problem. They were also asked to identify the limitations of their approach. Lock's results indicated the skills of observation and reporting were not clearly ability related, or alternatively, the tasks failed to discriminate effectively. However the results indicated interpretation, planning and manipulation skills were strongly related to ability. From this evidence teacher expectations of low ability students using observation and reporting should rise and that teachers should give them more opportunities and instruction to develop planning and interpretation skills. It is suggested that this may increase the motivation of these pupils.

The role of motivation has been described as the 'skill and will' to learn Paris and Oka, (1986). Cognitive theories of motivation suggest the student's expectations, regarding success and failure are important. They determine the amount of effort the student is willing to spend on the task and the degree to which they will persist in that task. Students' expectations of success or failure are derived from their previous experiences and prior

knowledge. Those students who have experienced repeated failure often develop an attitude of helplessness and are passive towards learning. They think their failure is attributed to a lack of ability and do not acknowledge the role of effort in attaining successful learning.

There have been many studies related to the resistance and the barriers to learning science. Lists of possible factors that may influence students' attitudes to learning science were made by Gardener (1975) and Schibeci (1984). The main factors remain the same today and the ones most relevant to this study are those of gender, culture and types of programmes available.

### **2.3.2 The teaching context**

In this thesis four main aspects of the teaching context are reviewed. They are the mode of delivery, the effect of curriculum requirements, teaching practice or methods and assessment. As the mode of delivery of the programme under investigation is not 'the teacher in front of a class' but is by teaching at a distance, it is discussed fully in section 2.4. The other three areas are viewed through research mainly directed at teaching in the classroom.

#### (i) The effect of changing curriculum requirements on the teaching environment

The change in curriculum requirements from 'science for the few' who became scientists, to 'science for all' was the challenge of science educators around the world in the 1980's. Some saw this challenge as being in conflict with the reasons why school systems were set up, that is to select and filter students before they enter higher education. Fensham (1985), said schools were expected to achieve a range of social requirements relating to the needs and demands of society by:

- reproducing the knowledge, skills and expertise needed to keep society as it is – a demand for specialists
- producing new sorts of persons with new skills and knowledge that are essential to the economic development of the country and the changing needs of the people
- contributing to 'law and order' by passing on the respect and appreciation of traditional knowledge, values and culture.

In trying to fulfill all these conflicting demands school education may swing towards one or the other. This may be true of the New Zealand Curriculum Framework (Ministry of Education 1993a, p1), with its emphasis on the second requirement.

Fensham (1985) described the attempts to improve and extend the effectiveness of science education in the USA, Britain and New Zealand. He said the call for 'science for all' was not new as there had been attempts in science education in the 1960's and 1970's to develop inclusive curricula. This work mainly focused on the separate sciences but general science at all levels was included. Millar and Driver (1987) also noted in the history of school science that there was a recurring cyclic pattern of times in which the method of science was strongly emphasized, interspersed with periods when content featured more prominently. They said the pattern was a world wide one. Millar (1996) says there have been very few dissenting voices when it comes to the idea of 'science for all'. Two, which were reported in Millar's article, were Chapman (1991 cited in Millar 1996) and Jenkins (1994). Chapman contested the arguments for compulsory 'science for all' while Jenkins is reported to have said 'the adult world does not require deep knowledge of mathematics and science and that the importance attributed to these subjects by politicians and industrialists is the result of a confidence trick played by the academic science community'. Even so, neither Chapman nor Jenkins is against the idea of science for all, but are suggesting different types of science are appropriate.

Fensham, Gunstone and White (1994) wrote that the gap between the policy documents (the intended curriculum) and the teaching in the classroom (the implemented curriculum) were too large for translation to take place. He believed the same problems occur in the national curricula of England and Wales, New Zealand and Australia where curriculum frameworks have been imposed on subjects such as science. They might do better with a different framework in order that more learners might acquire scientific understanding. Fensham concluded that the selection of 'Science for all' was a political decision.

Millar (1996) said there was a growing unease as evidence gathered indicates very little scientific understanding is actually assimilated by most students. Very few students at 16 years have a solid understanding of basic scientific facts, principles, concepts or ideas. Reasons put forward for this

lack of understanding have been that the content is inappropriate and students can see little point in learning science if it does not touch their lives. They reject the uniform and relenting pace of most science programmes, each lesson building on the next, introducing new ideas before the previous ones are established. In most senior school programmes there is no variety in pace and little time for consolidation, as so much has to be 'done' before the end-of-year exams or assessments.

In the development of 'Science for all' policy in New Zealand the emphasis is on learning science in appropriate contexts. McKinley, Waiti and Bell (1992) described the discomfort felt by many non-Maori at any suggestion that different aims for science education would be developed for Maori students. There was however, considerable support for the idea that 'Science for all' would provide relevant science education for Maori students. It was said that while Maori parents and educators wanted a science education that took account of cultural backgrounds, they also wanted Maori students to have an education that would enable them to compete for jobs in the scientific area in New Zealand and internationally. The Kura Kaupapa Maori wanted a curriculum based on Maori values, philosophies, principles and practices. For this the science curriculum would have to be holistic and integrated. Christie (1991) described how a science curriculum could take into account indigenous science where experiences are explained by using alternative ways of thinking and teaching. In New Zealand there is now a parallel Maori Science Curriculum by which Maori-speaking students can learn science in their preferred manner. However, many science teachers believe that science is dependent on scientific language and that you cannot separate science from how it is written – learning science is the same thing as learning the language of science. Nevertheless, Hill and Edwards (1992) believe students have to have their own language needs accepted first to be able to produce the language of science. In their book they go on to describe various strategies which can be used in the classroom that will lead the students from their own language understanding of science to the use of science language. Osborne and Freyberg (1985) said students often create their own scientific language but this caused concern, as there was an apparent mismatch between the language of the teacher and textbook and the language of the students themselves. They found that in the classroom the students' own language was often ignored completely, leaving gaps in their understanding.

Pitt (1990) suggested other reasons why science education was seen as failing the student population. He said the manner in which science was taught was no longer appropriate and said one of the main problems was the compartmentalization of the different strands of science into physics, chemistry and biology. It assumed that science is constructed to show logical relations between all the parts of scientific knowledge and that it is all derived from the axioms of physics. This view of science is usually recognized as a product of Europe developed within the last four centuries. It has been described by western scientists as being true, value free and universal and it has asked people to use the concepts in their everyday lives. However, this view is not held by everyone and Elkana, (1972: 1981, cited in Hewson, 1988), has argued strongly against it. Knowledge, Elkana suggested, was an idea that was dependent on time, place and culture. Hewson (1988), to illustrate this point, then described her experiences teaching science in southern African countries. The students learnt science by rote learning methods, mainly as they thought science rarely applied to the environmental problems around them. In a multicultural society such as New Zealand, sections of the population see science as unrelated to their lives and are resistant to learning about it.

Yeany et al. (1986) says there have been many studies on evaluating the effects of various curricula and special treatments on the acquisition of integrated science process skills. Results indicate that the integrated process skills can be mastered if the learning activities are appropriately matched to the level of the learner. Research also shows that several learning strategies, like those that help students with organizational or data processing tasks help students acquire integrated science process skills. However it is communication (language) that is the basis of the teaching context.

There are two aspects of language in science education that are important to teachers because they inform teachers of what is required in the teaching context. These are the language of the public documents and the language of teaching theory.

The type of language used in public documents, such as the *New Zealand Curriculum Framework* (1993a) and the *Science in the New Zealand Curriculum* (1993b) has been chosen to reinforce the philosophies and

theories behind it. At the present time the New Zealand educational documents pertaining to the *New Zealand Curriculum Framework* (1993a) are mainly in the language of constructivism which emphasizes teaching skills and processes for the purpose of gaining meaning. This could explain the changes in the way science was now perceived which was not only a consequence of emphasis on one theoretical point of view, but of other changes in social and political thinking. This sort of language use also extended to other official documents, discussions and assessment programmes and was explained by Hodson (1994). Previously, Millar and Driver, (1987) had described this use of a certain type of language as manipulation, and said the language of 'process' had been used to justify the change of emphasis to science process skills in the methods of teaching science found in the UK documents. Examples were found in the *Science 5-16: A Statement of Policy* (DES, 1985), and the *Warwick Process Science*, where the language of the documents aimed to produce a 'process led' as distinct from 'knowledge led' science curriculum.

To be useful in the classroom, the language of the curriculum documents is then translated by teachers into the language of the teaching programme and then into the language of the science lesson. Olugbemi, Taylor, and Okebukola, (1991) said this is what they meant by the three levels of curriculum development, - the intended, the implemented and the attained. Following these translations by the teachers, Hill and Edwards (1992) said that students then have to learn to use the kind of language that goes with science in order to understand it. This science language involves the shape and structure of the science expressions and the technical words both printed and spoken. When teachers try to diagnose the problems students are having, they often find it is the language of science, the 'jargon', that makes the student feel excluded and alienated from the subject matter. Halliday (1989 cited in Halliday and Martin 1994) says this experience is not confined to those who are studying their science in English as it often happens in other languages where the scientific forms are also difficult to understand. Although students with English as their first language and students with English as a second language may respond to scientific English in different ways, Halliday says it is the same features that cause difficulties for both.

### (ii) Teaching practice and method

Other factors that affect the performance of a skill are the teaching strategies used when the skill is taught. Clark, Aster and Hessian (1987) discussed the effects of unsuitable strategies and methods when teaching a skill. They claimed that such teaching could kill learning. Their research suggested it is the 'goodness of fit', of the teacher-determined strategies with student's existing procedures and motivation. Success was also dependent on how much of an increase in the processing load for each individual student there was and how well the students were taught.

Research into methods used to teach science has shown that using systematic modelling techniques encourages skill development. In modelling, attention is focused on the process being taught and the learner is given a concrete set of observable operations to perform. Bandura (1975) defined modeling as a process of learning through observing and imitating others. Modelling provides rules that the observers could use to guide their own performance. Modelling has been successful in teaching inference skills to improve reading comprehension and is also effective in teaching arithmetic skills. Schunk, (1981, cited in Rubin and Norman, 1992), says the modelling of arithmetic skills has been more effective than didactic instruction. Because many of the process skills used in reading, writing and mathematics are related to science process skills, it is expected that modelling would be successful in science skill instruction. Rubin and Norman (1992), found little research had been done on the use of modelling to promote science process skills. Their own research results suggest that students at the formal operational level of development will always perform better than students at the concrete operational level. The operational level students may need longer periods of modelled instruction and more opportunities to imitate before they become independent. Collins, Brown and Newman (1989) say the difference between formal schooling and apprenticeship methods is that in schooling, skills and knowledge have become abstracted from their uses in the world. Applying apprenticeship methods to largely cognitive skills requires the externalization of processes that are usually carried out internally. However, research by Roth and Roychoudhury, (1993) indicates that students can develop higher order process skills when they have the freedom to perform experiments of personal relevance in authentic contexts. This result suggests that the

process skills need not be taught separately but will develop to a higher level when students experiment in contexts meaningful to themselves.

### **2.3.3 Assessment of skills and learning outcomes**

Assessment is the measuring of effectiveness of learning and instruction. In the assessment situation students can show that they have acquired new knowledge and skills and can apply it to various situations. Wellington (1989) said there was a danger in teaching specific skills for assessment. He thought skill assessment would become isolated from other aspects of science teaching such as knowledge and context. The measurement of performance in a skill depends on the view of how skills develop. As mentioned before, Fairbrother (1986) said most people take the developmental view and see a need to bring together theories of child development, learning and methods of assessment. He then said a usable hierarchy of performance needed to be identified, so that numbers could be given to different stages in the hierarchy. These stages would then become the criteria of performance for the award of a particular number. These numbers would show how the students compared with each other and it would help solve the problems of determining overall grades. Once a standard had been decided, anyone who has reached the standard would be awarded it. This method is called criterion-referenced assessment. To assess effectively by this method, teachers have to develop items that assess various levels of learning. It is a major problem for teachers to provide sufficient opportunities for students to develop the skills and show what they can do in the assessments. It is important to identify the skill activities that produce a permanent assessable product and those that do not.

Distance education traditionally uses only permanent assessable products, such as descriptions and reports, for assessment purposes. This means the assessment of manipulative skills involving processes are difficult, as they need to be assessed as they occur. The classroom teacher is able to observe students in action but in distance education teacher observation is not possible. However, it is possible to make inferences from indirect evidence when a particular result has been obtained. An example of indirect evidence is the teacher receiving of separate, clean samples of the components of a mixture such as sand, salt and sawdust. It can be inferred the student has the skills to interpret and understood the instructions and

has the manipulative skills to add water, separate the floating sawdust, filter of the salty liquid from the sand and then evaporate the water from the salt.

Emphasis on science process skills in school curricula makes skill training very important in teaching programmes. Research shows teachers who have and use science process skills and give their students opportunities to learn those skills, enhance the students' achievement levels. Strawitz (1989) investigated teacher training in science process skills and found that those trainee teachers who studied using self-instructional materials could significantly outperform trainee teachers who were taught by a teacher.

These results raised the question of how self-instructional materials could be used to promote a higher level of process skill proficiency. An examination of the self-instructional material revealed that the students using it were frequently quizzed on the material and had review tests in addition to the final tests. However, findings from subsequent research showed that frequent quizzing and review tests did not enhance performance of the science process skills significantly when compared with the results obtained from students working through self-instructional material but not taking any quizzes or review tests. Because the students were self-instructed other variables such as prior knowledge of science process skills, developmental level, motivation and time on task, may have been responsible for the unexpected results.

In conclusion the characteristics that influence science process skill-learning are the ones which students bring to the tasks, the specific teaching context and way the learning outcomes are going to be assessed. Those student characteristics that promote science process-skill learning are a well-developed store of prior knowledge, proven language and general abilities and a willingness to learn. Teachers contribute to successful learning by planning, teaching and assessing appropriate learning contexts.

## **2.4 Distance Education**

Distance education is not always recognized as an interactive learning environment but most educational resources are designed to be a 'conversation' between the teacher and the learner so that learners can work at their own pace and in their own environment in a one-to-one relationship

with the teacher. In this situation the learners have more power over their own learning than is usual in the classroom setting.

The separation of the teacher and student in distance education may be seen, as a problem in that personal interaction cannot usually take place. However, with new communication technologies personal interaction is increasing. With these advances in communication there is a demand for real-time synchronization but this interrupts the freedom of distance education for students to study at their own pace in their own place.

Meaningful learning in distance education requires a deliberate effort on the part of teachers and learners to relate new knowledge to the relevant concepts the learners already possess. This dialogue is especially important as most distance education material remains print based and self-instructional. The type of language used in the printed material to express scientific ideas and processes is also important. In science education and distance education there has to be a balance between the technical language of the subject and the language used to explain what it means so that learners can develop their understandings.

#### **2.4.1 Student difficulties with science language**

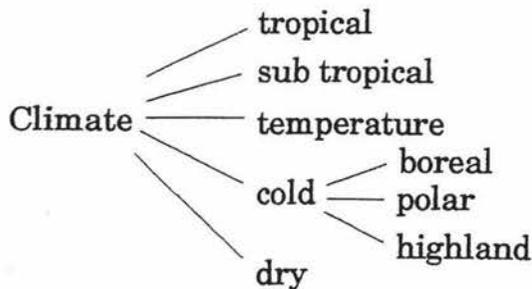
Some science teachers think of student difficulties with the language of science mainly as difficulties of vocabulary, the 'jargon' of science. 'Jargon' means a battery of difficult technical terms, but now also carries the idea that these terms are unnecessary and the same meaning could have been given without them in everyday language of 'plain English'.

Besides having the problem of moving between scientific language and everyday language, the students also have difficulty with terms that have new and specialized meanings, and ones that represent new ideas and use new terminology. Often they have not heard them said aloud and, when they meet them in a text, they have difficulties decoding them and are often intimidated by them. This is a particular problem of distance education where students have infrequent opportunities to 'hear' the terms spoken. Students also come across familiar words that seem to have changed their meaning from the use they have in 'everyday language', for example, force, power, energy etc. It is highlighted in The Learning in Science Project (1981) that students bring to the classroom 'views of the world' and

'everyday meanings' of words, which they then use to develop concepts quite unlike those intended by the teacher.

Another difficulty for students is that they may not recognize words they have met previously when the word is in a different grammatical form, for example, omit, omission, permit, permission.

Halliday and Martin (1994) believe it is the grammar of scientific language that is the main problem for students. An example given by Halliday (1990, cited in Halliday and Martin 1994) of a grammatical difficulty is the pile-up of nouns for example glass crack growth rate. The problem still remains to the present time, although teachers have noticed that students may use different ways to decode this type of statement. Halliday (1990) also says technical terms often form complex relationships with each other. One technical term often cannot be defined without using other technical terms. He explains that many of these definitions are interlocked and uses circle, center, radius, diameter, circumference as an example, where circle, center and radius are used to define each other; and other terms of distance, such as length and twice, are assumed to be known when defining diameter and circumference. Interlocking definitions are often used to form organized lists of terms called technical taxonomies. These are used to describe the common features of a group of related ideas as seen in the figure 2.5 below.



This example shows the general term 'climate' is divided into certain types of climate. Each type can then be described in relationship to temperature, pressure, humidity and radiation.

Fig 2.5 Interlocking definitions in technical taxonomies.

Another difficulty recognized by Halliday (1990) is described as lexical density. It is the measure of the density of information in any text according to how tightly the content words have been packed in the grammatical structure. The example glass crack growth rate is then used as a single

noun in a sentence. However, the students experience a lot of variation in lexical density. In informal spoken language it tends to be lower, while in written language, because it is planned, it tends to be higher. (4 – 6 lexical words per clause) but in scientific writing the lexical density may be as high as 10 – 13. Halliday and Martin(1994) gives the following example of high lexical density that is difficult to read.

Griffiths' **energy balance approach to strength and fracture** also suggested the **importance of surface chemistry** in the **mechanical behaviour of brittle metals**.

The reading of scientific writing is important in the development of most students' scientific language. In Australia, Wignell (1987, cited in Halliday and Martin 1994), states textbooks are the main source of models for most students but unfortunately, as more and more emphasis in schools is put on doing science 'in your own words', the situation is deteriorating rapidly. It was also noted that the removal of traditional textbooks from science classrooms over the last 20 years has meant that increasing numbers of students do not see or read any scientific language.

With the advent of the new curricula in Australia, England and New Zealand, new textbooks are only providing fragmented examples of scientific text, so that the problem will continue. Unsworth's (1993) research disagrees with the idea that modern textbooks will not redress the problem of student use of scientific language, but he recognized that schools have usually valued fiction above factual texts and have encouraged narrative genres. He believes two major influences have brought this about. Again it is the impression that there has been a 'retreat from print' in the teaching of sciences under the influence of 'process' oriented curricula of the 1970s and 1980s, and the prevailing ideology which sees children more interested in play and make-believe than exploring the reality in which they are growing up.

In his research Unsworth (1993) carried out critical analyses of a number of books that have been written to support the science curriculum. He concluded that the texts frequently fell into one of the following five categories:

Subverters: suggest scientific knowledge is like playing a game, collecting the pieces of information.

Simplifiers: seek to minimize technicalities and hence represent science as mainly commonsense knowledge. In some cases this oversimplification results in scientific inaccuracy.

Distractors: include a good deal of localized and/or peripheral information. The mode may include a good deal of language that is ancillary, accompanying illustrations rather than being part of the context. There may be a good deal of personal interaction with the reader.

Approximators: attempt to reconstruct specialist information. These texts need close examination to determine the integrity of the information and its accessibility to the reader.

Initiators: are the most successful recontextualisations of specialist knowledge for young readers.

Traditionally textbooks supply subject matter (the way in which scientific knowledge is constructed) in the form of scientific text. However, textbooks also use 'alternative science languages' such as written formulae, structural diagrams and representations of 3D models to describe an item of science knowledge in different ways. Chemists have four different ways in which they can describe the substances they study. An example of this is shown in figure 2.6.

Other non-verbal expressions in science such as physical models, charts, pictures, maps, graphs and diagrams and electronic circuits usually show interrelationships better than words but words are always needed to interpret and explain the meaning.

Each 'alternative language' has its strength and weaknesses for example scientific diagrams. Although scientists use scientific diagrams as summaries of ideas, students often find them confusing because diagrams concentrate on the main ideas and leave out supporting detail. The reader has to fill in the gaps and this is difficult for students who do not have a clear understanding of all the concepts involved. Under the constructivist umbrella the problem of understanding a diagram is seen as the question of ownership – a diagram is seen as a summary of the teacher's thinking not the student's. Research has shown that students often give interpretations to arrows in diagrams that are different from the teachers. Schollum (1983) says diagrams can be a hindrance to students learning, particularly if they seem to provide visual evidence to reinforce students' existing ideas.

However, diagrams and pictorial material are often used instead of text when teaching less able students in the belief that they will be able to 'see' the information more easily. In fact it may be more difficult for such students because of the increase in the amount of interference encountered. As they have to fill in the missing details, the students need to talk through the diagram with the teacher in order to understand it and make it their own.

|   | <u>Type of language</u>      | <u>Example</u>  |
|---|------------------------------|---|
| 1 | Verbal label                 | Methane   |
| 2 | Written Formula              | CH <sub>4</sub>   |
| 3 | Structural diagram           | $  \begin{array}{c}  \text{H} \\    \\  \text{H} - \text{C} - \text{H} \\    \\  \text{H}  \end{array}  $ |
| 4 | build a 3D structural model. |                       |

Fig. 2.6 Methane written in the four different ways.

Science text is not a straightforward single style. The style is adapted to different aspects of science during writing, for example, reports, explanations and experiments. If the different adaptations are not taught many senior students remain uncertain about what to expect in public examinations.

### Reports

The main style used for science textbooks is technically called a report. Its main function is to organize information topics. However reports can also describe functions, list properties and describe processes. McNamara (1989 cited in Halliday and Martin 1994) discussed the importance of models and structured questions when introducing students to report writing. In his teaching he encouraged students to use the models as guides and the

questions as the scaffold to build up a report. He believed students need a lot of practice at report writing to become proficient.

#### Explanations

The 'explanation' differs from the report in two important ways. First, that it has a higher percentage of action verbs and second, the actions are organized in a logical sequence.

#### Experiments

Science textbooks are traditionally procedural texts that act as recipes for activities. One of the distinctive features is the use of the imperative to direct student activity for example 'note the levels of water'. Usually experiments have very clear staging structures for example, Aim – Method – Result – Conclusion when written. McNarnara (1989 and Morris and Sclovart-Dare 1984 all cited in Halliday and Martin 1994) advise teachers to use an outline as a scaffold for writing up experiments because it gives efficient use of time and is a useful way of summarizing.

Most of the research literature describing science education delivery is about the face-to-face environment of conventional schools or colleges, while distance education writings in many instances refer only to adult students and tertiary institutions. In this study, distance education for students of the compulsory post-primary age group is already established.

Distance education is described by Keegan (1986), as a family of instructional methods which usually consists of two phases, 'the preactive' (development of teaching materials) and 'the interactive' the two-way communication between teacher and student. However, distance education is still evolving, as it needs to reflect the contexts of the institutions in which it takes place.

There have been many influential historical definitions of distance education, each emphasizing some form of separation of the students from the teacher, interaction between students and an institution and the industrialization of the teaching process. By the 1980s, definitions using Peters' terminology 'industrialization of the teaching process' (Peters, 1973) caused some controversy. 'Industrialization' of distance education was a term that compared the production of teaching materials to the industrial production of goods using the ideas of rationalization, division of labour, assembly line mechanization, mass production, formalization, standardization and

centralization. The terms Fordism, neo-Fordism and post-Fordism were used to describe the evolution of this industrial concept. By 1983, the definition of distance education had already evolved to a point where 'industrialization' had been accepted so that there was a clear separation in the large distance education institutions between the production of the teaching materials and the student support systems. The writing of Olugbemiro, Taylor and Okebukola, (1991) described how distance education courses were often written by multi-disciplinary teams of instructional designers, graphics artists subject teachers and others without recourse to student information. These systems, in turn, were supported by management, administration, a delivery system and an information service and resulted in an effective education system.

#### **2.4.2 Teaching/learning processes in distance education.**

Holmberg (1989), believes the basic practice of distance education has not changed appreciably over the years even with the availability of different forms of communication technology. He says distance education still relies on self-instructional texts and print-based communications. Garrison (1993) said the reliance upon pre-packaged self-instructional materials as the primary method of distance education reflected the underlying assumptions (teachers transmit knowledge, students receive it) held regarding the teaching/learning process. He then discussed the behavioural and cognitive views of teaching and learning at a distance, and attempted to distinguish existing and emerging patterns. Garrison (1993) suggested a fundamental change in distance education was taking place even though much of distance education's instructional design and delivery were based, either explicitly or implicitly, upon behavioural learning theories. According to Winn (1990) emerging perspectives and practices are, and ought to be, consistent with socio-cognitive constructivist theories of learning.

Two decades ago Baath (1981) had researched several examples of distance education programmes. He concluded that the programmes with stricter control of learning towards fixed goals had a greater emphasis on the teaching material than the two-way communication between the student and tutor/institution. The writing of Olugbemiro, Taylor and Okebukola, (1991), supported this statement. Conversely distance education programmes with less control of learning towards fixed goals tended to make two-way communication between student and teacher more desirable.

Holmberg (1989) saw distance education as a guided didactic conversation a method of teaching suited for learning at a distance. He said the presence of characteristics of conversation would facilitate learning. These are shown in figure 2.7

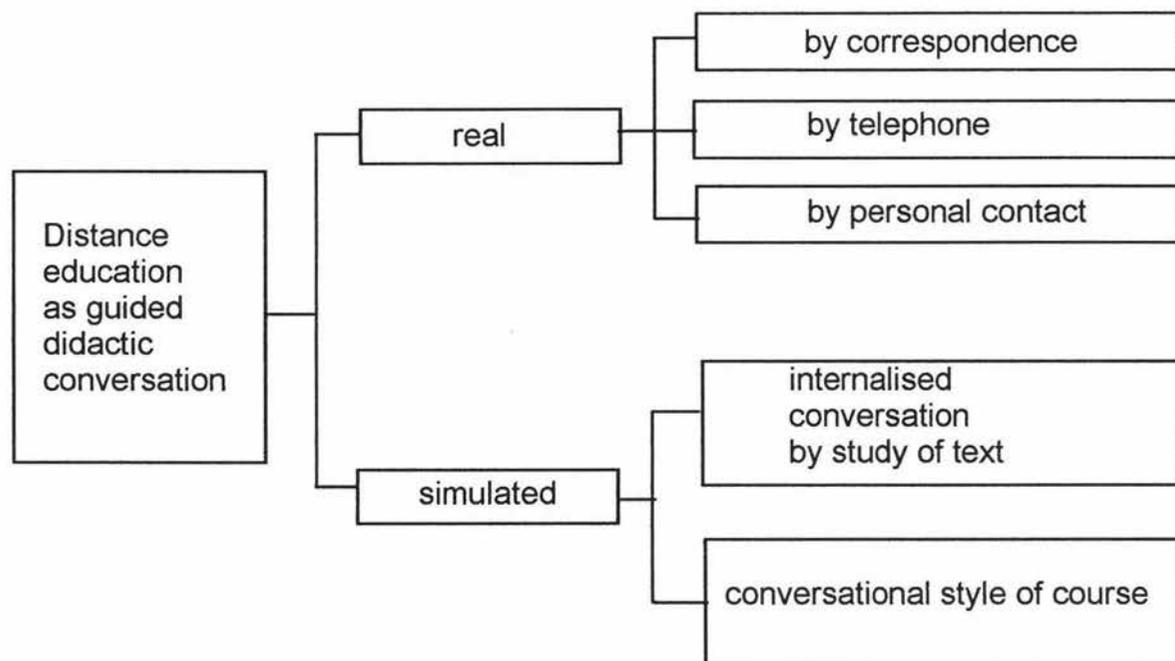


Fig 2.7 Guided didactic conversation (Holmberg, cited in Keegan, 1986 p 97)

Interpersonal communication is central to the teaching-learning process and has many functions. The most important of these functions are for providing information, control, social contact, stimulation, expressing feelings and alleviating anxiety. Distance education tries to replace these functions by printed, electronic or computer-based interaction and by the occasional face-to-face meeting. Of course, there are many differences between conventional face-to-face schooling and distance education but these differences are fading with the use of the new technologies. Some differences that still exist are given in appendix 2

When Cropley and Kahl (1983, cited in Keegan 1986) made the comparison between face-to-face and distance education, distance education was based

on pre-packaged instructional materials and print-based communication. Pre-packaged self-instructional course materials inherently have a behavioural orientation to learning. Even though attempts have been made to make them flexible and interactive, they have remained a prescriptive and private learning process. In contrast to the positive results of research conducted on self-instructed trainee teachers by Strawitz (1989), Winn (1990) believed behavioural theory was inadequate to prescribe instructional strategies that teach for understanding. In particular, Winn suggested the pre-selection of strategies before implementation of instruction was not appropriate for higher level cognitive goals. Little opportunity existed for the students to negotiate learning goals and make meaning for themselves based upon their previous knowledge structures. A behavioural approach to instructional design assumes a static and standardized view of knowledge. Feedback is simply whether responses are correct.

A cognitive approach may provide explanatory feedback and allow for the construction of new and unexpected knowledge structures. This is seen in the cognitive-constructivist learning theory that indicates knowledge is constructed by the individual in context and based upon interpretation of experience and previous knowledge structures it has known. In the constructivist theory the learner is said to take active responsibility to construct meaning, not in isolation, but using dialogue with oneself as well as others. The most important objective in the constructivist approach to learning is knowing which learning can be observed or measured. The implication is that learning goes beyond the assimilation of facts. The teacher may provide a tentative structure of knowledge, but it is through sustained communication that students will begin to construct and confirm their own understanding. Students build upon their previous experience and cognitive structures to develop new views and knowledge structures by interaction with the teacher. Teachers must become facilitators of learning where the teacher and learner share control of the learning transaction.

From a theoretical perspective of distance education Holmberg (1990) raised the issue of a paradigm shift from behaviourism to constructivism in distance education in 1990. His argument is that the paradigm shift was a myth since today's distance education is either identical with or a direct descendent of traditional correspondence education (Holmberg, 1990). He continued to say the teaching function is the responsibility of course authors and tutors in

distance education. The course authors reflect the paradigm of pre-produced, self-instructional texts. Tutors are available to respond, often by print, to assignments of pre-produced course units. At the end of these course units students are invited to answer (and ask) questions, compute, translate, solve problems, write essays, etc. and to submit this work for correction and comment. The tutor is a marker and often a resource of last resort. Holmberg (1990) saw this as a subtle denigration of the teaching function in correspondence-based delivery that significantly altered the educational process. Learning in an educational sense necessitates consideration of alternative perspectives, discussing discrepancies with regard to previous understanding, and generally negotiating meaning with the teacher and fellow students. This does not happen as such in distance education. However, Hall (1996) said the emerging educational paradigm shift is learner-centered and outcome-based thus requiring new roles for distance education. Campbell (1997) has said a paradigm shift to active learning has required distance education to think about group work as the move to co-operation rather than competition is obvious in the new teaching/learning structures. With the move to new teaching /learning structures also comes the recognition that access to teaching does not equate to success at learning. It is now recognized that providing access to new technologies such as a video signal, TV, Radio and CD-ROM disk does not automatically result in successful learning. Campbell said comparison studies of media have shown that the type of technology used is not the key variable in enhancing learning, as design of instruction, teaching expertise and learner support are critical to success. Hall (1996) and Campbell (1997) both say the rigidity of organizational structure, roles and reward systems and traditional funding formulae are barriers to the complete acceptance of the educational paradigm shift.

Support for successful learning is very important to distance learners. Although they have the opportunities to learn at a distance, in their own time and at their own place, they need extra knowledge, skills and attitudes different from those that are required for face-to-face teaching and learning. Often the distance learners require skills in time and stress management, increased self-direction in goal setting and assuming new roles and responsibilities for learning. Too often they only receive support for access to programmes, but not to the skills, knowledge and attitudes needed for success in distance education. Many writings about distance education are

based on the assumption that teaching at a distance requires different skills than those needed in a conventional educational setting (Beaudoin 1990). Research has found successful distance education does indeed depend on different sets of skills for the teacher and the students.

Bereiter and Scardamalia (1989) stated that to 'develop high-level skills of learning from text, the student must do more than try to answer assigned questions'. It is argued that the dominant idea in distance education of pre-packaged materials designed for minimum tutor/teacher contact ensures that new technologies capable of supporting sustained two-way communication will simply remain as 'unimportant add-ons'. It is difficult to see how pre-packaged self-instructional course materials by themselves can do otherwise but encourage surface approaches to learning.

### **2.4.3 Teaching science skills by distance education**

The researcher found very little literature on teaching science skills to school aged students by distance education. A search of American ERIC, International ERIC, the indices of the British Journal of Education and various Internet library sources yielded few papers or references for the keywords used in this study. The keywords used were combinations of: teaching, learning, science skills and distance education.

This may be due to the fact that science skills are usually taught to school aged-students in schools, while most research literature on distance education concentrates on tertiary level.

A Correspondence School science teacher, Morgan (1990) said science teaching had one major difference from most other subjects that are taught at a distance and that was the need for practical science activities. He explained this was not just pupil performed activities but practical science activities requiring equipment. The experiments and equipment is tested by the Correspondence Science teachers before being packed into science boxes that are then sent to the enrolled fulltime students. Other enrolment groups, such as the Secondary School students, can get the equipment either through their secondary schools or as the Adults and Home Schoolers do, by buying the prepared boxes.

Rowntree (1990) says there are a number of reasons why practical science activities should be offered to distance education students even if they present difficulties. The reasons considered by the Correspondence School

to be important are mostly related to student expectations, linking distance learning to classroom learning, as an aid to learning and adding interest.

Most students think of science as 'doing things' with test-tubes, of mixing chemicals, having them blow up, change colour or something spectacular. It happens on TV so why not when they do science? Practical science activities link distance learning to classroom learning. Most distance students have been in a school classroom situation at some time and have experienced practical science. Distance science education needs to keep in step with the conventional teaching styles so that distance education is not thought of as different or second best.

Science teachers see practical science as an aid to learning. Distance students have the same range of learning styles as other students. Some prefer learning by listening to the spoken word, others prefer a visual approach and learn from the written word, while others prefer physical manipulation of things. Practical science exercises offer distance education students experience in different learning styles and add interest by giving a change of pace from the continuous reading and writing exercises. They may even create a life long interest in some aspect of science.

It is important that distance education teachers in science keep in touch with current trends in school based science teaching as the practical exercises and laboratory work are seen as the forefront of current curriculum initiatives. However Morgan (1990) says there are concerns for this approach in distance education. The most important is a concern for safety. Safety considerations limits practical exercises to those that can be performed safely without close supervision and still show clearly the idea that is to be learnt. This rules out the use of many chemicals or chemical liquids such as the common mineral acids (hydrochloric, nitric and sulfuric acids). Alternatives are used where possible, for example solid tartaric acid can be sent to students, who then make it up into a solution for experiments.

The second major concern is one of reliability. Nothing is more discouraging for students than spending a lot of time setting up an experiment that does not 'work'. In the classroom the teacher can often use this situation as a teaching point or demonstrate the point. This cannot be done in distance

education easily. Many standard practical exercises are discarded from the distance education point of view because they are not reliable.

The third concern for distance education is the cost of sending equipment and materials to **each** science student. Distance students very rarely work in groups. Each piece of equipment has to have multiple uses. For economy reasons second choice equipment is used for some experiments so that it can be used in another but different activity later.

A fourth concern, especially for teachers of senior science classes where there is an internally assessed component of practical work, is that of authenticity. How can distance educators be sure it is the work of the student? The Correspondence School uses signed declarations by students and their supervisors as evidence that the work is authentic.

Nevertheless the researcher recognizes there are some advantages to doing practical science by distance education. Students actually do the experiments themselves. They are not pushed aside by more dominant students in a group or class. Distance students often find it easier to set up and follow through with long term experiments and intensive care experiments can be looked after during weekends and holidays.

## ***2.5 This study***

The literature review has indicated that teaching science and science skills by distance education put a different emphasis on the teaching and learning methods used. The level of language ability of the students has a large impact on the success students have in studying at a distance because the course is presented in the printed form. Those students who find reading difficult are already at a disadvantage before they start learning the course work.

Science skills and science process skills have been studied in the face-to-face system and this has been documented but little research in the distance education setting has been recorded. It is important to know if science skills and science process skills are transferable from one task to a similar one in the same context or from one curriculum strand to another when taught at a distance. In fact, Rowntree (1990) suggested that education delivered in

the distance mode could reduce many of the barriers that are found in the conventional face to face situation.

The main objective of the study was to investigate the learning and transfer of science process skills in a distance education setting, such as the Correspondence School, Wellington, New Zealand.

The specific aims of the research were to:

- 1 determine which science skills are specified in *Science in the New Zealand Curriculum* (1993b)
- 2 determine how the performance of The Correspondence School students compares with student performance from conventional, face-to-face schools.
- 3 investigate if science skills are transferable from one task to a similar one in the same context or one curriculum strand to another when taught at a distance through The Correspondence School;
- 4 gather information on the perceptions students have concerning the science course developed by The Correspondence School to enhance their skill learning;
- 5 gather information from teachers who were involved in teaching the science course, on the success or failure of the course to enhance science skills of the students.

### 3 Methodology

This chapter describes the research method and techniques used to collect information about the effectiveness of skill learning/teaching of the Level 6 distance education science course written by The Correspondence School.

The study was designed to address the following research questions:

- 1 Which skills are specified in level 6 *Science in the New Zealand Curriculum* and how they are taught in the Correspondence School programme
- 2 How well do Correspondence School students achieve in the skills taught through the level 6 Correspondence School science programme when analyzed by gender, ethnicity and enrolment group
- 3 What skills are transferable from one task to another when taught through the level 6 Correspondence School science programme
- 4 How does the performance of Correspondence School students compare with student performance from conventional schools
- 5 How do the Correspondence School students perceive the level 6 Correspondence School science programme, especially its teaching of skills
- 6 How do the Correspondence School teachers perceive the level 6 Correspondence School science programme and its teaching of skills.

To answer these research questions, illuminative evaluation was chosen as a general research strategy so that the context in which science process skills were learned could be fully examined. Illuminative evaluation is flexible and adaptable in that it uses the most appropriate research techniques suited to answering the research questions. In this study document analysis, measurement of student performance and investigation of student and teacher perceptions were used.

#### 3.1 Research method

In 1972 Parlett and Hamilton described the disquiet that researchers felt about the traditional approaches to educational evaluation. Noting these concerns, they developed a new method called illuminative evaluation that took account of the wider contexts in which educational programmes function. This shift in thinking required more than a change of methodologies as it also involved new suppositions, concepts and terminology. Norris (1990) thought of this shift as a rejection of the

psychological tradition and a move towards a sociological focus and an emphasis on cultural influences. Central to the understanding of illuminative evaluation were the two concepts of 'instructional systems' and 'learning milieu'.

An instructional system is made up of the formalized plans and statements that are found in curricula and prospectuses and includes a set of pedagogic assumptions. A change of instructional systems as seen recently in New Zealand has resulted in a new curriculum and learning/teaching approach along with suggestions of the contexts, learning experiences and assessment techniques to be used.

Parlett and Hamilton define the learning milieu as the social-psychological and material environment in which students and teachers work together. It is a network of cultural, social, institutional and psychological variables which interact in complicated ways to produce a unique pattern of circumstances, pressures, customs, opinions and work styles in which the teaching and learning occurs. Acknowledging the diversity and complexity of the learning milieu is an essential prerequisite for the study of educational programmes. Connecting changes in the learning milieu with intellectual experiences of students is one of the chief concerns of illuminative evaluation. The learning milieu concept is necessary for analyzing the interdependence of learning and teaching and for relating the organization and practices of instruction with immediate and long-term responses of students. This is particularly true in the distance education environment.

One of the main concerns about illumination evaluation is its 'subjective nature' and whether personal interpretation can be scientific. The extensive use of open-ended techniques and qualitative data in illuminative evaluation leaves room for partiality on the part of the researcher. In this study researcher partiality was checked by using different techniques to crosscheck the findings. Different techniques are combined to throw light on common problems or questions. Besides viewing the problems or questions from a number of angles, this triangulation approach facilitates the cross-checking of otherwise tentative findings.

Triangulation is important as a methodological tool (Denzin, 1978). It uses multiple methods and data sources to improve the validity of the research (Anderson, 1990). It is a strategy aimed at reducing any bias that may be in

the research design. Mathison, (1988) explained how the use of triangulation strategies can show that:

- data from different sources, methods and investigators can agree (convergence).
- a range of data from multiple sources may not confirm a single idea about a social phenomenon (inconsistency)
- data from different sources may actually be contradictory.

Mathison (1988) suggested that several levels of information was required so that reasonable explanations could be made. Data would be one source of information available, also an understanding of the whole programme, its history, the intentions of the developers and how the programme was functioning. Around these factors an understanding was needed of how learning and teaching was affected by the distance education situation.

The study of learning and transfer of science process skills found in the level 6 science Correspondence School course has been based on the illuminative evaluation concept. The triangulation strategies deployed used information from the analysis of:

- official documents - for example Curriculum Statements, School Certificate prescriptions and the level 6 Correspondence School science programme.
- student performance data
- student perceptions of level 6 science course
- teacher perceptions of level 6 science course.

Each of these will be discussed in turn.

### **3.2 Document Analysis**

Data was collected from official documents, namely the *New Zealand Curriculum Framework* (Ministry of Education, 1993a), *Science in the New Zealand Curriculum* (Ministry of Education, 1993b), *Assessment: Policy to Practice* (Ministry of Education, 1994), *Developing Science Programmes (1994)*, and the *School Certificate Examination in Science Prescription* (New Zealand Qualification Authority, 1994). These were analyzed for content and context requirements and comparisons were made with the student booklets of the level 6 science Correspondence School course. Content analysis identified general science skills and science process skills in the documents. The data were recorded to show the intended programme and implemented programme, and any differences between the skills and content of each document.

The documents were also examined for any consideration of the distance mode of education.

### 3.3 *Student performance*

Student performance was only measured by teachers' numerical grades of student course work on skills and from examinations due to funding and time restrictions. Distance makes it difficult to measure other types of performance, such as practical skills in progress, inter-group skills and some self-management skills, because teachers are unable to observe the processes in action. Distance teachers mark the end products of these skills.

#### 3.3.1 *Student population*

It was intended to use the whole population of students studying at a distance the level 6 science Correspondence School course. This population however was found to be always changing due to the withdrawal and entry of students during the school year. To have a relatively stable population it was decided to use the active population (those students who were on the active school roll and were expected to produce work) available on July 14, 1995, and follow this population through to the end of the programme disregarding any students who joined the course after this date.

Table 3.1 Student enrolment groups.

| Sub-groups  | student numbers |
|---|-----------------|
| • adult open learning students: adults who want to further their education.   | 100             |
| • home-schoolers: school-age children whose parents educate them at home but buy in the courses and the teaching services developed by the Correspondence School                  | 48              |
| • secondary school students: students who attend secondary schools but take one or more subjects courses with the Correspondence school because their school cannot provide them. | 47              |
| • full-time students: students who obtain all their education through The Correspondence School.  | 201             |
| • Total   | 396             |

The active population consisted of 396 students who were from four sub-groups that are segregated out by the enrolment requirements of the Correspondence School and the Ministry of Education.

These sub-groups are:

The full-time students were further classified by the reason they were enrolled on The Correspondence School roll, namely distance, medical, psychological, suspension, itinerant, pregnant or overseas.

Enrolment data was collected from the (Correspondence) School Information Systems (SIS), and encoded onto an excel spreadsheet to which data from student logsheets, internal examination marks, external examination marks and coded questionnaire replies were added. A student logsheet is a paper record kept by the student's teacher on which marks awarded are recorded along with comments about the student's work, the number of booklets completed and other materials and resources sent to the student.

To distinguish between each enrolment category of the student population a seven digit code was used. Student characteristics were also coded for the variables gender and ethnicity: and the values female/male and Non Maori/Maori/Others. This information was obtained from Student Information Systems records. Table 3.a and 3.b in appendix 3 show the code numbers used for these variables on the spreadsheet.

(i) Population for skill marks in course work

All the active population was used for the collection of skill marks. When students withdrew from the course during the year their data was incomplete but retained. If these students' marks had been eliminated from this study, only data from the students who remained and persisted with the course would be available. Information would have been lost or it might have been skewed in favour of the more capable student. The number of students still active in the course decreased as the year progressed.

(ii) Population for examination mark comparisons

The student population for the comparison of Correspondence School internal and School Certificate external examination results in 1995 was from the active population. Only the marks of those students who completed both the internal school examination and the national School Certificate in science could be compared.

### 3.3.2 Assessment data

The assessment data were collected from two sources, the skill mark from the student logsheet and the examination marks from the Student Information Systems (SIS)

#### (i) School course skill marks

The skill marks were collected from the student logsheets and recorded on a spreadsheet for analysis. As there were several teachers marking work from the same course, marking criteria were set out and assessment was moderated between teachers by the use of standardized marking sheets, assessment meetings and standardized method of recording marks (appendix 3A fig 3.1). Standardized methods of recording marks are important as they allow easy collection of data and the methods can be made available to other people. How far such assessment records match the student's actual performance was unclear because, in distance education, other people may have assisted the student. The science process skills under investigation are seen in table 3.2.

Skill assessment marks for these science process skills ranged from 0 to 8 on an approximated interval scale which allowed statistical analysis to determine which skills may be transferable from one task to another.

Table 3.2 Description of the science process skills in level 6 science course.

| Science process skills   | Abbreviation |
|--|--------------|
| • processing and interpreting scientific information                     | P & I        |
| • communicating scientific information - in the form of reports          | WR           |
| write-ups  | <u>Coml</u>  |
| drawing scientific diagrams  | DSD          |
| • carrying out an investigation  | CInv         |
| planning simple investigations that can be classified as a 'fair test'   | Plg In       |
| • using scientific information - to extract information for other tasks. | UI           |

Abbreviations for the skills were shown because they are used in following tables.

### (ii) Examination performance

Data were collected from statistics available from the Students Information Systems of the Correspondence School from 1995. This data showed the range of 5th form student performance in the internal examinations of the Correspondence School and their achievement in the national School Certificate science examination of the same year. The results were studied to see if there was a relationship between the sets of internal and external examination scores.

The student marks for internal exams and external exams were recorded as an interval scale and ranged from 0 - 100.

## **3.4 Student perceptions**

A selected sample of students was surveyed in an attempt to find out their feelings, experiences and reactions to the level 6 science programme. The survey took the form of a questionnaire covering various areas of interest and measuring student perceptions of the learning content, practice activities, teacher marked work, student progress, course delivery and skill learning. A questionnaire was considered the only way distance education students could be surveyed successfully as it was impractical, due to time restraints and costs, to personally interview each student, even by phone and collect the information required. It was recognized that a single questionnaire cannot establish causal connections between variables as it can only show possible relationships between the variables at one point in time.

### (i) Advantages of using a Questionnaire

The advantages of using a questionnaire for surveying distance education students were that:

- it was an economic alternative compared with other survey methods such as telephoning and personal interviewing
- it could be sent anywhere to a larger sample size
- all potential respondents received the same set of questions, phrased exactly the same way in order to yield more comparable data (Cohen and Manion, 1989)
- some open questions could help overcome motivational problems by allowing the students to answer in their own way (Cohen and Manion, 1989).

### (ii) Disadvantages of using a questionnaire

Several disadvantages of using a questionnaire were recognized, many of them being a consequence of surveying a sample population who studied at a distance. These disadvantages were problems of control and standardization of conditions under which the questionnaire was answered and of judging the validity of the responses because the motivation of the students could not be checked. Also there was the assumption that the respondents were able to read or speak the same language as the questionnaire. Finally, there was the problem that each questionnaire not returned would increase any bias already in the population sample.

Sax (1979) said research showed that the percentage return depended on the length of the questionnaire, the complexity of the questions, how important the study was to the respondents and to what extent they believed their answers were important. There was no previous information available about how the distance education student population sample would respond or whether they thought their answers were important, however, the questions were edited to have an appropriate reading and language level.

#### **3.4.1 Student questionnaire population sample**

A representative sample of the population active in July, was chosen by using stratified random sampling (Anderson, 1990). The four enrolment groups (adults, home schoolers, secondary school students group and full-time students) were used as stratification. From the total number of students in each group, a randomized sample was obtained by selecting every fourth student in a randomized list until the required number had been selected from each group. This sample size of each group was selected in proportion to the total numbers of students in each group. This method gave a sample population of two hundred students, (100 full-time, 50 adults, 25 home schoolers and 25 secondary school students).

A systematic sample procedure like the one above provides an acceptable approximation of random sampling. This procedure aimed at overcoming researcher bias in sample selection as this type of selection is independent of the researchers' preference or prejudice. So long as any biases in the ordering of the list do not occur at the same interval as the sampling interval, a reasonably reliable sample is obtained.

Not all members of the total student population of July 14th 1995 were eligible to be part of the sample population. Some (N=20) were excluded because other research programmes in the Correspondence School had recently surveyed them and it was felt necessary to preserve future programme-auditing and avoid over-use of students' goodwill in answering questionnaires. This did not affect the random selection because earlier selections were random also. However, five such students were asked if they would pilot this study's questionnaire and they all agreed.

### **3.4.2 Construction of the questionnaire**

The questionnaire was designed to collect relevant contextual information on students' experiences, practices and perceptions of the level 6 science programme. The framework of a school-wide questionnaire was already in existence when this research was approved by the Correspondence School and the researcher was required to use this framework. Consistent with the policies of the Correspondence School in 1995 all the questions were positively worded, encouraging a positive response through compliance. Most of the developed questions were relevant to the main areas of the present study but with permission, several of the questions were modified to fit the research questions of this study and some entirely new questions about the science skills were added. Questions addressed learning content, practice of skills, teacher-marked work, progress through course, layout and writing style of course and skills.

The final form of the questionnaire had several open-ended questions as well as closed questions, which were included to allow the respondents some freedom to elaborate on how they felt about the level 6 science course. The measurement technique used in closed questions to rank opinions and attitudes was a five point Likert-type scale that could be treated as an ordinal measurement. Ordinal scales involve ranking but make no assumptions concerning equality of difference between ranks. The number of students giving each of the five responses on each item was recorded and percentage responses calculated. The researcher decided not to code the information given to the open questions but to use it as anecdotal evidence where appropriate because of the very wide variation of answers given.

The questionnaire was used with the intention of collecting a baseline of written data on the ways students worked in distance education and what they thought about their work.

(i) Pilot testing

Five students from the excluded population were asked to test the questionnaire. Their answers to the pilot test gave the researcher the opportunity to detect and remove ambiguities in wording such as double-barreled questions, to see the range of possible responses, especially those to open-ended questions that may need coding, and to see if the items were giving the information desired. Information gained from the pilot testing allowed limitations to validity to be recognized. Some questions were reworded so that they did not lead the students to particular answers or to anticipate what they thought the researcher was expecting to hear. The final form of the questionnaire appears in appendix 3.

### **3.4.3 Questionnaire administration**

Two hundred copies of the questionnaires and return-addressed envelopes were collated and coded and sent to the selected sample. Checklists of the students in the sample were set up with the codes and their ID numbers. The initial posting of the questionnaire was put into the first return mailing of the student's marked work after 14 July 1995. The posting included a cover letter, the questionnaire and a stamped return-addressed envelope. The cover letter was important because it established the authenticity of the study and the researcher. It also covered the following points: the purpose of the study, and how the student's privacy and confidentiality would be preserved (copy in appendix). The stamped return-addressed envelope to the researcher was important for the privacy of the students' answers because the study was conducted by a member of the Correspondence School staff and promoted by the Correspondence School and entailed the evaluation of a Correspondence School course.

Each student was coded according to their position in the stratified sample population. This code was used on the questionnaire in place of their name and was used on the database when recording the student's answers. The students were not anonymous, but confidential to the researcher. The reason for the lack of anonymity was that if a poor final return eventuated, a method to find information about the non-respondents was needed. Non-respondents would be identified on the database and their school records compared with the respondents as a check on potential bias and sampling error.

A period of a month was given for the respondents to return their questionnaires. After this, follow-up notes were sent to those who had not responded and were attached to their marked schoolwork for one more month, then the remaining non-respondents were telephoned if this was possible. The 31st October was the final date for replies to count. Previous Correspondence School studies using postal questionnaires indicated some groups of students were poor responders but there was little data to support this. Response rates and analysis of the students' answers followed.

### **3.5 *Teacher perceptions***

The full-time teachers who had marked the Level 6 science Correspondence School course in 1995 were asked to fill in a survey on whether they felt the course had fulfilled its purpose. They were also asked about any shortcomings they perceived and whether there was anything that needed revision. This survey had a very low rate of return, but pointed to ambiguities, which were rectified in the final 1996 version of the survey. This final survey was of an unstructured form with topic headings as guidelines allowing free expression of opinions. Even though there were only nine teachers involved a written questionnaire was chosen because there was a lack of a private place to conduct interviews. The teachers were very reluctant to be identified with the answers they gave. Open questions were chosen because they allowed the teachers to answer freely and openly.

#### **3.5.1 *Teacher participants***

The nine full-time teachers (three female, six male) who marked the level 6 Correspondence School science course in 1995 were invited to comment on topics about the course. Three External Tutors (casual out-markers, two females and one male) who also marked work in 1995 were not included because they were not available when the survey was required, as they only worked when required at peak times during the year. All the teachers were well qualified and experienced each with many years in the classroom situation before coming to distance education. However, as the Correspondence School level 6 science course was new, the teachers had only one year's experience of marking it.

### **3.5.2 Teacher questionnaire construction**

The anonymous questionnaire covered the teaching approach, perceived student learning styles, choice of contexts, course contents, the use of scientific and technical terms, teaching of skills and curriculum expectations. (Questionnaire can be seen in appendix 3). These topics were selected to complement the questions used in the students' questionnaire.

#### Pilot testing

Pilot testing of the final questionnaire was done by a science teacher not concerned with the marking of the course but who edited and rephrased some of the questions before they were used.

### **3.5.3 Teacher questionnaire administration**

The full-time teacher population was requested by the Head of the Science Department to fill in the questionnaire early in the school year of 1996. This was done at the end of a departmental meeting when all were present. When completed the questionnaires were put into the researcher's post-box during that morning. Eight replied but one did not. There were no reminders given as no more time was available. The teachers did not identify themselves on the questionnaires and their responses were not discussed so that only the researcher had access to their collected comments.

## **3.6 Ethical considerations**

Snook (1981) pointed out that educational research is about gaining worthwhile knowledge about educational processes. It is recognized that educational research cannot be done without research with humans, which requires ethical considerations more than those of 'harm' and 'consent'. The design of this research was guided by the ethical requirements of the *Code of Ethical Conduct for Research and Teaching involving Human Subjects (1990)*. The main principles of ethically-conducted research cover informed consent, confidentiality, minimizing of harm, truthfulness and social sensitivity. In this section the role and responsibilities of the researcher are addressed.

In planning research the researcher should be satisfied that the proposed activities will give worthwhile results, that they could not be performed without human participants and that there are adequate resources so that they can be completed successfully.

Snook (1981) said researchers have responsibilities beyond planning activities and the analysis of data because other people may use any information gained. The researcher must be sensitive to the possible uses of the information. Snook (1981) continued to say confidentiality had to be maintained as it was related to privacy and that published information should not allow identification of individuals or institutions. In this research the identity and privacy of individuals has been preserved by coding their details, but the identity of the institution has not. This is because there is only one school in New Zealand that is involved in distance education in the way described and that is the Correspondence School, therefore privacy is not possible. The Correspondence School recognized this but agreed to this study.

The researcher is also responsible for writing a research report that is not harmful to the institution's reputation. This may involve taking decisions about what shall be included and excluded from the report. Burgess (1985) thought there was always a concern about what is investigated, how the data are collected and analyzed and the way in which research data are dispersed.

Since the collection of the data in this research, there has been a considerable time lapse to the writing of the report. This time lapse helps protect the privacy of individual students, teachers and the institution. During this time the institution has developed new strategies and administration procedures that may tackle some of the concerns raised in the research.

The researcher has to be careful not to interpret results in a manner that would be detrimental to one particular group. Maori writers, such as Durie (1992), said there was a general dissatisfaction with research methodologies and outcomes of research because they have ethical concerns about research on Maori. In educational research it has been reported that there is an 'achievement gap' (Durie, 1992 p6) that refers to the difference between rates of achievement by Maori and those of others. He said the Maori community see a need to identify all available resources that would lead to successful educational outcomes and feel researchers have an obligation to seek ways to rectify the negative findings. Bishop and Glynn (1992, p125), suggested research had:

oversimplified Maori history, undervalued Maori knowledge and underestimated Maori learning processes.

They said the research process and findings should be shared with the Maori community in a culturally appropriate manner. As Maori students are part of the study's population these concerns need to be heeded. Results from this study will be made available through the Correspondence School.

The status of the researcher in relation to the research project may also raise some ethical concerns. In this research, the researcher was also in the position of teacher to some of the student sample, a colleague to the teacher population surveyed and an employee of the institution concerned. As a teacher it was necessary for the researcher to separate the research process, data collection and data analysis from the teaching duties as far as possible. The researcher also had a responsibility to colleagues not to use, or record any information or opinions given in personal conversations and meetings assuring colleagues of confidentiality and that full disclosure was most unlikely.

Ethical issues related to cost/benefit considerations were examined, such as the use of existing Correspondence School administrative processes. It was decided the administrative costs should be kept to a minimum by posting the surveys with returning work to the students instead of separately, and by supplying addressed envelopes for the return of the questionnaires which could be posted post free, or put into work coming to the school.

### **3.7 Trustworthiness**

The research was designed to ensure that it was a trustworthy study. It attempted to satisfy four main criteria of trustworthiness: confirmability, credibility, dependability and transferability (Lincoln and Guba, 1985, 1990).

Confirmability refers to the degree with which the method and data are shown to reflect the researcher's way of thinking. All decisions made throughout the research process should be visible and justified.

Confirmability also requires there remains an adequate record of data so that someone else could follow the procedures and replicate the study.

Credibility or internal validity of reports refers to other people finding the interpretations and analysis acceptable and judging the results as being faithful to the data. Do they say what the researcher says they do?

Triangulation of different data-gathering techniques in several contexts helped to ensure the overall precision of the research process.

Dependability or reliability refers to the consistency of the research findings and the fit between the reported data and what actually occurred in the collection of the data. The study involved a number of research and data-gathering techniques in several contexts over a period of time.

Transferability or external validity refers to the researcher giving sufficient descriptive information for another researcher to be able to relate the findings to another site.

### **3.8 *Limitations to this research.***

There are a number of limitations to the methodology of this research that must be acknowledged before presenting, interpreting and discussing the results. The limitations recognized by the researcher are:

1. Student sample population was not totally representative because students transferring in and out of the course were not taken into account and only those students active on July 14 included.
2. A time restraint of two months for the return of the questionnaire, as some students may have found it difficult to return the questionnaires because of where they live.
3. Conditions of response were uncontrolled so that the students may have not completed the questions by themselves and may not have been as honest as they might, because of the Correspondence School role in the Questionnaire.
4. Using the same questionnaire format of others used in the Correspondence School so that information could be shared, restricted the questionnaire design.
5. Teacher survey did not include outmarkers.

The next chapters record this research.



## 4 Analysis of science skills in curriculum documents

In this chapter the relationships between *The New Zealand Curriculum Framework* (Ministry of Education, 1993a) *Science in the New Zealand Curriculum* (Ministry of Education, 1993b), *School Certificate Science Examination Prescription* (New Zealand Qualification Authority, 1994) and the level 6 science Correspondence School course (1994) are analyzed.

The investigation began by identifying the science skills found in *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and *The New Zealand Curriculum Framework* (Ministry of Education, 1993a). The science process skills in level 6 of *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) were then examined.

The next section looked at the science skills specified in the *School Certificate Science Examination Prescription* (New Zealand Qualification Authority, 1994) and compared these skills with those of the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) statement.

The third section identified the science process skills of the level 6 Correspondence School course and discussed the effects of distance education. All the documents referred to above contribute to the educational environment and system of New Zealand in which this research took place.

### 4.1 The educational system

An educational system is divided into many different levels or subsystems, interacting with each other and the educational environment. From an ecological-contextual approach, such as that developed by Bronfenbrenner (1979), the influences of the education system can be analyzed.

Bronfenbrenner (1979) proposed a systems approach in which there were distinct levels of organization embedded in one another but with interactions between them. These levels were the exo-, macro-, meso- and micro-systems. In New Zealand science education the macro level consists of the *New Zealand Curriculum Framework* (1993a) and the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b), *School Certificate Science Examination Prescription* (New Zealand Qualification Authority,

1994). These have an impact on all the other systems. The meso-system consists of the schools' policies that develop the science curriculum statements and examination prescriptions into working programmes for the teachers and students. The smallest subsystem or micro-system is the classroom science programme with which the teachers and students interact. Outside of all this is the exo-system, which consists of all the influences that are not directly involved with science education but may affect it.

McMillan (1991) saw the output of a subsystem at one level as the input for the subsystem on the next level. Previously, Goodlad et al (1979 cited in Pelgrum and Plomp 1991) viewed these input and output levels as five developmental steps of a curriculum and named them the ideal, formal, perceived, operational and attained. However, Pelgrum and Plomp (1991) reduced that number to three:

1. the intended curriculum, consisting of the curriculum plans laid down in official documents
2. the implemented curriculum, consisting of the content, time allocations, and instructional strategies which the school develops for the teacher to follow
3. the attained curriculum, including what the students have learnt as a result of the teaching.

The three steps of Pelgrum and Plomp (1991) provide a framework for discussing major influences that affect the learning environment of this research. These influences are:

1. the intended curriculum of the *The New Zealand Curriculum Framework*, the *Science in the New Zealand Curriculum* and the *School Certificate Science Examination Prescription*
2. the implemented curriculum of the level 6 Correspondence School science programme and
3. the attained curriculum of the students.

The *New Zealand Curriculum Framework* (1993a) is the official policy document for New Zealand along with supporting national curriculum statements. It consists of the principles of teaching and learning, seven essential learning areas and eight essential skills (appendix 4A ). It also describes the attitudes and values each student should develop and the way specific national curriculum statements should be used. It outlines the policy for assessment at school and national levels.

The *New Zealand Curriculum Framework* (1993a) requires all national curriculum statements to specify clear learning outcomes against which student's achievements can be assessed. These learning outcomes are defined over eight progressive levels and grouped into a number of strands. The *New Zealand Curriculum Framework* (1993a) also requires the development of essential skills in each learning area. Science is one of the seven identified learning areas and as with each such area, the curriculum statement for science has three main thrusts:

1. continuity and progression in learning as seen in the achievement objectives;
2. the use of diagnostic and formative assessment to raise the standard of learning and teaching for all students;
3. the need for learning to be in meaningful contexts to the students.

The achievement objectives of each level of learning within the essential learning areas give the prescribed learning content. Besides the essential learning areas, eight groups of essential skills are identified that cut across the areas. The skills are to be developed to different degrees in different areas. In science at level 6 the development of these essential skills continues are evident in the science skills. (Achievement objectives for levels 5-6: Developing skills and attitudes are in appendix 4B).

#### **4.2 Science skills at level 6 Science in the New Zealand Curriculum**

*Science in the New Zealand Curriculum* (1993) replaced all previous science syllabuses. It was first published in a draft form first for public and professional discussion and feedback. *Science in the New Zealand Curriculum* in its final form took on legal status when it was gazetted in December 1994 for implementation in 1995. Because *Science in the New Zealand Curriculum* was referred to in the National Education Guidelines, schools are legally obligated to provide programmes developed from it. (Education Amendment Act, 1991 s60A).

The objectives in the *Science in the New Zealand Curriculum* statement are broad. They refer to scientific investigations, understanding scientific concepts, principles and models and the understanding of how things work. In this section the level 6 science skills are identified and are discussed in line with the threefold thrust of the curriculum statement previously

mentioned.

#### **4.2.1 Specified skills of level 6**

Developing scientific skills and attitudes is one of the integrating strands of *Science in the New Zealand Curriculum*. This integrating strand, along with the other integrating strand, 'Making sense of the nature of science and its relationship to technology', is designed to be interwoven between the four contextual strands which are

Making sense of the Living World

Making sense of the Physical World

Making sense of the Material World

Making sense of the Planet Earth and Beyond. (Ministry of Education, 1993, p7).

The achievement aim of 'Developing scientific skills and attitudes' is for students to

further develop their investigative skills and attitudes within the content and contexts of the learning strands (Ministry of Education, p42).

The term 'investigative skills' refers to all the skills identified by Watts (1991) as process skills and how they interact when used by students to complete an investigation. This is seen as part of the shift to the child-centered constructivist model. The final outcome of this achievement aim is for students to carry out complete investigations. The individual process skills of science identified are: (a) focusing and planning; (b) information gathering; (c) processing and interpreting information and (d) reporting and communication, and are the subject of this research. (Appendix 4B)

Process science skills are usually positioned in the middle of a simple hierarchy that goes from generic (essential) skills to science process skills to investigative skills. Research by Yeany, Yapp and Padilla (1986) and Duschl (1989) support this type of hierarchy and the relationships between the three identified groups of skills. The relationship of these groups suggests a progression of skill learning and assumes the skills can be transferred from one situation to another giving continuity by accumulation of learning and skill development. The debate about skill transferability is documented in the literature review where research of Soloman (1983), Brown and Palinscar (1989) and Tamir (1989) indicates that transfer is possible if certain conditions are observed.

Nevertheless, science teachers are informed that the division into these six strands does not indicate that the learning in each strand is to be developed independently from one another, (Ministry of Education, 1993 p14). It is expected that the combination of all strands should integrate knowledge and skills, however, it is left up to teachers to achieve this.

The relationship between knowledge and skills in this curriculum is not clear and is seen as a problem for teachers by Bell (1995). Other researchers, Kelly (1995) and Neyland (1995) also recognized this problem and have raised it in their debates on the curriculum policy of 'science for all'. Neyland (1995) said the views of knowledge given by the *Science in the New Zealand Curriculum* (1993b) follow two main pathways. One pathway described knowledge as individualistic, based only on what the senses perceived and that it was a collection of isolated pieces of information separated from any values. The other pathway was that knowledge was not only facts but concepts and skills and the relationships between all of them. This knowledge originates in society as well as individuals and comprises observable information along with other less observable relationships that reflect historical and social factors that act on its construction. The two identified pathways give a conflicting philosophical base from which teachers have to choose the most appropriate for the work they are doing at any one time.

#### **4.2.2 Knowledge and skill relationships**

The strands in *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) show different views of knowledge and their relationship to skills. The contributing biologists, who advised on the 'Making sense of the Living World, and chemists, who advised on 'Making sense of the Material World", saw knowledge as progressing from concrete experiences to abstract logical operations (Ministry of Education 1993b p 52, 88-89). To the physicists, who advised on 'Making sense of the Physical World', progression was about the development of skills such as exploring and observing, to trends and patterns (Ministry of Education 1993b, p71) indicating that skills should be developed before knowledge and that the learning of skills is more important than content.

The *New Zealand Curriculum Framework* (Ministry of Education, 1993a) makes skill education explicit within general education. However the introduction to the *Science in the New Zealand Curriculum* (Ministry of

Education, 1993b) appears to emphasize skills in isolation from knowledge and implies transfer of these skills to other situations is expected, by constructing the separate integrating strand, 'Developing scientific skills and attitudes'. On the other hand it is acknowledged that the integration of knowledge and skills with investigations allows the development of ideas and knowledge.

The development of scientific skills and attitudes is inextricably linked to the development of ideas in science (Ministry of Education 1993a p14).

If skills are separated from their scientific conceptual base it may give rise to problems and give rise to fragmented information. Skills have to be learnt within a context. Kelly (1995) questions what ideas each student would learn about isolated skills and suggests the different skills should be related as far as possible to content matter and scientific processes. This is acknowledged by the curriculum and it states that

in practice, science is a process involving the integration of knowledge, skills and attitudes to develop scientific understanding (Ministry of Education, 1993a p42).

This looks like an attempt to address the process and content debate familiar to science teachers as it asserts that skills are subservient to the greater goal of understanding. On the topic of skill transfer Wellington (1989) said transfer of separate skills would probably be successful when a teacher taught the ideas behind the skill and the skill was reinforced by repetition. A skill like using a thermometer would be transferable when the student had learnt how to read the thermometer, and under what conditions to use it. Singley and Anderson (1989) also said learning was a pre-requisite for skill transfer. However, the skills in the Making Sense of the Living World strand are not as clearly defined as the skill for using a thermometer. For example, the essential skill of observing ranges from direct observation, as in animal behaviour, to indirect observation of the effects of a biochemical reaction (production of starch in photosynthesis). Each type of observation is tied to its context and has to be taught in each.

The problem of ill-defined skills is found in the other science strands as well. Named skills change in complexity from one context to another and students

could have difficulties in showing they have acquired the skills. Wellington (1989) saw a danger in teaching skills for assessment. He thought the skills would be isolated from subject knowledge and context.

#### **4.2.3 Assessment of skills in the curriculum**

Assessment in the New Zealand curriculum has several main purposes of which improvement to students' learning, maintenance of quality of learning programmes and identification of learning needs so that resources can be upgraded are important. Assessment also provides feedback to students and care-givers and is the basis for awarding qualifications and monitoring educational standards. To meet all these requirements, a range of assessment procedures is needed that is designed to attend to specific learning needs of students.

The assessment is mainly school-based and directed towards individual student progress. Its main aim is to improve teaching and learning by diagnosing students' strengths and weaknesses and measuring students' progress against the achievement objectives of the national curriculum statements. Student profiles can be built up from the information gained. Evaluation of this summative information then helps teachers provide the best programmes.

In the senior secondary school, examinations and assessments for the purpose of awarding qualifications are the responsibility of the New Zealand Qualifications Authority. However, the standards for these assessments, for example School Certificate Science examination, are based on the learning outcomes of the national curriculum statements.

### **4.3 Skills in the School Certificate Science Prescription**

This prescription was examined for the first time in 1995. It provided the specifications for the School Certificate examination and was derived from the achievement objectives for level 6 of the *Science in the New Zealand Curriculum* (Ministry of Education 1993b). The relationship between the prescription and the science curriculum was such that the curriculum provided the framework for school courses in science while the prescription specified the requirements for the examination.

As the prescription was based on the achievement objectives of level six, the

same process skills were specified. The prescription set out to examine candidates' ability to plan a practical investigation, process and interpret scientific information, and communicate scientific information. These process skills were further defined by giving lists of component skills that would be assessed as given in table 4.1.

In addition to these process skills, two other groups of skills which are not part of this study, were to be assessed (a) use scientific knowledge and understanding to describe and explain scientific phenomena, (b) apply scientific knowledge and understanding in a variety of contexts. Range statements were provided for use and application of scientific knowledge, They prescribed the knowledge and understanding candidates were expected to have and were taken from the achievement objectives for each science strand in the curriculum.

Table 4.1 Process science skills and their component skills.

| Process skill                                  | Component skills  |
|--|---|
| 1 plan a practical scientific investigation by | <ul style="list-style-type: none"> <li>• making testable predictions</li> <li>• identifying procedures for trialling</li> <li>• designing a fair test with clear specification and control of likely variables</li> <li>• selecting equipment</li> <li>• selecting a range of measurements</li> </ul> |
| 2 processing and interpreting                  | <ul style="list-style-type: none"> <li>• identifying trends, relationships, patterns</li> <li>• interpreting graphs</li> <li>• drawing and justifying conclusions</li> <li>• evaluating an investigation</li> </ul>   |
| 3 communicating scientific information         | <ul style="list-style-type: none"> <li>• writing text and symbols</li> <li>• drawing diagrams</li> <li>• drawing graphs</li> <li>• tabulating data</li> </ul>   |

The range statements in the School Certificate science prescription clarified the depth of study expected of the Level 6 science student. The prescription indicated that at least one third of the examination would assess these identified process skills which would be integrated with material from the strands of the science curriculum. Any extra information the students needed would be provided as resource material in the examination questions.

#### **4.4 Science skills in the Correspondence School level 6 course**

This section sets the context in which the students study science. The level 6 Correspondence School science course is planned, written and produced in the school for distribution to the students. Descriptions of the course writing, structure of the level 6 programme and the science skills follow.

##### **4.4.1 Management of course writing**

When the Correspondence School level 6 science programme was produced (1994-1995) educational resource development at The Correspondence School was a team affair. It was composed of a project manager, support systems (word processing, visuals, illustrations) and course writing team. The course writing team consisted of subject teachers with expertise in at least one of the curriculum strand areas and an overall subject editor who was the senior science teacher. The production was carried out as an industrial process with the writing team pivotal to the whole process, but subject to the requirements of all other departments involved in the production of the course as seen in Fig 4.1.

There were restrictions on the size of the booklets that were both cost related and educational. Cost of new courses has to be found within the Correspondence School's bulk funding and relate to production, print and postage costs, illustration costs and time costs in the form of salaries. Also from an educational view the book size restrictions are necessary as distance students receive most of their courses in print form. It is generally thought by the Correspondence School teachers that the students would probably be put off reading anything if there was too much to get through.

The subject teachers' work is edited before production begins and sometimes results in sections being deleted because the editorial staff considered them unnecessary. As these courses were prepared for distance learners isolated by circumstances from a teacher and other learners, the lack of personal contact requires the writer to use different techniques. These techniques are described as 'teaching by design' and they are based on work done by Rowntree (1990 and 1992), Evans, (1991) and Evans and Nation, (1989). Training was provided for the writers, which focused on the 'way' the Correspondence School wrote for distance education. This

included extra information that was needed by distance education students. It consisted of extra skills on how to learn by distance, deal with course administration, manage time and recognize course expectations.



Fig 4.1 Support systems of the writing team.

The Correspondence School 'way' in 1995 was based on the writings of Holmberg, (1989) and Baath (1981) that incorporated aspects of the behavioural theory. It also included school policies and practices on language levels to be used, gender inclusiveness and the consideration of Maori.

#### 4.4.2 Structure of the level 6 science programme

Not all of the level 6 *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) or the *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994) was put into the Correspondence School science program. Differences in interpretations of the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994) occur when teachers with subject expertise interpret and develop the course in one way and editorial staff interpret differently.

On top of the structure imposed by *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the new *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994) there was a programme structure that The Correspondence School used which spread the level 6 science course throughout the academic school year. It had been estimated that there were thirty weeks in the academic year available

to the students to do course work. The rest of the academic year was used for school camps and assessment activities such as examinations and practical projects. To cover the course students were expected to return one booklet every two weeks.

The resource planning and approval process for the development of this course passed through several committees such as the Board of Trustees curriculum Committee, Heads of Departments and Curriculum Coordinator, Principal's Curriculum Advisory Group, Management Group, Project Manager and the Board of Trustees' Executive Steering Group.

There were fifteen booklets to the Correspondence School level 6 science programme. Fourteen of them covered the course requirements of level 6 *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the new *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994) and the fifteenth booklet consisted of revision exercises and questions similar to School Certificate examination questions for the students to practice.

Every third booklet contained a teacher-marked assessment test to be done under examination conditions. From this assessment test teachers could pick up problems or areas of concern in the students' learning. The teachers were then able to give further support to their students in their letters that accompanied the return of work. Fig 4.2 shows the general plan of the course.

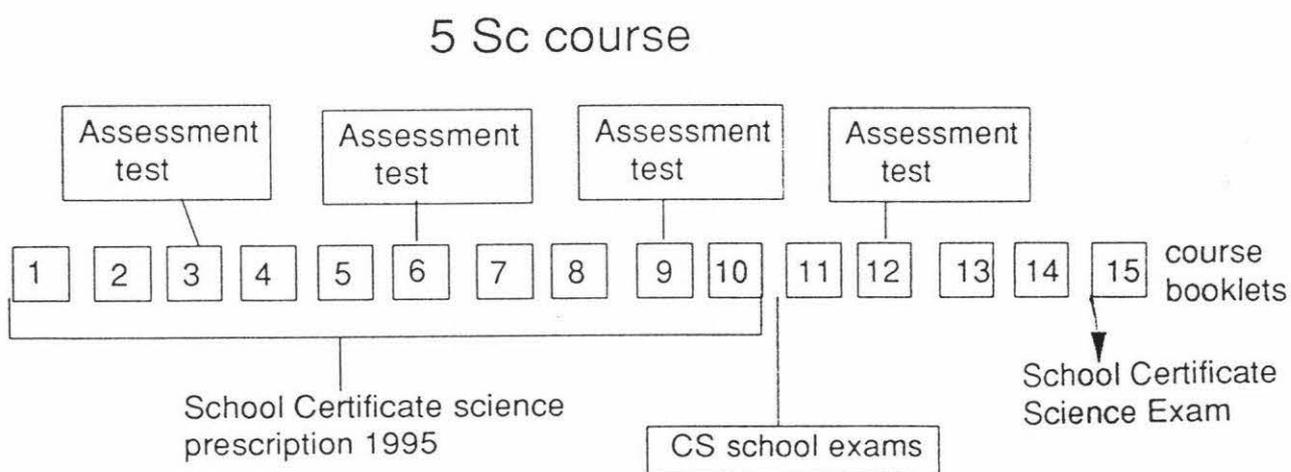


Fig 4.2 Plan of The Correspondence School level 6 science course.

Each lesson had a given structure. The lessons began with a short introduction to orientate the learner. Often it began:

In this lesson you will...Or - At the end of this lesson you will be able to....,

followed by a list of behavioural objectives and expected results. Specific instructions and activities followed this. Activities were an important part of the lesson and told the students what to do or how to actively use the material. This has been described as 'trying to simulate a tutorial in print' (Rowntree, 1990, p.120). In the Correspondence School level 6 science programme the activities consisted of:

- self-marked written and practical exercises where students could assess their progress by marking them from answers at the back of the booklet. This was to foster independent student learning.
- teacher marked written and practical exercises, which gave the teacher the opportunity to gauge the learning that had taken place and award grades or marks.
- assessment tests that were done under examination conditions and were teacher marked. These were designed to show whether learning objectives had been attained.

The lesson structure was supervised by the Resource Editor/Distance Education Adviser who also saw that appropriate reading levels and the style the Correspondence School set for writing were followed. The Correspondence School science department did not send textbooks to students but attempted to include the information needed to do the course in the booklets. Scientific language was kept to a minimum.

The reading and writing of scientific language was discussed in the literature review where textbooks were identified as the main source of models for most students in the past for both normal scientific text and the alternative science languages. With the removal of the traditional textbook from the classroom and distance education many students do not have the opportunity to see or read any scientific language. Those who do see the new textbooks designed for the new science curriculum find they only provide fragmented examples of scientific text and often appear not to match the language of examinations. In an analysis of some new textbooks such as *The Living World* (Relph, Black and Jamieson, 1994) and *Planet Earth and Beyond* (Relph, Walker, Vallender and Dunlop, 1994) written for the

*Science in the New Zealand Curriculum* (1993b) and the resource material used in the science examination, it was found the reading ages of the two types of text differed considerably. The Flesch reading ease index is based on the average number of syllables per word and the average numbers of words per sentence. Scores range from 0 - 100. The higher the score the greater the number of people who can readily understand the document. A second index, the Flesch-Kincaid grade level is based on the same average syllables per word and the average number of words per sentence. The score in this case indicates a grade school level. The results shown in table 4.2 compare the three kinds of writing the students in this study may be required to read, the Correspondence School course, the School Certificate science examination paper and specific classroom textbooks if they are available. Most school students doing Curriculum level 6 are in year 11 and are aged between 15 -16 years. Investigation shows that the Correspondence School science course is written at a younger reading level than the School Certificate science examinations or the textbooks. This may disadvantage some students in not preparing them for the reading level of the text they would meet in the examination questions or resources.

Table 4.2 Comparing reading ease and grade levels.

|                                    | Level 6<br>science | Classroom<br>textbooks | School<br>Certificate |
|------------------------------------|--------------------|------------------------|-----------------------|
| Flesch reading ease                | 79.4               | 43                     | 52.1                  |
| Flesch - Kincaid grade level       | 4.7                | 12                     | 9.7                   |
| Expected reading age of<br>student | 9 -10              | 16 - 17                | 13 - 14               |
| Year level in New Zealand          | Year 5             | Year 12                | Year 10               |

To achieve the learning objectives of level 6 science The Correspondence School had some support structures in place. These were:

- science boxes filled with equipment and chemicals that were sent to the students so that they could do the practical work
- teaching notes which consisted of model answers to the teacher-marked written exercises and information that gave students the opportunity to go over their work again and check on their learning
- personal letters from teachers structured to comment on something positive and what the student has done well, followed by comment or instruction on how to improve two or three learning points

- phone calls if the student had a phone connected.

The student questionnaire asked about the suitability and usefulness of this support.

#### **4.4.3 Booklets of the level 6 science course**

Each booklet was self-contained within a topic area and did not link or refer to other booklets. This was to cater for the ever-changing student population throughout the year. The booklets had discrete chunks of the course that contained the information to introduce the context and required for the activities. A summary of the topics chosen by the Correspondence School is in Fig 4.4. It was assumed students would finish the fifteen booklets after the Correspondence School practice examination in early September and have time to revise using booklet 15 before sitting the School Certificate Science Examination.

The aims and objectives used to guide the content matter in the level 6 Correspondence School science course were explicit and appropriate. The content fitted the objectives and distance education requirements. The course was factually correct in the main and at the time of writing, it was up-to-date. However, as the course usage continues this will not remain so. Within each content area it is considered that the course holds together logically. As students worked through the course and sat the School Certificate Examination in Science 1995, it was recognized that there were some omissions in the content areas covered due to over-simplification and over-generalization. Examples of these omissions were found in the description of the particle theory and parts of the Making Sense of the Planet Earth and Beyond strand. Some other omissions were deliberate, such as activities involving peer debate and assessment, because of the nature of distance education. Other omissions occurred when course size was taken into consideration. These types of omission included opposing viewpoints, non-examples were not given and some theories were ignored or treated as facts.

Table 4.3 Selected content analysis of booklets.

| % use in booklets                                | Selected content analysis of booklets   |
|--|---|
| <b>Use of science concepts</b>                   |   |
| 75%  | Presented concepts (scientific ideas) to students   |
| 75%  | Of the concepts presented were defined clearly  |
| 58%  | Used the presented concepts as used in School Certificate examinations                                |
| 16%  | Compared presented concepts with related concepts   |
| 8%   | Used concepts with reference to the social text of students or work                                   |
| 8%   | Related concepts to scientific principles   |
| <b>Use of diagrams to present subject matter</b> |   |
| 100%   | Used diagrams of apparatus, organisms and materials   |
| 33%  | Used some form of flow chart  |
| 16%  | Used a matrix or graph  |
| 0%   | Spider charts, concept or mind maps and cause and effect networks were not used to show relationships |
| <b>Sequencing of learning</b>                    |   |
| 100%   | Topic by topic  |
| 16%  | By chronological sequencing   |
| 16%  | By logical sequencing   |
| 8%   | Spiral sequencing   |
| 0%   | Causal or problem sequences, backward chaining or concentric circles.                                 |
| <b>Use of questions (Bloom's classification)</b> |   |
| 100%   | Recall  |
| 60%  | Response comprehension  |
| 40%  | Application   |
| 10%  | Analysis  |
| 0%   | Synthesis, assimilation or evaluation   |

Fig 4.4 Distribution of teaching content, skills and assessment

|   | Skills      | Topic test | Assessment test | Technology | Maori content |
|---|-------------|------------|-----------------|------------|---------------|
| <b>Genetics:</b><br>variation, chromosomes and cell division, DNA, Mendel, Punnett squares, sex chromosomes.  | P & I       | ✓          | –               | –          | –             |
| <b>Biotech:</b><br>biotechnology and selection, breeds and cultivars. Selection in horticulture and agriculture, biological principles of management. | P & I       | ✓          | –               | ✓          | –             |
| <b>Resourceful rocks:</b><br>how rocks are formed, rock types, rock cycle, rock properties and uses.  | DSD and WR  | –          | ✓               | –          | ✓             |
| <b>Chemical collisions:</b><br>effect on chemical reactions of temperature, surface area, catalysts and solution concentration.                       | PlgInv      | ✓          | –               | –          | –             |
| <b>Energy:</b><br>heat transfer by conduction, convection, radiation, other forms of energy, energy conservation.                                     | CInv        | ✓          | –               | –          | –             |
| <b>Chemical families:</b><br>acids, bases, metals and metal carbonates.   | CInv and UI | –          | ✓               | –          | –             |
| <b>Electricity:</b><br>voltage, current, resistance, circuits.  | UI          | ✓          | –               | –          | –             |
| <b>Fuels:</b><br>hydrocarbons (alkanes and alkenes), oil, natural gas, alcohols.  | ComI        | ✓          | –               | –          | –             |
| <b>Rumbling rocks:</b><br>earthquakes, volcanoes, crustal plates, fossils, meteors, rock dating, climate and sea level changes.                       | UI          | –          | ✓               | –          | –             |
| <b>Microorganisms:</b><br>bacteria, fungi and viruses. Useful micro-organisms, disease and the body.  | P&I         | ✓          | –               | –          | –             |
| <b>Patterns and predictions:</b><br>displacement, speed, velocity, force and acceleration.  | CInv        | ✓          | –               | –          | –             |
| <b>Heavenly motion:</b><br>our solar system, orbits, the moon, satellites, earth's rotation, star charts, the night sky.                              | ComI        | ✓          | –               | ✓          | ✓             |
| <b>Chemtech:</b><br>ironsands, iron and steel industry, effects of mining, non-metal oxides.  | P&I         | ✓          | –               | ✓          | ✓             |
| <b>Ecotech:</b><br>water-borne diseases, water treatment, micro organisms and food, managing a fishery, fishing technology.                           | WR          | ✓          | –               | ✓          | ✓             |
| <b>Revision:</b>  |             |            |                 |            |               |

An examination of the course booklets showed there was little variation in the way content material was presented. In four aspects of analysis used, namely concepts (scientific ideas), the diagramming of subject matter, sequencing of learning and types of questions asked, only a few of the possible types were used. The results of the analysis are shown in table 4.3.

#### **4.4.4 Skills in the level 6 science course**

The Correspondence School level 6-science course taught the science process skills as directed by the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) through the content topics. Fig 4.4 shows the distribution of skill teaching and practice through all the booklets and whether they tested in a topic test or an assessment test. Fig 4.4 also shows the technology topics and where Maori content is included.

The decisions of where and how the skills were distributed through the course were made by the writer/teachers who chose the appropriate skill to match the content they were teaching. The decisions were made in response to the specific learning outcomes they had developed from the achievement objectives. Because the course was limited in size due to educational and costs restraints, each type of skill was taught twice. However, some skills, such as processing and interpreting, were used in most booklets.

The skills taught followed requirements of the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the new *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994), but there were differences in emphasis due to teaching at a distance.

#### Effect of distance education on skill emphasis

In distance education the response time between teacher and student is longer than within a classroom so that debate and discussion is prolonged. This hinders distance students from generating and developing ideas. The generation and development of ideas, especially those suitable for scientific investigation are made for the students by the writers. The selection of information and the locating of information are also made for the students within the booklets, but students may be asked to find information from catalogues, indexes and other sources of information. The feedback to the teacher is by reporting rather than the teacher observing the process of information gathering. If the end product shows what is needed then the

process is assumed to have been done.

Some skills, in the *New Zealand Curriculum Framework* (Ministry of Education 1993a) and *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) are not emphasized in distance education although they are present in certain circumstances, for example some aspects of the social and physical skills. Many distance education students work in isolation but do have opportunity to practice these skills at school days, camps and subject seminars.

Other skills listed in the curriculum documents are at the forefront of distance education. Distance students develop independent work skills and study skills, skills of self appraisal, build on their own learning experiences, and take responsibility for their own learning. To be successful they have to manage their time effectively.

In the Correspondence School level 6 science course science process skills are emphasized. Each type of process skill is modelled for the student to follow and then the students are helped through a practice run which they can check through the self-marking. Finally they use the skill unaided and their account of what they did is checked by the teacher.

Distance education is not singled out in the curriculum documents as being different from conventional classroom education. There is no recognition that distance education requires a different approach or different resources. It is not mentioned separately in the *New Zealand Curriculum Framework* (Ministry of Education, 1993a) or *Science in the New Zealand Curriculum*. (Ministry of Education, 1993b) It is assumed that the Correspondence School, as a distance education establishment, will be able to fulfil the requirements of the *New Zealand Curriculum Framework* (Ministry of Education, 1993a) or *Science in the New Zealand Curriculum*. (Ministry of Education, 1993b)

#### **4.4.5 Assessment in the level 6 science programme**

Assessment covered three main areas, skills, knowledge and applications. The skills and their applications were assessed in several ways ranging from teacher marking of student reports of practical experiments they carried out, to self-marked activities and teacher marked assessment tests. Most

assessments of skills were based on the written word but a few solid products from chemical experiments were sent in for the teacher to actually see. Not all skills of the *New Zealand Curriculum Framework* (Ministry of Education, 1993a) and *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) were assessed. For example, the group skills, because most distance education students work alone. The methods of assessment are limited by the isolation of distance students, as direct observation and discussion cannot take place.

Scientific knowledge and its application in new situations were assessed by means of teacher marked written tests and an end-of-year practice examination before the external *School Certificate Science Examination* paper.

#### **4.5 Summary**

It was found the course met most of the requirements of the *New Zealand Curriculum Framework* (Ministry of Education, 1993a) and *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) but it was modified by the demands of distance education. As would be expected, the level 6 Correspondence School science course was to be positioned on the middle ground between the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) and the *School Certificate Science Prescription* (New Zealand Qualification Authority, 1994). In assessment, the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) emphasizes assessment of the processes of doing science which are assessed by direct observation by the teacher, the School Certificate examination does not have practical work assessment and only reported outcomes are assessed. However, the level 6 Correspondence School science course, on the other hand, does have students doing practical work, but teachers do not directly observe this. The teachers assess the evidence of the process of doing science and the end reporting.

Another example of this type of dichotomy is seen in *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) which advocates a wide use of social contexts and student co-operation on the one hand, but competition and a movement towards a training culture on the other. Meanwhile the School Certificate examination emphasizes competition only, and the level 6 Correspondence School science course fosters independent learning, less competition and less peer co-operation.

This chapter has reviewed the curriculum documents that were used to develop the level 6 Correspondence School science course. The next chapter reports on how well the students performed when using this course.

## 5 Student performance

This chapter reports findings on student performance on science process skills. The chapter is divided into three sections outlined below and is followed by a summary.

The first section aims to answer the research question

How well do Correspondence School students achieve in the skills taught through the curriculum level 6 Correspondence School science programme when analyzed by gender, ethnicity and enrolment group?

It looks at student performance in science skills found in the different science strands of *Science in the New Zealand Curriculum* (Ministry of Education, 1993b).

The second section aims to answer the research question

What skills are transferable from one task to another when taught through the curriculum level 6 Correspondence School science course?

It was necessary to find out how well the skills were identified and distinct from each other and whether the skills were transferable or context bound. Kok-Aunoh and Woolnough (1994) and Lock (1990), suggested that student performance levels could indicate which skills were transferable or those which were context bound.

The third section aims to answer the research question

How does the performance of Correspondence School students compare with student performance from conventional schools?

The 1995 performance results of those students who took the Correspondence School internal science examination and the *School Certificate in Science Examination* (1995) were compared to see if performance in the internal examination was an indication of performance in the national examination. Secondly the results obtained by the Correspondence School students in the *School Certificate in Science Examination* (1995) were compared with the 1995 national results obtained by students from conventional schools.

### **5.1 Student performance scores from teacher logsheets**

Evidence of student performance was collected from the logsheets kept by the teachers who marked the booklets (also called sets) sent in by the students. The evidence was in the form of a score between 1 and 8 marked on an interval scale. This score did not differentiate between skills and tasks or the mastery of skills and tasks. It was an overall score for the skills tested in each booklet (appendix 3A, fig 3.1).

There were 396 students on the level 6 Correspondence School science roll on the 14 July 1995. Of these 396 students 45 students did not send in the first booklet due to change of course, withdrawal from the course or return to other schools, leaving 351 students working. The number of students responding to each booklet also declined as the year progressed due to further withdrawals (36% of students) or non-completion of booklets. However, some students, who did not finish the 10 booklets before the school examination time, sat the internal exam and/or the 1995 School Certificate Science examination.

It was the intention of the course design to introduce level 6 science with a first booklet that most students could do well. An average score of 6.5 out of 8 shows most students coped with it. The writers and editors then pitched all the other booklets at what they thought was an appropriate level for year 11 students studying for the 1995 *School Certificate in Science* examination. In studying the average scores for booklets 2 to 7 this would appear so, but the lower average scores for booklets 4 and 6 may indicate that the students found the chemistry skills and tasks a little more difficult to manage. As the year progressed the proportions of the different groups changed. The higher average scores seen in booklets 8, 9, 10 may show that the students who stay with the course and complete more sets achieve better or that students who achieve better stay and finish the course. Table 5.1 shows the mean scores per booklet of all students and the main enrolment groups.

The enrolment categories, home schoolers, adults and the secondary school students' performances were compared with that of the full time students who are the charter students of the Correspondence School. The full time students are those for whom the Correspondence School is their only option. The comparative performance of the home schoolers is shown in table 5.1. The numbers of home schoolers remained more stable throughout the year

than the other groups, with less student dropout. Their performance was varied, measuring significantly above the mean score of the full time students for booklets 1, 3, 4, 5, 6 and 9 but significantly lower than the mean for 7, the physics booklet.

The next enrolment category, the adults, had a high dropout rate and the numbers of adults continuing with the course through to booklet 10 was small. Only 25% of those that returned booklet 1 progressed to booklet 10. Their performance, however, was significantly above the mean for the full time student group for all booklets. Their performance data is shown in table 5.1 as well.

The last enrolment subgroup, the secondary school students, also had their performance compared with the fulltime group as seen in table 5.1. The secondary school students were those students who attended secondary schools throughout New Zealand. Their performance was significantly lower than the average for the full time student group in booklets 1, 3 through to 9.

In summary the adult students gave evidence that they could perform the skills at a higher level than the rest of the students. Of the compulsory school-aged students, the home schoolers obtained the highest scores, followed by the full time students and lastly the secondary school students.

As the full time students were further categorized into enrolment sub-categories of distance, medical, psychological, suspension, itinerant, pregnant schoolgirls and overseas students, further analysis of this group was undertaken. Table 5.2 shows the mean scores for the full time student group and this is used as the basis for comparing the subgroups. The results show that each enrolment sub-group achieved differently.

**Table 5.1 Skill scores for all students and main enrolment groups**

| Booklet N | All students |            | Fulltime students |            | Adult students |            | Home schoolers |            | Secodary students |            |
|-----------|--------------|------------|-------------------|------------|----------------|------------|----------------|------------|-------------------|------------|
|           | N            | mean score | N                 | mean score | N              | mean score | N              | mean score | N                 | Mean score |
| 1         |              |            | 210               |            |                |            |                |            |                   |            |
| biology   | 351          | 6.5        | + 3               | 6.3        | 73             | 7.1*       | 27             | 6.7*       | 38                | 5.9        |
| 2         |              |            | 196               |            |                |            |                |            | 38                |            |
| biology   | 328          | 5.6        | +3                | 5.3        | 64             | 6.5*       | 27             | 5.5        |                   | 5.2        |
| 3         |              |            | 183               |            |                |            |                |            |                   |            |
| geology   | 301          | 5.5        | +1                | 5.4        | 55             | 5.6*       | 26             | 6.5        | 36                | 4.6*       |
| 4         |              |            | 155               |            |                |            |                |            |                   |            |
| chemistry | 263          | 5.3        | +1                | 5.3        | 46             | 5.7*       | 26             | 5.8*       | 35                | 4.5*       |
| 5         |              |            | 137               |            |                |            |                |            |                   |            |
| physics   | 238          | 5.7        | +1                | 5.5        | 42             | 6.5*       | 23             | 6.3*       | 35                | 5.1*       |
| 6         |              |            | 117               |            |                |            |                |            |                   |            |
| chemistry | 206          | 5.3        | +1                | 5.3        | 34             | 6.6*       | 22             | 5.6*       | 30                | 4.9*       |
| 7         |              |            | 105               |            |                |            |                |            |                   |            |
| physics   | 191          | 5.5        | +1                | 5.5        | 33             | 6.0*       | 22             | 4.9*       | 30                | 5.1*       |
| 8         |              |            | 97                |            |                |            |                |            |                   |            |
| chemistry | 178          | 6.0        | +1                | 6.1        | 28             | 6.9*       | 22             | 6.1        | 30                | 4.9*       |
| 9         |              |            | 150               |            |                |            |                |            |                   |            |
| geology   | 151          | 6.8        | +1                | 6.5        | 20             | 7.3*       | 19             | 7.1        | 28                | 6.3*       |
| 10        |              |            |                   |            |                |            |                |            |                   |            |
| biology   | 126          | 6.5        | 126               | 6.9        | 18             | 6.8*       | 19             | 6.3*       | 22                | 6.4        |

Significant differences between full-time students and each other group. Two-tailed t-tests for unequal variances, \*  $p \geq .05$

The + numbers beneath the number of full-time students achieving a score indicates the number of students who did not return work for that booklet.

**Table 5.2 Booklet scores for subgroups of fulltime students**

| Booklet No.    | All fulltime students |            | Distance |            | Medical |            | Psychological |            | Suspension |            | Itinerant |            | Pregnant girls |            | Overseas |            |
|----------------|-----------------------|------------|----------|------------|---------|------------|---------------|------------|------------|------------|-----------|------------|----------------|------------|----------|------------|
|                | N                     | mean score | N        | mean score | N       | mean score | N             | mean score | N          | mean score | N         | mean score | N              | mean score | N        | mean score |
| 1<br>biology   | 210                   | 6.3        | 32       | 6.4        | 50      | 6.6*       | 44            | 6.1*       | 24         | 5.4*       | 32        | 6.6*       | 15             | 6.6        | 13       | 6.0        |
| 2<br>biology   | 196                   | 5.3        | 32       | 5.5*       | 49      | 5.8*       | 39            | 5.0        | 21         | 4.1*       | 30        | 5.8*       | 12             | 5.4        | 13       | 5.3        |
| 3<br>geology   | 183                   | 5.4        | 30       | 5.5        | 46      | 6.2*       | 36            | 4.6        | 17         | 4.3*       | 30        | 5.8*       | 12             | 6.0*       | 12       | 5.5        |
| 4<br>chemistry | 155                   | 5.3        | 25       | 5.7*       | 40      | 5.1        | 28            | 4.5*       | 13         | 4.5*       | 28        | 5.4        | 11             | 5.6        | 10       | 6.7*       |
| 5<br>physics   | 137                   | 5.5        | 23       | 5.2        | 34      | 5.6        | 25            | 4.4*       | 9          | 4.1*       | 27        | 6.2*       | 9              | 6.5*       | 10       | 6.2*       |
| 6<br>chemistry | 117                   | 5.3        | 22       | 5.4        | 29      | 4.7*       | 21            | 3.9*       | 7          | 5.3        | 24        | 6.0*       | 7              | 5.8        | 7        | 6.4        |
| 7<br>physics   | 105                   | 5.5        | 23       | 6.1        | 24      | 5.3        | 17            | 4.9*       | 5          | 5.0        | 23        | 6.1*       | 6              | 5.8        | 7        | 6.4        |
| 8<br>chemistry | 97                    | 6.1        | 21       | 7.1*       | 22      | 6.2        | 15            | 5.6*       | 5          | 6.7        | 22        | 6.5*       | 6              | 5.8        | 6        | 5.5        |
| 9<br>geology   | 69                    | 6.5        | 19       | 6.3        | 18      | 6.8        | 13            | 6.2        | 4          | 7.4        | 19        | 6.5        | 4              | 7.3        | 6        | 7.3        |
| 10<br>biology  | 38                    | 6.9        | 16       | 6.6        | 14      | 6.3        | 9             | 6.0        | 3          | 5.5        | 16        | 6.6        | 5              | 7.3        | 4        | 6.5        |

Significance of differences between full-time students and each other group, two-tailed t-tests for unequal variances, \*  $p \geq 0.05$   
 The small numbers of students still studying the later booklets of the course are shaded. The corresponding results were considered unreliable.

The 'distance students', those enrolled at the Correspondence School because they lived too far from a local school, performed in a very similar way to the whole of the full time student group but their scores were significantly higher in booklet 2 (biology), booklet 4 (chemistry), and booklet 9 (geology).

There was a higher dropout rate (72%) for the medical enrolments than the rest of the enrolment groups, due to recovery or deterioration of their condition. Their mean scores (table 5.2) were higher at the beginning of the course where the mean scores were significant in booklets 1 (biology), 2 (biology), 3 (geology) and booklet 6 (chemistry) but physics booklets 5 and 7 proved more difficult for them.

The psychological group mean scores were below the fulltime group mean scores throughout the level 6 science course. Their mean scores were significantly lower as shown in table 5.2, especially in the physics booklets 5 and 7, and chemistry booklets 4, 6 and 8.

The suspended students mean score was significantly lower than the mean score of the fulltime students for booklets 1, 2, 3, 4 and 5. Very few suspended students sent in work from the rest of the level 6 course as highlighted in table 5.2.

Itinerant students mean score was significantly higher than the fulltime students' mean score, except for booklets 9 and 10. This is also shown in table 5.2, as are the pregnant girls' mean scores. When the pregnant girls' mean scores were compared with the fulltime students' mean scores it showed they were very similar even though the pregnant girls had to overcome many unfamiliar situations during the time they studied.

The overseas students' mean scores were significantly higher than the fulltime students' mean scores for booklets 4, 5, 6 and 7, but there were only two significant differences similar to the pregnant girls. As there were very few students in this group as highlighted in table 5.2, the results may be misleading.

In summary, the analysis of the mean scores of the sub-enrolment groups showed that the groups achieved at different levels when compared with the

mean scores of the whole fulltime group. The distance, medical, itinerant and overseas groups were comparable or better than the whole fulltime group, while psychological and suspended students did not do as well. This may indicate the single course was not suitable for all the enrolment groups.

## **5.2 How well are the science process skills identified?**

Kok-Auntoh and Woolnough (1994) suggested that as a pre-requisite to investigating the transferability of science process skills, it was necessary to find out how well each of these processes was identified. Lock (1990) said the distinctiveness of each science process skill could be reflected in the very low correlation between pairing of skills, and this suggested each process skill have some unique characteristic not identified in the others. This was done by looking at the correlation between student performance on each of the process skills, using Pearson's product moment correlation coefficient.

Each booklet of the level 6 Correspondence School science course assessed a single process skill in its teaching of the course content. Table 5.3 shows the type of task undertaken, the number of students returning work for that task and the average score for those students. Examples of these tasks from the booklets are found in appendix 5.

In this research it was recognized each process skill was composed of a group of sub-skills (Appendix 4b). The *Science in the New Zealand Curriculum* (Ministry of Education 1993b) assumes the students will have learnt the sub-skills in the previous curriculum levels. It could be difficult to differentiate which sub-skill or sub-skills were responsible for any distinctiveness, but relationships between the skills have been investigated.

The correlation coefficients obtained are for correlations between process skills on paired tasks. The observed relationship between pairs of skills on two different tasks is shown in table 5.4. The results suggest the pairs of tasks are not correlated to any high degree as the coefficients did not reach the level of significance.

Table 5.3 Showing types of task and context, skill and mean scores for students.

| Booklet     | Tasks using  | N   | Skills mean scores |      |      |     |
|-------------|--|-----|--------------------|------|------|-----|
|             |  |     | P&I                | Coml | CInv | UI  |
| 1 biology   | genetic fingerprint work sheet                                 | 351 | 6.5                |      |      |     |
| 2 biology   | Biotechnology resource material                                | 328 | 5.6                |      |      |     |
| 3 geology   | Scientific drawing and reporting                               | 301 |                    | 5.5  |      |     |
| 4 chemistry | Chemical rates of reaction                                     | 263 |                    |      | 5.3  |     |
| 5 physics   | Heat transfer by conduction,<br>radiation and convection.      | 238 |                    |      | 5.7  |     |
| 6 chemistry | Reactions of acids, bases, metal<br>and metal carbonates       | 206 |                    |      | 5.3  |     |
| 7 physics   | Electricity, voltage, current,<br>resistance and circuits.     | 191 |                    |      |      | 5.5 |
| 8 chemistry | Hydrocarbons, fuels  | 178 |                    | 6.0  |      |     |
| 9 geology   | Using info about earthquakes,<br>volcanoes, crustal plates etc | 151 |                    |      |      | 6.8 |
| 10 biology  | Micro-organisms and health                                     | 126 | 6.5                |      |      |     |

Table 5.4 Correlation between process skills.

| Observed<br>relationship | Correlation coefficient 1 |          |          | Correlation coefficient 2 |          |          |
|--------------------------|---------------------------|----------|----------|---------------------------|----------|----------|
|                          | N                         | booklets | <i>p</i> | N                         | booklets | <i>p</i> |
| PI x Coml                | 173                       | 1 x 8    | .64      | 104                       | 2 x 8    | .25      |
| PI x CInv                | 214                       | 1 x 5    | .25      | 157                       | 2 x 6    | .35      |
| PI x UI                  | 168                       | 1 x 7    | .25      | 168                       | 2 x 7    | .39      |
| Coml x CInv              | 167                       | 8 x 5    | .33      | 99                        | 8 x 6    | .43      |
| Coml x UI                | 69                        | 3 x 9    | .33      | 168                       | 8 x 7    | .46      |
| CInv x UI                | 128                       | 6 x 7    | .46      |                           |          |          |

Pearson Product Movement \* significant at  $r > 0.05$

Kok-Auntoh and Woolnough, (1994) said nearness of contexts to being the same may imply there could be transference of skills from one situation to another. This may be indicated by the coefficients not showing significant difference between the pairs and/or the pairs were close to zero. It may also indicate consistency of student performance in these processes from task to task or could indicate consistency regardless of differences in the task.

The higher correlation of 0.43 between communicating information and carrying out an investigation may suggest a degree of association. This may indicate the ability to perform investigations and report on them is transferable. However, if a lower correlation calculated from a previous investigation of these two skills is considered it could suggest the strength of the relationship is more dependent on the context and the type of task undertaken.

The correlations of 0.33 and 0.46 between communicating and using information in two different tasks may suggest there is a stronger association between these two skills than between other skills.

The skill relationships as indicated by the coefficients, could be affected by distance education because all work graded, including investigations and processing, was based on written answers and it is not known how well students record what they do. The relationships could also be affected by the fact that the skills were not investigated in any way before the level 6 Correspondence School science course was written. There could be poor discrimination between the tasks so that the skills were not clearly defined. However, the skills were used as suggested by the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b).

Finally the context used for the skill used may have had an effect.

It was important to find out whether the skills were clearly defined. Table 5.5 shows the analysis of the difference between events of the same skill.

One result CInv, (carrying out an investigation), stands out from the others because it was not significant. It could mean the students were just following instructions well, or there was little difference between the two tasks using this skill. This may also indicate that the skill of carrying out an investigation was transferable from one task to another.

Table 5.5 Analysis of the difference between same skill events.

| Skills | P&I   | Coml   | CInv | UI     |
|--------|-------|--------|------|--------|
| P&I    | 5.25* |        |      |        |
| Coml   |       | -2.18* |      |        |
| CInv   |       |        | 1.8  |        |
| UI     |       |        |      | -6.68* |

\* significant at  $p = 0.05$ .

In CInv, it is suggested that because students were able to look at the problem as a whole and to find solutions; they may have used different skills than those looked for in the tasks. This result is similar to those found in previous research (Pouler and Wright, 1980; and Rowell, 1984: cited in Kok-Auntoh and Woolnough, 1994). Kok-Auntoh and Woolnough, (1994, p37), said this finding was educationally important for:

those who believed in the importance of whole investigations instead of merely focusing on the constituent parts.

*The Science in the New Zealand Curriculum* (Ministry of Education, 1993b) focuses on constituent skills until the senior levels, such as 12 and 13, are reached.

The significant differences found with the other skills may indicate the tasks were not testing what was intended, or the contexts used were too different to allow the transfer of the skills. A further reason may be related to the level 6 Correspondence School science course being written with the underlying idea of constructivism. Constructivists do not support transfer unless the learner can see the relationship between the parts of the tasks. This was discussed in the literature review. Perhaps the relationships between the skill elements of the tasks were not obvious to the students.

As a general conclusion to this part of the study, the data suggest that the skill of performing an investigation is transferable from one situation to another but the other skills of processing, interpreting, and using information are more context dependent. In these situations the science skills may take on different characteristics depending on the context of the different science strands. This would mean a change in context and mode for assessment

would make the distance between the two tasks too great for transfer to occur. This is speculative as there is no information on the reliability of the test scores or on the validity of the tests or the other tasks.

### **5.3 Ethnicity, gender and student performance**

Variables that may affect student performance are those of gender, ethnic origin and cultural values. In this study there are two declared ethnic groups to which the students belong, Non Maori and Maori.

To see if there were any differences in student performance that may be due to gender or ethnic origin the mean score for booklets 2 -9 of work were tested for significant difference. The tenth booklet was not considered because there were very few Maori boys who reached this.

Female and male mean scores for booklets 2 -7 are seen in table 5.6 and indicate the female students mean scores were significantly different to the male students' mean scores in booklets 2-8. This indicates female students perform better on this particular distance education course. It could also indicate the course had a bias to female students more than male, and that the student characteristics of the two groups were not the same, for example, in language and reading abilities. As a distance education course reading was significant, and traditionally it is thought girls read better than boys.

The male and female categories consisted of members of the two main ethnic groups about which the Ministry of Education requires information, Maori and non-Maori. To find out how well the level 6 Correspondence School science course accommodated these groups, the following pairs of categories were investigated:

- (a) non-Maori and Maori females
- (b) non-Maori and Maori males
- (c) non-Maori females and Maori males
- (d) Maori females and non Maori males.

These categories were not analyzed against the total male and female samples because each category had contributed to the total male and female scores. The numbers and mean scores of the non-Maori and Maori female students are shown in table 5.7.

In table 5.7 the non-Maori female student sample performs significantly better than the Maori female sample in booklets 2, 3, 4, 8 and 9. In table 5.8 the non-Maori male student sample performs significantly better than the Maori male student sample in booklets 2, 3, 4, 5, 6 and 9. These results indicate that the level 6 Correspondence School science course was better suited to the non-Maori student sample. The male and female student samples within the Maori and non-Maori were also analyzed. The results are seen in table 5.9 (Maori sample) and 5.10(non-Maori sample).

The results indicate that the Maori female sample performs better than the Maori male sample, while the non-Maori female sample performs better than the non-Maori male sample. To complete the student performance analysis a study of the performance between Maori female students and non-Maori male students was needed. Table 5.11 gives this information. By comparison of these results it can be shown that non-Maori female perform better than Maori males.

In summary it can be seen that female students perform better on this particular distance education course than males. There is a difference between non-Maori and Maori female performance but between non-Maori males and Maori males there is a significant difference in performance. Non-Maori females perform better than all the other groupings and Maori females perform better in several booklets than non-Maori males. The achievement of Maori males is lower than any other grouping.

Table 5.6 Mean scores for booklets 2-9 for all female and male students.

|             | Female students |            | Male students |            |
|-------------|-----------------|------------|---------------|------------|
|             | N               | Mean score | N             | Mean score |
| 2 biology   | 182             | 5.9        | 146           | 5.2        |
| 3 geology   | 162             | 5.8*       | 139           | 5.1        |
| 4 chemistry | 145             | 6.0*       | 118           | 4.8        |
| 5 physics   | 132             | 5.9*       | 106           | 5.5        |
| 6 chemistry | 108             | 5.7*       | 98            | 5.0        |
| 7 physics   | 99              | 5.7*       | 92            | 5.4        |
| 8 chemistry | 95              | 6.2*       | 83            | 5.9        |
| 9 geology   | 84              | 6.8        | 67            | 6.8        |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

Table 5.7 Mean scores for booklets 2-9 for all non-Maori and Maori female students

| Booklets    | Non-Maori females |            | Maori females |            |
|-------------|-------------------|------------|---------------|------------|
|             | N                 | Mean score | N             | Mean score |
| 2 biology   | 150               | 6.0*       | 32            | 5.1        |
| 3 geology   | 133               | 5.9*       | 29            | 5.3        |
| 4 chemistry | 118               | 5.7*       | 27            | 5.2        |
| 5 physics   | 109               | 5.9        | 23            | 5.9        |
| 6 chemistry | 89                | 5.7        | 19            | 5.7        |
| 7 physics   | 82                | 5.6        | 17            | 5.4        |
| 8 chemistry | 78                | 6.3*       | 17            | 5.4        |
| 9 geology   | 69                | 7.0*       | 15            | 6.2        |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

Table 5.8 Mean scores for booklets 2-9 for all non-Maori and Maori male students

| Booklets    | non-Maori males |            | Maori males |            |
|-------------|-----------------|------------|-------------|------------|
|             | N               | mean score | N           | mean score |
| 2 biology   | 116             | 5.3*       | 30          | 4.6        |
| 3 geology   | 113             | 5.2*       | 26          | 4.8        |
| 4 chemistry | 99              | 4.9*       | 19          | 4.4        |
| 5 physics   | 92              | 5.6*       | 14          | 4.6        |
| 6 chemistry | 85              | 5.0*       | 13          | 4.4        |
| 7 physics   | 79              | 5.4        | 13          | 5.3        |
| 8 chemistry | 71              | 5.9        | 12          | 5.8        |
| 9 geology   | 59              | 7.0*       | 8           | 5.4        |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

Table 5.9 Mean scores for booklets 2-9 for Maori female and Maori male students.

| Booklets    | Maori females |            | Maori males |            |
|-------------|---------------|------------|-------------|------------|
|             | N             | mean score | N           | mean score |
| 2 biology   | 32            | 5.1*       | 30          | 4.6        |
| 3 geology   | 29            | 5.3*       | 26          | 4.8        |
| 4 chemistry | 27            | 5.1*       | 12          | 4.4        |
| 5 physics   | 23            | 5.9*       | 14          | 4.6        |
| 6 chemistry | 19            | 5.7*       | 13          | 4.4        |
| 7 physics   | 17            | 5.4        | 13          | 5.3        |
| 8 chemistry | 17            | 5.4        | 12          | 5.8        |
| 9 geology   | 15            | 6.2*       | 8           | 5.4        |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

Table 5.10 Mean scores for booklets 2-9 for non-Maori female and non-Maori male students.

| Booklets    | Non-Maori females |            | Non-Maori males |            |
|-------------|-------------------|------------|-----------------|------------|
|             | N                 | mean score | N               | mean score |
| 2 biology   | 150               | 6.0*       | 116             | 5.3        |
| 3 geology   | 133               | 5.9*       | 113             | 5.2        |
| 4 chemistry | 118               | 5.7*       | 99              | 4.9        |
| 5 physics   | 109               | 5.9*       | 92              | 5.6        |
| 6 chemistry | 89                | 5.7*       | 85              | 5.0        |
| 7 physics   | 82                | 5.6*       | 79              | 5.4        |
| 8 chemistry | 78                | 6.3*       | 71              | 5.9        |
| 9 geology   | 69                | 7.0        | 59              | 7.0        |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

Table 5.11 Mean scores for booklets 2-9 for Maori female and non-Maori male students.

| Booklets    | Maori females |            | Non-Maori males |            |
|-------------|---------------|------------|-----------------|------------|
|             | N             | mean score | N               | mean score |
| 2 biology   | 32            | 5.1        | 116             | 5.3        |
| 3 geology   | 29            | 5.3        | 113             | 5.2        |
| 4 chemistry | 27            | 5.1        | 99              | 4.9        |
| 5 physics   | 23            | 5.9*       | 92              | 5.6        |
| 6 chemistry | 19            | 5.7*       | 85              | 5.0        |
| 7 physics   | 17            | 5.4*       | 79              | 5.4        |
| 8 chemistry | 78            | 5.4        | 71              | 5.9*       |
| 9 geology   | 69            | 6.2        | 59              | 7.0*       |

Two-tailed t-test for two independent means between subjects. \* significant at  $p \geq .05$

## **5.4 Student performance in examinations**

The students taking this level 6 Correspondence School science programme were also prepared to take the *School Certificate Science Examination* (1995) based on the *Science in the New Zealand Curriculum* (Ministry of Education 1993b). Part of the preparation for the *School Certificate Science Examination* (1995) was an internal practice examination.

The performance of the students in this population was followed through their attempts at the Correspondence School science internal examination and the *School Certificate Science Examination* (1995) and then compared with the national results.

### **5.4.1 The Correspondence School internal examination**

The 1995 internal examination was designed and written by the Correspondence School science teachers before the structure of the *School Certificate Science Prescription* (1994) was gazetted. The reason for this premature action was due to the length of time it took for printing and dispersing of the internal examination papers to students who could be on the other side of the world. There had also been repeated delays in releasing the prescription.

The Correspondence School students sit this internal practice examination at the end of August so that it can be marked and returned to them before they sit the external School Certificate science examination. The internal examination is designed so that half the students can get 50% or more correct. This is a mechanism to rank the students on normal distribution similar to School Certificate examinations.

### **5.4.2 School Certificate science examination**

The 1995 *School Certificate Science Examination* (New Zealand Qualifications Authority 1995) had the same structure as 1994 but took into account the new prescription. The resource material gave the context and the problems tested various science skills. In 1995 the markers' raw marks were adjusted and the marking schedules were changed to give an altered distribution of scores similar to a normal bell curve. The students received this adjusted mark as their results.

The results of the 1995 examinations are given in table 5.12. There were 57 students who sat the internal Correspondence School science examination

who did not sit the *School Certificate Science Examination (1995)*. The reasons for this ranged from being overseas with no examination centre, did not intend to sit, too sick on the day or just forgot. The results show the Correspondence School internal science examination was a reasonable indicator of *School Certificate Science Examination (1995)* results for those Correspondence School students who sat it.

Not all Correspondence School School Certificate students' results were available to the Correspondence School in January 1996 when the results were released. The overseas students received theirs directly from the examination board; the adult students received theirs independently of the Correspondence School; and the students at other secondary schools, but those on The Correspondence School roll for level 6 science, received their results through their own schools.

The results that were available are shown in table 5.12.

Table 5.12 Examination results for science 1995

| Year | Correspondence School<br>internal science<br>examination students |              | Correspondence School<br>School Certificate science<br>students |              | All New Zealand<br>School Certificate<br>science students |
|------|---|--------------|---|--------------|---|
|      | N   | Mean score % | N   | Mean score % | Mean score %  |
| 1995 | 233   | 53.4         | 176   | 50.3         | 55  |

These gaps in the results make the mean score % for the Correspondence School students in the School Certificate science examination unreliable. Information taken from the Students Information Systems (SIS) of the Correspondence School distribution of grades by enrolment category suggests the mean score % for the Correspondence School students taking the *School Certificate Science Examination (1995)* could have been higher as shown in table 5.13 if all the examination results had been known.

Table 5.13 Percentage distribution of School Certificate grades in all subjects 1995 by enrolment category

| Enrolment category     | Percentage of grades A -C awarded |
|------------------------|-----------------------------------|
| Full time students     | 52.9                              |
| Secondary School group | 56.9                              |
| Home Schoolers         | 72.2                              |
| Adult students         | 67.1                              |

It is interesting to note that the Secondary School students group have a higher percentage of A-C grades over all the School Certificate subjects than the Correspondence School fulltime students. In science they did not perform as well as the fulltime students in the teacher assessed booklet grades (table 5.1). The percentage of grades A -C awarded to non-Maori students was 58.5% and to Maori students was 26.7%.

From the Correspondence School students' grades in the *School Certificate Science Examination* (1995) when compared with the distribution of grades shown above, the explanations for the differences could be, firstly, the student results, which were unavailable to the researcher, could have enhanced the level of the grades awarded, and secondly, the Correspondence School students found science one of the more difficult School Certificate Examinations.

### **5.5 Summary**

This chapter reports findings on student performance on science process skills, the School Certificate Science Examination 1995 and the internal science examination of the Correspondence School. It was found that there was a large dropout of students from the course for whom there were incomplete results.

Each enrolment group (fulltime , home schoolers, adults and secondary school students) achieved in different ways and at different levels. The adult group performed the science process skills at a significantly higher level than the fulltime students with whom they were compared. This was probably due to their prior knowledge, experience approach to learning or diligence. The home schoolers' level of performance varied from booklet to booklet but averaged out slightly above mean score of the fulltime students.

The secondary school students performed poorly in comparison the fulltime students.

The fulltime students were looked at in more detail and were divided up according to their sub groups based on enrolment criteria supplied by the Ministry of Education. The analysis of the mean scores of the sub-enrolment groups showed that the groups achieved at different levels when compared with the mean scores of the whole fulltime group. The distance, medical, itinerant and overseas groups were comparable or better than the whole fulltime group, while psychological and suspended students did not do as well. This may indicate the single course was not suitable for all the enrolment groups.

The second part of the chapter investigated whether the science process skills were identified and separated clearly from each other so that they could act independently. The results suggest the skill of performing an investigation is transferable from one situation to another but the other skills of processing, interpreting, and using information are more context dependent. In these situations the science skills may take on different characteristics depending on the context of the different science strands. This would mean a change in context and mode for assessment would make the distance between the two tasks too great for transfer to occur.

The third section of this chapter investigated whether there was a difference between the performance of male and female, Maori and non-Maori. It appears from this study that female students perform better on this particular distance education course than males. There is a smaller difference between non-Maori and Maori female performance but between non-Maori males and Maori males there is a significant difference in performance. Non-Maori females perform better than all the other groupings and Maori females perform better in several booklets than non-Maori males. The achievement of Maori males is lower than any other grouping.

The grades of the Correspondence School students who sat the School Certificate Science Examination 1995 suggest they are comparable to the national grades, but due to the unavailability of some results of the Correspondence School candidates, no reliable conclusions can be drawn.

## 6 Students' perceptions of the level 6 science course

In this chapter students' perceptions of their teaching and learning are reported. Two hundred questionnaires (Appendix 6) were sent out to a random sample taken from the population at the 14 July 1995, who were studying the Correspondence School science course. By the time the replies had been collected seventeen students had withdrawn from the course leaving one hundred and eighty three possible replies of whom 83 responded

### 6.1 Sample characteristics

A representative sample of the level 6 science population used in this study was selected by using stratified random sampling. The four main enrolment groups (full time students, home schoolers, adults and secondary schools group) were used as stratification. From the total number of students in each group a randomised sample was obtained by selecting every fourth student. The selected population is shown in table 6.1. The total population at the 14 July was not selected because of cost and time considerations.

Table 6.1 Characteristics of total population, selected sample and obtained sample.

|                    | Population July 14 | Sample selected | Sample obtained |
|--------------------|--------------------|-----------------|-----------------|
| Fulltime students  | 201                | 100             | 41              |
| Home schoolers     | 48                 | 25              | 12              |
| Adult students     | 100                | 50              | 19              |
| Secondary students | 47                 | 25              | 11              |
| total              | 396                | 200             | 83              |

Only 83 students responded out of the 200 sent questionnaires (41.5%). This low response rate makes any conclusions tentative.

#### 6.1.1 Response characteristics of enrolment groups

The characteristics of the students responding and not responding when grouped by enrolment criteria are shown in table 6.2. Of the four enrolment categories used to select the population, the home schoolers replied at a

higher rate (48%) than the rest of the selected sample. The adult students replied at a rate of 38% while the secondary school students replied at a rate of 44%, full time students replied at a rate of 41%. In a postal survey of this kind the results will be skewed towards the perceptions of the more conscientious student who replies but will be non-representative of the student population as a whole.

Table 6.2 Response characteristics of the selected sample.

|                    | Selected sample |       | With drawn | Possible replies | Obtained sample |       | Non-responders |       |
|--------------------|-----------------|-------|------------|------------------|-----------------|-------|----------------|-------|
|                    | N               | %     | N          | N                | N               | %     | N              | %     |
| Fulltime students  | 100             | 50%   | 9          | 91               | 41              | 41%   | 50             | 59%   |
| Home schoolers     | 25              | 12.5% | 0          | 25               | 12              | 48%   | 13             | 52%   |
| Adult students     | 50              | 25%   | 7          | 43               | 19              | 38%   | 24             | 62%   |
| Secondary students | 25              | 12.5% | 1          | 24               | 11              | 44%   | 13             | 56%   |
| Total sample       | 200             | 100%  | 17         | 183              | 83              | 41.5% | 100            | 58.5% |

### 6.1.2 Response characteristics by ethnicity and gender

The sample consisted of two main ethnic groups, Maori 14.3% and non Maori 83% with a very small Asian representation of 2.7%. This type of ethnic grouping is tied to the statistics required by the Ministry of Education in 1995 and the restricted ability of the School Information Systems' computer to hold information. The Maori are those students who declare themselves to be Maori. The non Maori group was composed of European New Zealanders and Pacific Islanders with a small group of students from other countries of the world who are New Zealand citizens.

Table 6.3 shows the percentages of responders and non responders by ethnic groups. Non Maori and Asian students responded at a higher rate than Maori students.

Table 6.3 Response rates by ethnic groups.

| Ethnic group | Selected sample |      | Responders |      | Non responders |      |
|--------------|-----------------|------|------------|------|----------------|------|
|              | N               | %    | N          | %    | N              | %    |
| Asian        | 5               | 2.7  | 3          | 60   | 2              | 40   |
| Maori        | 27              | 14.3 | 8          | 29.6 | 19             | 70.4 |
| Non-Maori    | 151             | 83   | 72         | 47.4 | 79             | 54.6 |
| Total        | 183             | 100  | 83         | 45.3 | 100            | 54.7 |

The response characteristics of the selected sample population were further analyzed by separating out the population by gender. Table 6.4 shows the response patterns and rates of male and female students.

Table 6.4 Response rates by ethnicity and gender.

| Ethnic group | Gender | N   | Responders N | % reply rate |
|--------------|--------|-----|--------------|--------------|
| Asian        | male   | 4   | 2            | 50%          |
|              | female | 1   | 1            | 100%         |
| Maori        | male   | 14  | 0            | 0%           |
|              | female | 13  | 8            | 61.5%        |
| Non-Maori    | male   | 71  | 29           | 40.8%        |
|              | female | 80  | 43           | 53.8%        |
| Total        |        | 183 | 83           |              |

Of the total sample population 37.3% of males responded to the questionnaire while 62.7% of females did. Although a very small group, the Asian female students had a 100% response rate followed by Maori female students with 61.5% and non Maori with 53.8%. This results in a very low response which in turn reduces reliability, especially for any conclusion made about males.

## **6.2 Student responses and their perceptions**

The questionnaire was designed so that the questions were grouped in a pattern that followed the way in which the students worked through each booklet. In the level 6 Correspondence School science course each lesson was considered to be the amount of science to be done by the student each day and was expected to be completed within an hour. This was similar to the length of lessons that take place in conventional schools. The eight lessons per booklet therefore add up to two weeks' work.

The questionnaire gave six types of information, which were discussed in the methodology. They have been used here to organize the students' responses.

### 6.2.1 The learning content and the teaching provided

This section of the questionnaire covered the learning content of the course and how the teaching was provided. Questions one, two, three and seven asked the students what they thought about the language used in the explanation of the learning content.

Table 6.5 Students' perceptions about language used in learning content.

| Questionnaire items  | Responses                    |      |       |                          |       | Positive Response |
|--|------------------------------|------|-------|--------------------------|-------|-------------------|
|  | 1                            | 2    | 3     | 4                        | 5     |                   |
| Show the extent to which you agree or disagree with each of the following statements.                          |                              |      |       |                          |       |                   |
|  | Strongly Disagree            |      |       | Strongly Agree           |       |                   |
| 1. 1 The <b>words</b> used to explain what you have to learn are clear and easy to understand.                 | 1                            | 2    | 3     | 4                        | 5     | 80%               |
|  | 2.5%                         | 1.3% | 16.5% | 48.1%                    | 31.6% |                   |
| 2 <b>Explanations</b> of what you have to learn are easy to follow.  | 1                            | 2    | 3     | 4                        | 5     | 73%               |
|  | 2.5%                         | 8.9% | 15.1% | 50.1%                    | 22.8% |                   |
| 3 The <b>amount</b> of learning in each lesson is right.   | 1                            | 2    | 3     | 4                        | 5     | 71%               |
|  | 2.7%                         | 9%   | 19.2% | 34.6%                    | 34.6% |                   |
| Indicate how <b>helpful</b> each of the following has been in <b>your learning</b> of the work in your course. |                              |      |       |                          |       |                   |
|  | Not very helpful to learning |      |       | Very helpful to learning |       |                   |
| 7 Working through the <b>explanations</b> in the lessons.  | 1                            | 2    | 3     | 4                        | 5     | 75%               |
|  | 1.3%                         | 8.7% | 15%   | 32.5%                    | 42.5% |                   |

The majority of the students (80%) thought the language in the booklets was clear and easy to understand. The students answered questions two and seven in a similar manner. 73% and 75% thought the explanations used were easy to follow. In response to question three 71% thought the amount

of learning in each booklet was appropriate. These results are shown in table 6.5.

### 6.2.2 Practice activities

The practice activities are those which the students marked themselves so that they could have immediate feedback and guidance on their work and progress. In response to question four 90% said they were able to do the practice activities and 84% found them easy to mark.

Table 6.6 Students' perceptions about the practical activities.

| Questionnaire items  | Responses         |      |                |       |       | Positive Response |
|--|-------------------|------|----------------|-------|-------|-------------------|
|  | Strongly Disagree |      | Strongly Agree |       |       |                   |
|  | 1                 | 2    | 3              | 4     | 5     |                   |
| 4 I can do the practice exercises                                | 1.3%              | 2.5% | 6.3%           | 36.3% | 53.6% | 90%               |
| 5 I do not take a lot of time to answer the practice activities. | 4.8%              | 8.5% | 28.1%          | 28.1% | 30.5% | 59%               |
| 6 The practice activities are easy to mark.                      | 1.3%              | 1.3% | 13.9%          | 27.8% | 55.7% | 84%               |
| 8 Completing practice activities and marking them yourself.      | 3.7%              | 7.5% | 22.5%          | 27.5% | 38.7% | 66%               |

The answers they used to check their work were situated at the end of the booklet and were available to the students all the time. When the students were asked (question eight) how helpful were the practice activities and being able to mark them themselves only 66% thought the activities were useful. It appears that 18% of the students did the activities and marked them but do not think they are useful. The reasons for this are not known – perhaps they were too easy or too hard or they looked up the answers first. The results to questions four, five, six and eight are shown in table 6.6. In

response to question five 59% of students agreed the practice activities did not take a lot of time to do but 13.3% thought they took too long.

### **6.2.3 Teacher-marked work and teacher responses to students**

This section asked the students what they did when they received their marked work back from their teacher. It also asked the students what they felt was important when the teacher was communicating with them. The students were divided in their perception about the reading over of returned work. Table 6.5 shows 58% of the students felt it was useful going over the work even if it was two to four weeks old when it reached them. A possible reason why 42% did not read the returned work was that they had passed on to new topics.

Question 10 asked whether the student read the teaching notes that came back with the teacher marked work. Teaching notes consist of the answers that the student was expected to give. Sometimes extra information was included about some topics. 51% of students read these notes. This means 49% of students did not

Question 12 asks if the students found the teaching notes understandable and instructive. 66% said they were, even though only 51% said they read the teaching notes thoroughly.

The last question in this group, question 14, asked if the students thought it would <sup>be</sup> helpful if they could contact their teachers **before** they did their work. 40% thought it might be a good idea but comments in the open question section indicated that some students thought it was more helpful to contact the teacher during the work if a problem arose.

### **6.2.4 Progress through the course**

This section of the questionnaire asked the students what they felt about the course and their progress through the course.

Questions 15 - 19 are aimed at finding out what the students expect of themselves. Question 15 asked the students if they were satisfied with the amount of work they had completed.

Table 6.7 Students' perceptions on teacher marked work.

| Questionnaire items  |  | Responses         |            |                        |            |            | Positive Response |
|--|--|-------------------|------------|------------------------|------------|------------|-------------------|
| Indicate how thoroughly you would normally read through each of them.          |  | Don't read much   |            | Always read thoroughly |            |            |                   |
| 9  | Your marked work   | 1<br>3.8%         | 2<br>10.2% | 3<br>27.8%             | 4<br>31.6% | 5<br>26.6% | 58%               |
| 10   | The teaching notes.  | 1<br>10.4%        | 2<br>22.0% | 3<br>16.9%             | 4<br>24.7% | 5<br>26.0% | 51%               |
| 11   | Letters and general comments from your teacher.  | 1<br>0%           | 2<br>1.3%  | 3<br>8.9%              | 4<br>13.9% | 5<br>76%   | 90%               |
| Indicate the extent to which you agree or disagree with each of the following. |  | Strongly disagree |            | Strongly agree         |            |            |                   |
| 12   | The teaching notes are understandable and instructive.   | 1<br>0%           | 2<br>7.7%  | 3<br>26.9%             | 4<br>39.7% | 5<br>25.6% | 66%               |
| 13   | Letters from my teacher are understandable and helpful.  | 1<br>1.3%         | 2<br>2.6%  | 3<br>7.7%              | 4<br>25.6% | 5<br>62.8% | 88%               |
| 14   | Being in contact with my teacher as I am first learning the work would be more helpful than the letters and comments with my completed work. | 1<br>10.3%        | 2<br>17.9% | 3<br>33.3%             | 4<br>20.5% | 5<br>19%   | 40%               |

66% said they were satisfied with their progress and the amount of work they had done. However, 80% (question 16) said they were satisfied with their results which may indicate students have an internal fail/success barrier which may not be related to the course.

Question 17 asked about the amount of reading and work that the students were expected to cover. 71% of those who read and answered the questionnaire thought it was about right.

Table 6.8 Student satisfaction with progress and course expectations.

| Questionnaire items  | Responses         |       |       |       |                | Positive Response |
|--|-------------------|-------|-------|-------|----------------|-------------------|
|  | Strongly disagree |       |       |       | Strongly agree |                   |
| Indicate the extent to which you agree or disagree with each of the following.             |                   |       |       |       |                |                   |
| 15 I am satisfied with my progress to date in terms of the number of sets I have completed | 1                 | 2     | 3     | 4     | 5              | 66%               |
|  | 3.8%              | 6.3%  | 24.0% | 35.4% | 30.1%          |                   |
| 16 I am satisfied with the results I have gained.  | 1                 | 2     | 3     | 4     | 5              | 80%               |
|  | 1.2%              | 2.5%  | 16.5% | 41.8% | 38.0%          |                   |
| 17 The amount of reading and work I am expected to cover is right.                         | 1                 | 2     | 3     | 4     | 5              | 71%               |
|  | 0%                | 7.8%  | 20.8% | 35.0% | 36.4%          |                   |
| 18 The amount of time I need to spend working on the course is about right                 | 1                 | 2     | 3     | 4     | 5              | 67%               |
|  | 0%                | 14.1% | 19.2% | 30.8% | 35.9%          |                   |
| 19 The difficulty level of what I am learning is too difficult?                            | 1                 | 2     | 3     | 4     | 5              | 15%               |
|  | 32.9%             | 31.6% | 20.3% | 12.7% | 2.5%           |                   |

Question 18 referred to the number of hours it took students to complete a booklet (set). 67% of the responding students thought it was what they expected. There was a follow up question in the open section of the questionnaire which asked how many hours did it take the student to finish the work in each booklet. The answers ranged from 1 hour to 20 hours but the average amount of time taken was 8 hours.

Question 19 is important as it relates to the replies to questions 4, 7, 17 and 21. Only 15% of the respondents thought the level of learning was difficult, leaving 85% who thought it was all right. (This question gave rise to many of the comments made in the open section of the questionnaire). This level of response resembles the positive results of 90% who could do the practical

activities, 75% who found the explanations and teaching all right and 71% who found the amount of reading and work is about right. From this it would be reasonable to expect a high level of positive results in the *School Certificate Science Examination* (1995). Of the 176 who sat the examination 50.3% got grades A-C. This means 88 students out of the original student population of 14 July 1995 (351) succeeded, just 25%. Not a good pass rate.

### 6.2.5 Layout and writing style

The next two questions are about presentation and clarity of writing style. 76% of the respondents thought the presentation was attractive while 85% thought the writing style was clear and understandable.

Table 6.9 Students' perceptions of presentation and clarity of style.

| Questionnaire items  | Responses         |      |       |                |       | Positive Response |
|--|-------------------|------|-------|----------------|-------|-------------------|
|  | Strongly disagree |      |       | Strongly agree |       |                   |
| Indicate the extent to which you agree or disagree with each of the following. |                   |      |       |                |       |                   |
| 20 The layout, presentation and look of the sets is clear and attractive.      | 1                 | 2    | 3     | 4              | 5     | 76%               |
|  | 1.3%              | 7.6% | 15.2% | 40.5%          | 35.4% |                   |
| 21 The writing style used in the sets is clear and understandable.             | 1                 | 2    | 3     | 4              | 5     | 85%               |
|  | 0%                | 3.9% | 11.5% | 33.3%          | 51.3% |                   |

### 6.2.6 Skills

This section asked the students what they thought about the science process skills presented in the level 6 Correspondence School science course. Table 6.10 shows the responses the students gave. Questions 22 and 23 are related, asking about whether the topics chosen to explain the skills were easy to follow and whether the examples of skills were easy to follow. Both questions show similar positive results, 69% and 68% respectively.

Table 6.10 Learning science process skills by distance education.

| Questionnaire items   |   | Responses         |       |                |       |       | +Response |
|---|---|-------------------|-------|----------------|-------|-------|-----------|
| Processing, interpreting, planning an investigation, carrying out an investigation and communicating are important skills in SC500. Indicate the extent to which you agree or disagree with the following |   | Strongly disagree |       | Strongly agree |       |       |           |
|   |   | 1                 | 2     | 3              | 4     | 5     |           |
| 22  | The topics chosen to explain the skills were easy to follow.  | 1.2%              | 4.8%  | 21.6%          | 53%   | 15.5% | 69%       |
| 23  | The examples of the skills were easy to follow  | 0%                | 2.4%  | 29.3%          | 39%   | 29.3% | 68%       |
| 24  | I believe these skills will be of use to me in the future   | 6%                | 12%   | 13.3%          | 37.3% | 31.3% | 69%       |
| 25  | I find I can use these skills in other science exercises  | 2.4%              | 7.2%  | 21.7%          | 37.3% | 31.3% | 68%       |
| 26  | I find I can use these skills in other subjects eg maths, economics or geography                          | 13.3%             | 13.3% | 25.3%          | 33.7% | 14.4% | 48%       |
| 27  | I find I can use these skills in everyday life  | 14.2%             | 15.6% | 31.3%          | 28.9% | 9.6%  | 39%       |
| 28  | It is easy to learn these skills by correspondence  | 6.0%              | 7.2%  | 22.9%          | 33.7% | 30.1% | 64%       |
| 29  | There were enough practice opportunities to develop these skills  | 4.8%              | 12%   | 28.9%          | 30.1% | 24.1% | 54%       |
| 30  | I think this course will prepare me for next year's science course such as biology, chemistry or physics. | 2.4%              | 3.7%  | 25.6%          | 36.6% | 31.7% | 68%       |

Question 24 asks whether the students if they believed that schools would teach them things that will be of use in the future. 69% thought the science process skills would be of use in the future.

In question 25, 68% thought they would be able to use them in other science exercises (near transfer and context bound), but 48% (question 26) thought they would be of less use in other subjects such as mathematics, economics or geography and considered the skills were not fully transferable.

Only 39% of respondents thought the science process skills would be useful in everyday life (question 27). The adult group had most doubts about the skills being useful.

The last three questions asked the students again about the level 6 course. The results are shown in table 6.10. Question 28 referred to learning the science process skills by distance education. 64% thought it was easy to learn the skills by correspondence.

Question 29 asked if the students thought there were enough opportunities to practice the skills. 54% thought there were, but as the course only provided two opportunities at each skill this may indicate lack of experience of how many times skills have to be practiced to be maintained.

The last question asked the students if they thought the level 6 Correspondence School course would prepare them for next year's science courses, (years 12 and 13). 68% thought it would but they had no experience of next year's courses on which to make this judgment.

### **6.3 Student response to the open-ended questions**

Opportunity was given to students to comment more about how they perceived the level 6 Correspondence School science course at the end of the questionnaire.

The first group of comments re-enforced the positive answers given to questions about learning content, teaching approaches and practice activities.

Science is easy to understand and if you don't understand you can go over the work and figure it out. Student 210

I have found the science course really good. All pretty easy. Student.260

It has been explained to me fully in each set I have done. Student 27

I like the way the definitions have been explained simply. Student 184

Most of the writing and explanations are good to follow. Student 167

There were 20% who did not think the work was easy enough. They said

Some things need to be explained in more depth.

They should be easier to understand. Student 213

Student 213 was a non-Maori female, psychological enrolment. Her performance in the booklets was erratic with average to good scores alternating with very low ones for the seven booklets she attempted.

Some of these sets are hard to understand and some questions are hard for me. There's always a lot of reading. Student 109

Student 109 was a non-Maori male attending a secondary school that used the Correspondence School science course. His performance in the booklets was very poor. He received no score for four booklets, one 2, two 3s, a 5 and for the geology booklet 9 he got 6.5. This student (109) also said it took him only three hours to do each set which was a lot less than the average time taken by most students.

Some students made the comment that they had found the course easy and secondary school student coded 132 and full time student 005 asked:

is this too easy?

(Each student had a nominated supervisor who helped them organize their school work. Often it is a parent or caregiver who may communicate with the teacher about the lessons. In this instance two supervisors, not connected with student 132 or 005, sent letters commenting about the academic level of the science course. One supervisor with six years experience of Correspondence School courses asked:

Is this course up to 5th form level? If it is, other 5th form courses must be to 7th form level!

The other supervisor suggested the science course was not worthy of a third former. The supervisor continued to say that he knew the work had been revised down to the lowest common denominator but the local High School course was way ahead of this course).

It was the adult group that had most doubts about the skills' usefulness in the workforce. Comments such as:

the skills are no use in my everyday job, Student 147

were made while other students indicated they thought the skills were not 'real' ones. The last word goes to an overseas student who said

I liked the course, I have done all the practical activities and I am pleased with my results, but what are skills? Student 214

This remark may indicate that 'skills' is a technical term and is what governments, teachers and employers talk about, but not school students.

#### **6.4 Summary**

This chapter set out to answer the research question

How do the Correspondence School students perceive the level 6 Correspondence School science course and its teaching of skills?

The 40% of students who responded to the questionnaire were mainly positive about the science course. This may be due in part, to the fact that most of the questions were asked in a positive manner, in the in-house style of the Correspondence school. Even so, it was a low response rate so that any conclusions must be made with caution.

The unstructured response sections were designed to help overcome problems of limitation of expression of the questionnaire. It was hoped the motivation of the respondents would be increased if they could express themselves in their own way.

There were, however, three areas the students who responded were concerned about:

The first concern asked 'was the academic level of the Correspondence School science course comparable to *Science in the New Zealand Curriculum* (1993b) level 6 and the *School Certificate Science Examination* (1995)?'

Most of the queries about the academic level of the course were raised in the open questions at the end of the survey. However, there was some support for the concern coming from question 19, where 33% of the respondents strongly disagreed the course was too difficult. All the students who replied to this question had had experience in conventional schools at some time, so that they should be able to have a valid opinion.

The second concern was – 'were the science skills transferable to other school subjects?'

48% of those that responded to the survey thought the skills could be used in other school subjects, while 27% of the respondents definitely thought the skills could not be transferred, (question 26). 25% did not know.

The third concern was – 'were the science skills any use in everyday life, now or in the future?'

The students were almost evenly divided about this question. 39% thought they would be able to use these science skills in everyday life while 30% thought they would not use them. 31% did not know.

It is difficult to come to any conclusions that apply to the total population of students that studied the Correspondence School level 6 science course and come from their replies to the survey. Because no male Maori students replied to the questionnaire there is no perspective on what they thought about the course and a whole group of students are unrepresented in the findings.

The next chapter reports on the perceptions of the science teachers at the Correspondence School who taught and marked the Level 6 science course.

## 7 Teachers' perceptions

This chapter reports on how eight of nine Correspondence School teachers who marked the level 6 Correspondence School science course viewed it. Their perceptions were recorded as responses to a questionnaire with an unstructured format (appendix ). Each response was in the form of a comment that made a statement about how they perceived the course. There were no restrictions placed on the number of comments they could make to the various sections. They were, however, reluctant to spend time on the questionnaire due to pressure of work but did so when asked by the Head of Science.

The teachers were asked about whether they thought the course had fulfilled its purpose in providing a science programme for level 6 of the *Science in the New Zealand Curriculum* that also covered the *School Certificate prescription*. They were also asked if the course prepared students for levels 7 and 8 of the *New Zealand Curriculum Framework* and the New Zealand work force.

### 7.1 Teacher sample

The questionnaire was given to the nine full time Correspondence School teachers who marked the level 6 science course. The three external tutors who also marked the Correspondence School level 6 science course, were not available to answer the questionnaire at the beginning of 1996 because they were only employed at peak marking periods in the 1995 school year. The nine full time teachers were highly qualified, all were trained and registered, and had science degrees and education diplomas or degrees. They consisted of six males and three females, all non-Maori, who had been with the Correspondence school from four to twenty years. Whatever length of time they had been at the Correspondence School, they had had only one year marking this particular course and their marking procedures were moderated by methods described in the methodology.

Each teacher had a spread of students from all the enrolment categories. Three teachers of the nine surveyed were also form teachers. They marked the work of their own form students who may have only been from a particular enrolment category, as well as the students from the other categories. Concerns for their own form students may have been a factor in

the way they commented on the course. Of the nine full time teachers eight replied to the questionnaire, the non-responder being too busy.

## 7.2 Response to the questionnaire

The eight full time teachers made ninety-seven separate comments about the course. Although not part of the research, it was interesting to note that the teachers who had been at the Correspondence School a comparatively short time expressed their opinions more frequently than the other teachers did.

The comments have been grouped into seven main categories that have emerged as being important throughout the research. They arise from the literature review, document analysis, performance data and the recorded perceptions of the students. These categories are shown in table 7.1. together with the number of comments made in each.

Table 7.1 Response grouping of teacher comments.

| Teacher response groupings  | number of comments |
|---|--------------------|
| General perceptions of course   | 18                 |
| Teaching approach   | 18                 |
| Learning styles presented to students   | 7                  |
| Use of scientific language  | 11                 |
| Contexts used   | 8                  |
| Teaching skills within the course, transfer of skills and the use of skills in other situations | 23                 |
| Preparing students for the future.  | 12                 |

### 7.2.1 General perceptions of the course

Teachers made eighteen comments about their general perceptions of the level 6 science course. The comments were varied and covered academic level of the course, and the effect of the *New Zealand Curriculum Framework* (Ministry of Education 1993a), the new *School Certificate Science Examination Prescription* (NZQA, 1994) and the *Science in the New Zealand Curriculum* (Ministry of Education 1993b). Some comments ranged over several topics and are recorded under different categories.

The table 7.2 shows the spread of comments when teachers considered the level of teaching of the level 6 Correspondence School science course compared with the teachers' perceptions of the level of other level 6 courses (Q4).

Table 7.2 Academic level of level 6 Correspondence school science course

| Academic level   | too low | just right | too difficult |
|--|---------|------------|---------------|
| Level 6 science course compared with teacher perceptions of academic levels of other level 6 courses | 4       | 5          | 3             |

Four respondents thought the course was at a lower academic level than they expected for a level 6 course. They were concerned that the level 6 science course did not challenge the academically bright or the interested and more able students.

Doesn't challenge academically bright students T1

There is little to challenge or interest the more able or interested students. What concerns me is the cumulative effect of lower level courses on bright students. 75% of possible reached over three years? Gives 40%! T3

The academic level at this school level has progressively declined. This course follows that decline. T2

This course is lower than I would think it should be because of the curriculum currently in place. T6

Five teachers perceived the level 6 science course to be at the right level for the majority of students at the Correspondence School as the student roll had a high number of poor achievers or poor attendees. One of these five teachers said they thought the level 6 science course was at the right academic level for a level 6 science course and School Certificate but added the Correspondence School students did not reflect this in their School Certificate results.

It (*the course*) is a compromise aimed at the middle of the road students T1

I guess so (*the course being at the right level*) but it is not reflected in the SC results. T4

The level is just right but the nature of the activities weren't in some cases. T5

In the group I taught 50% got over 50% in School Certificate. T7

Three teachers felt the level 6 science course was too difficult for the students they taught. One of the teachers thought the low ability students could not do it. They also said they thought the practical activities should be simple, easy and more relevant to the content of the booklets.

Some booklets seemed too hard for some students. Too technical in the presentation. T8

Probably not (at the right level) in view of poor language development in some students. T6

Probably too difficult which means the low ability students don't cope very well. T1

It is noted that teacher 1 and teacher 6 had qualified views of the level of the course. Both thought the course was aimed at a too low academic level for a level 6 science course but then related their view to the type of student they had taking the course.

Two teachers commented about the effect they perceived of introducing the *New Zealand Curriculum Framework* and the new *School Certificate Science Prescription* together. They felt the *School Certificate Science Prescription* had dictated too much of what was done in the Correspondence School level 6 science course but that it was difficult to know what is to be taught from the new *Science in the New Zealand Curriculum statement*. May be these comments were made because, like the *School Certificate science prescription*, the level 6 science course was written for all New Zealand students wherever they were, while the *Science in the New Zealand Curriculum* could be adapted for local conditions and regions by individual schools and teachers.

Once again, requirements of the SC prescription dictated much of what is done in the course. T1

Guided more by the prescription T7

This could be the effect of distance education. The course had to be of a limited size for the students to read and work through. This necessitated the restriction of content and practice to make the course manageable, so that the content and skills that were to be assessed in the examination the student were working towards were chosen first.

Six similar comments were made in this section but they also cover other categories where they are recorded.

### 7.2.2 Teaching approaches

The teachers were asked to describe the teaching approaches they thought were used in the level 6 Correspondence School science course. There was a wide range of opinions on teaching approaches, teaching contents, teacher expectations and writing styles. The range of comments made is shown in table 7.3.

Table 7.3 Range of comments relating to teaching approaches

|                       | teaching<br>approach | teaching<br>contents | teacher<br>expectations | writing style |
|-----------------------|----------------------|----------------------|-------------------------|---------------|
| number of<br>comments | 6                    | 6                    | 4                       | 2             |

Some comments are quoted below, but other teachers made similar remarks.

Four teachers described the teaching approach as basic and minimal, producing a very uniform and bland course.

It is a basic, minimal approach that is very uniform and to an extent bland. It communicates the basics well. It has one style, from the general to the particular, and this won't suit everyone. There seems to be a lack of range of information. T3

Another teacher described the teaching approach as superficial.

Probably a bit superficial. A smart kid would respond primarily to the expectations of the assessment exercises and miss understanding the contents of the booklet.

T2

Opposite views were expressed in two other teacher comments that described the teaching approach as varied and usually stimulating so that it communicates the basics well. Again other teachers expressed their ideas

in a different way saying the teaching approach was reassuringly similar throughout the course to help students gain useful routines.

*(The teaching approach is) varied, visually stimulating, reassuringly similar throughout. It would help the student gain useful routines. T6*

The teachers' comments show that there is wide range of views on what teaching approaches are. To some the teaching approach is about the amount and range of information given and the sequencing of this information for learning. To others teaching approach is about the format of the course and how the student might view and work with it. It is interesting to note, that as teacher/markers of a distance education course, they did not have anything to do with the planning, writing or production of the course.

There were six teacher comments about the content of the teaching material. These can be grouped into three categories, amount of information given, interesting material and type of instructions given

there should be more information in the booklets. T8

there is little of interest in the course, such as biographical information of the scientists who researched the topics used. T3

students have difficulties following instructions. T5

Four teacher comments discussed the booklet content in terms of what the students were expected to do with the information in the booklets. The comment were

there was little application of material to illustrate and clarify science principles for the students. T3

students are expected to deduce science concepts from the contents. T1

booklets lack range of information from which the student can subsume a principle. T3

students have difficulties relating the objectives of activities to the aims of the booklets. T2

The researcher detected the teachers were not in sympathy with the course written by others. They found it difficult to personalize the course for their own students as they saw only the end products of the student responses to the course. They express concern that the interesting background to some topics was sacrificed because it did not fit into a preconceived plan of size and function of the course. Two teachers commented directly on the writing style of the booklets. One took a theoretical view and stated the writing style was mainly guided didactic conversation (see 2.5.1 and fig 2.10) while the

other took an administrative point of view and said writing style was dictated by the distance teaching adviser as they edited the booklets. Neither thought the writing style gave enough scope to demonstrate the depth of the subject matter. From all teacher comments, there emerges a wish for something better, a change of process and format in the production of distance education courses such as this level 6 science course.

### 7.2.3 Learning style presented to the student

The teachers were asked to comment on the learning styles presented to the students in the level 6 Correspondence School science course. The term learning style was understood by the researcher as being the way students prefer to work with their studies, such as a visual, audio and kinetic approach. There were seven replies, which gave different points of view depending on each teacher's understanding of the term 'learning style' compared with the term 'teaching approaches'.

the learning style was visual in that the students read print and look at printed diagrams, charts and pictures; no audiotapes and no videotapes. T6

the learning style presented was mainly 'read and do' and then 'read and do and interpret' models. T1

it is a rigid step by step process, which would be frustrating and superficial for some students. The 'give a little bit, repeat this', is at the heart of this course. T3

the student is allowed to respond at their appropriate level. T6

difficult to know what kind of learning style the course should have because of the high number of lower ability, less motivated students we have to teach by distance education. T3

the learning style is varied for distance education, for example, learning from practical activities, using resource material, being guided through thinking processes, different writing activities, filling in tables, using graphs and completing charts. T7

the learning style is constrained by the *School Certificate Science Prescription*. T5

The teachers who mark this level 6 science course are aware that students may prefer to use different learning styles other than visual but each has their own ideas of what learning styles are. However they are restricted to responding to the learning style presented in the course when they mark the students' work.

#### 7.2.4 The use of scientific language

The question about how the teachers perceived the level and use of scientific language in the level 6 Correspondence School course produced eleven comments.

Six teachers said the scientific terms used were those that year 11 students should understand, but two teachers qualified their comments by saying the scientific language was probably difficult for many students due to their poor language development.

Two other teacher comments indicated that they thought the scientific language was more like scientific jargon.

Two more felt the scientific language used was kept to a minimum, just enough, necessary for teaching the science strands of the curriculum.

Another comment said much of the scientific language was not suitable for many students or for the *School Certificate Science Prescription*. (This comment was not explained).

Considering the importance of language and scientific language to this course, the teachers did not comment at depth on this aspect but seven out of eight teachers were negative about the scientific language used. They thought the scientific language would be too challenging for the students to use.

#### 7.2.5 Contexts used

The teachers were asked to comment on the learning contexts used in the level 6 science course. There were eight comments made. Four of the comments thought the contexts chosen for use in the course were good and very appropriate, giving a 'line of best fit'. T2

Two felt the *School Certificate Science Prescription* limited the choice of contexts that could be used. T1 and T5

One teacher comment said something a bit more catchy and relevant to the students would have been better, such as sport, space or travel. T3

Another comment described complaints from students and parents about the high Maori content. These complaints were difficult to understand when compared with the actual amount and position of Maori content in the course (see 4.5.3, fig 4.7).

In summary, half of the teachers thought the contexts used were appropriate for the course, the other half felt the contexts had been limited either by the School Certificate prescription or by the planners and writers.

### 7.2.6 Teaching science skills within the course

The teachers were asked how did they view the teaching of science skills in this level 6 science course. They were asked their opinions on whether they thought the skills were taught successfully, whether the skills could be transferred across the science strands with ease, and if they thought students could transfer the skills to other situations. All eight teachers thought the level 6 Correspondence School science course taught the skills successfully within the contents of the course. It was felt that the course had fulfilled the requirements of the *Science in the New Zealand Curriculum* although with some difficulties because of the distance education aspect. One teacher added the students learnt the skills because they were channeled into what responses they could give.

Only one teacher thought skills could be transferred across the science strands but only with difficulty because of the distance education aspect. The other seven expressed serious doubts but hoped it was possible, however, it was not obvious to them.

I would hope so, but the evidence is not good. not enough situations were used. T3

Maybe, but one can't tell unless this was tested. You would have to measure it somehow to be sure. T1

Can't comment knowledgeably - but I would suspect not. T2

The other teachers said the same as they felt the transfer of skills should be tested carefully because the evidence for transfer was not good. One of the reasons for this they said was because there were not enough different situations used to see if transfer took place.

The course was designed to teach skills so that they could be used in different situations other than in the science course. None of the teachers were confident that students would be able to use the skills in different situations. They used the words

hopefully the skills could be used...T4

can't be sure the skills can be used.....T1

difficult to say if the skills are.....T8

I would suspect that the skills couldn't be used in other situations. T2

In summary to this section teachers thought the Correspondence School level 6 science course taught science process skills successfully within the context of the course. They hoped the skills could be transferred to other science strand than the one in which they were taught but they doubted if this was so. They said each skill would have to be tested and transfer measured somehow. None of the teachers thought the skills would be transferred to different situations successfully but again the transfer would have to be measured.

### 7.2.7 Preparation students for the future

In this section the teachers were asked if they thought the course prepared the students for the levels 12 and 13 of the *Science in the New Zealand Curriculum* (1993b) and to be future skilled members of the New Zealand workforce.

One teacher comment was positive that the level 6 Correspondence School science course would prepare students for levels 7 and 8 of the *Science in the New Zealand Curriculum*.(1993b). The other seven did not think the level 6 science course would prepare the students for either. The reasons given were

the course was not written to prepare students for those levels. T4

the course only gives the basics, they (*the students*) need a larger range of contents, broader interests covered and a higher standard of work. T3

they were prepared as well as can be expected given the course was written for a School Certificate prescription. T1

Six teachers commented on whether they thought the level 6 Correspondence School science course prepared students for a future skilled work force. One teacher said the level 6 science course did, the other five teachers said it was very unlikely.

Sixth form chemistry would be very difficult for most students with just SC500 (*level 6 science course*). T2

Two comments were qualified by pointing out that most students at this level did not leave school for the work force.

Very few leave after the form 5. It is one step along the way. T1

One other commented that we did not know which skills would be wanted in the future so that the course probably did not prepare students for a future, skilled work force. In conclusion the teachers did not think the course would prepare students for work outside of school.

### **7.3 Summary**

The teacher comments about the level 6 Correspondence School science course reported in this chapter covered a wide range of ideas that often reflected how each teacher perceived how their own groups of students managed the course.

Most comments were critical of the course when the teaching approach was considered and they also pointed out different limitations of distance education, types of students taking the course, contexts used and the scientific language used to communicate the science content.

Concern was expressed about the performance of bright, interested and more able students and the students at the opposite end of the scale. Teachers thought these students would not reach their potential doing a course like this one.

All the teachers thought the science skills were taught successfully in this level 6 science course but most thought it unlikely that these skills could be transferred to other science situations because there had not been enough practice.

The majority of the teachers were not confident the students would be able to use the skills in different situations and subjects. They also felt the level 6 science course did not prepare students for the higher levels in *Science in*

*the New Zealand Curriculum* (1993b) levels 7 and 8. This lack of confidence in the course followed through as the teachers had a common perspective and thought it was unlikely that it prepared students for a future skilled work force.

It was expected the teachers would comment in the teaching approach section about their role in teaching science through the teaching notes and their contact with students through their letters and telephone calls. This did not happen. It appears that the teachers did not consider it a part of the course.

## **8 Discussion chapter**

The main objective of this study was to investigate the learning and transfer of science skills in distance education. It involved the use of several different research methods and the consideration of many different views about science skills, science process skills, teaching and learning. This chapter draws together data from many different sources and will discuss how the effects of research methodology, curriculum, teaching and learning strategies have impacted on student science skill learning and transfer in relation to each research question.

### ***8.1 The research methodology***

The choice of the illuminative evaluation process allowed the researcher to take account of the wider contexts in which educational programmes function. It became evident during the planning that there would be several small research studies undertaken to get the information required. These covered document analysis, student performance data and questionnaires on student and teacher perceptions of the course. Although accounts of how such studies could be carried out in conventional schools in face to face situations were found, there were difficulties in transferring and adapting successful methods from classroom to the distance education setting. The main problems encountered were due to the fact that everything was at a distance. Using a postal questionnaire brought lack of control of research settings and standardization of conditions under which the questionnaire was answered. The physical distances between the researcher and the respondents made timely follow-up and feed-back procedures more difficult. The distance also contributed to the type of results obtained with the possibility of only the conscientious and conforming students answering. Sections of the student sample did not respond to the questionnaire even after reminders. They may have felt their opinions did not count or that there was no valid reason for replying. Unfortunately, without their answers the concerns that they may have, or the concerns the Correspondence School may have about their learning will not be addressed. Other ways and approaches will have to be found to tap this information.

In the introduction to the methodology used in this study, Parlett and Hamilton

(1972) described the learning milieu as a network of cultural, social, institutional and psychological variables that interact in complicated ways. The learning milieu of this study was the level 6 science Correspondence School programme developed as a stand-alone distance education course for a diverse student population. It was designed to teach science process skills for level 6 *Science in the New Zealand Curriculum* (1993b) and the new prescription for *School Certificate Science Examination* (1994).

## **8.2 Curriculum requirements and the level 6 science course**

The analysis of the documents found there were differences between the intended curriculum and the implemented curriculum. The "General Aims of Science Education" (*Science in the New Zealand Curriculum* 1993b p9) shows the intended curriculum as having three viewpoints of science, science as a specialist activity, a common activity for all students and implications for other human activities. These three aspects emphasized the flexible and openness of the *New Zealand Curriculum Framework* (1993a) to curriculum construction and delivery. It focused on the individual student in all the suggested learning and teaching, however the emphasizes was on the processes of study rather than the content to be learned. It also pointed to the individual needs of the students and their local circumstances as being more important than a common core curriculum. The wide range of learning experiences, learning contexts and assessment examples provided was to give teachers the choice of what experiences would best suit their students. Accompanying this choice was the huge expectation that schools were responsible for developing their own science programmes and that these programmes would include preparation for work or future study, help cure social problems and meet the economic needs of New Zealand. The *New Zealand Curriculum Framework* (1993a) reflects the political stance of the New Zealand Government of the 1990s which promotes competitiveness, economic efficiency and a tendency towards a training culture where skills-based training is emphasized.

The outcome of these expectations has been for each school or schools of a particular area to develop their own courses that may have a common base with the next school or region, but it could mean something different is taught and at a different times of the year.

The teachers developing the level 6 Correspondence School science course faced all these difficulties of choice plus others that were related to the distance education situation and the time needed for the production of distance courses. They also had to develop a type of generic science course that would allow students to transfer in and out of the course as they moved from one school situation to another without too much repetition or omission. The Correspondence School science teachers also had to produce a course that suited the students who were enrolled under several different categories (refer table 3.1) depending on their age, physical and mental health, home and living situations, educational and school subject availability. The course had to be universal in nature, as special local content for one group of students would disadvantage other groups. Without a common core to the subject curriculum the choice was very difficult (refer to fig 4.4). Some of the Correspondence School teachers indicated that they felt there should be directions on what should be compulsory in the curriculum so a balance could be made between the science process skills requirements of the science curriculum and the science knowledge needs of the School Certificate in Science Prescription.

Converting a general curriculum based on social group work and debate, which could integrate many facets, to one that had relevance to the lone, normally isolated, distance student was a challenge without a framework of agreed basic content and advice on the weighting to be given various science topics. As pointed out before, many students are with the Correspondence School for short periods of time only (36% turnover in sample population) and when they return to their own schools their science learning with the Correspondence School should relate to the science of their classroom. Students returning to the classroom will find a range of interpretations and possible standards as they move from one educational situation to another. Kelly (1995, p7 and quoted in chapter 4 p 85) commented on this situation and said parental mobility will cause concern in the future as students are adversely affected. Again skills and science process skills that students learned with the Correspondence School may not be transferable to the new situations.

Distance education courses, such as the level 6 science Correspondence School course, have found it difficult to develop the type of constructivist model expected by the *New Zealand Curriculum Framework* (1993a) because the

learning and practice of skills have been predetermined by the writing process as a pathway leading to an expected outcome. Although this emphasis on expected outcomes is evident in the *Science in the New Zealand Curriculum* (Ministry of Education 1993b, p.14) it points out that science is an integrated discipline with the development of ideas in science (declarative knowledge) being linked to scientific skills (procedural knowledge).

Schools may achieve a balanced and broad curriculum in a number of ways; for example, by organizing their programmes around subjects, by using an integrated approach, or by using a topic or thematic approaches.

Nevertheless this statement appears to make the assumption that the way the curriculum is delivered is unrelated to the way the students perform and is designed more to teach about science rather than to teach science.

### **8.3 Discussion about research findings**

Each research question is considered in turn, stating what was found out and the perceptions of the students and teachers.

#### **8.3.1 Research Question 1**

The first research question was in two parts, the first part asked which skills are specified in level 6 *Science in the New Zealand Curriculum* (Ministry of Education 1993b) while the second part asked how they (the skills) are taught in the Correspondence School course. The documents of the *New Zealand Curriculum Framework* (Ministry of Education 1993), *Science in the New Zealand Curriculum* (Ministry of education 1993), *Investigating in Science* (Ministry of Education 1995) *Learning and Assessment* (NZQA 1996) all adopt the inclusive definition to classify single skills and complex process skills as skills. In *Learning and Assessment* (NZQA 1996, p14) the relationship of these skills to those listed as Essential skills is explained. These considerations have been discussed in the literature review where both Watts (1991) and Bridges (1993) agreed there was not a clear distinction between skills and process skills and they should be dealt with together. In this thesis the skills and process skills are put together and are referred to as science process skills.

The emphasis of science process skills in the curriculum documents show the importance placed on the doing of science. It also reflects the shift towards a child-centered model with group learning and away from the traditional didactic methods. Much of distance education course materials are still didactic, but distance education is no more or less constructive than any other form of learning. Nevertheless, Solomon and Harrison (1991) thought there may be a fundamental incompatibility between the expected Vygotskian constructivism of the curriculum and individual separate students working alone.

Kelly (1995) questions what ideas each student will learn about science process skills when apparently there is such a wide variation in each category. He suggested the different skills should be related as far as possible to content matter and other scientific processes. The curriculum does state that in practice, science is a process involving the integration of knowledge, skills and attitudes to develop scientific understanding, (Ministry of Education, 1993a p42) which attempts to address the process and content debate familiar to science teachers. However the coverage of science process skills as found in the 'Making sense of the Living World' for example, is not straight forward because the skill of observation ranges from direct observation, for example of animal behaviour, to indirect observation of the effects of a biochemical reaction. There appears to be a gradient of meanings for the term observation determined by the context of the situation.

Developing science process skills and scientific attitudes is the achievement aim of one of the integrating strands of *Science in the New Zealand Curriculum* (Ministry of Education 1993b) which states that students should in the end of their studies be able to carry out complete investigations. As referred to in chapter 4, (4.2.1) and appendix 4B, the individual science process skills are identified as (a) focusing and planning; (b) information gathering; (c) processing and interpreting information and (d) reporting and communicating.

The emphasis on science process skills was continued in the level 6 Correspondence School science course. It taught the science process skills as specified by the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) through the content topics. (Fig 4.4 in chapter 4 shows the distribution

of skill teaching and practice across the course). The decisions of where and how the science process skills were distributed through the course were made in response to the specific learning outcomes developed from the achievement objectives. Each type of skill was taught at least twice, however, some skills, such as processing and interpreting, were used more frequently. Besides teaching to the requirements of the *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) the science process skills in the level 6 science course also followed the requirements of the new *School Certificate Prescription for Science* (New Zealand Qualification Authority, 1994).

On top of these structures there were differences in emphasis due to teaching at a distance. In distance education the response time between teacher and student is longer than within a classroom and this has a marked effect on the emphasis placed on science process skills. The feedback to the teacher is by the student reporting rather than the teacher observing the process. If the criteria requirements of the end product have been met, then the process is assumed to have been completed.

Some science process skills, in the *New Zealand Curriculum Framework* (Ministry of Education 1993a) and *Science in the New Zealand Curriculum* (Ministry of Education, 1993b) such as discussion and debate, are not emphasized in distance education, although they are highlighted in certain circumstances, such as school days and camps along with the social and group skills.

(i) How well are the science process skills identified?

Kok-Aunoh and Woolnough (1994) suggested it was necessary to find out how well each of the science process skills were identified in a science course before investigating how students used them. This objective was achieved by looking at the correlation between student performance on each of the science process skills, using Pearson's product moment correlation coefficient. Lock (1990) said the distinctiveness of each science process skill would be shown by very low correlation between pairing of skills, because the low correlation suggested each process skill could have some unique characteristic not identified in the others. Table 5.5 shows the correlation between two tasks of the same skill. The result CInv, (carrying out an investigation), stands out from

the others because it was not statistically significant at  $p = 0.05$  and shows there was little difference in performance between the two tasks. This may indicate the skill of 'carrying out an investigation' was clearly identifiable. The correlations between the other paired tasks are statistically significant indicating the skills in the paired tasks were not so similar even though named the same. This meant these skills were not as clearly identifiable.

This lack of distinctiveness between the science process skills was not recognized by the students as a problem. 64% of those that responded to the questionnaire thought it was easy to learn science process skills by correspondence and that there were enough opportunities to practice them.

Part of the identification and separation of science process skills is deciding their position in a skills hierarchy. Yeany, Yapp and Padilla (1986) and Duschl (1989) decided science process skills are part of a simple linear hierarchy, moving from generic (essential) skills to science process skills to investigative skills. This hierarchy suggests there is a progress of skill learning and it assumes the skills can be transferred from one situation to another by continuity of skill learning. However, this progression of skill learning is not as straight forward as it seems when different approaches to knowledge and its relationship to skills of each science strand in the *Science in the New Zealand Curriculum* (Ministry of Education 1993b) is taken into consideration. This is discussed in section 4.2.2, along with the possibility of fragmentation of information if skills are separated from their scientific conceptual base. The learning of isolated skills is questioned by *Science in the New Zealand Curriculum* (Ministry of Education 1993b) in respect to the 'process and content' debate. The Correspondence School level 6 science course generally assumes that skills progress within a hierarchy.

Progression in science learning is seen as the increasing depth of understanding of concepts and procedures within an ever-widening framework of contexts. Sorby (1995) suggested course writers should map out the progression both for the teaching of scientific concepts and skill learning. The Correspondence School level 6 science course was written with an implied progression pathway through the course work. It was assumed that if students moved through the course in a sequential manner they would be able to build on their learning, their skills would improve, they would become more

accomplished and the transfer of skills would take place. This reflected *Science in the New Zealand Curriculum* statements, which aimed to produce accumulative progression from level to another.

Teachers were concerned that the level 6 Correspondence School science course would not enable all students, such as the academically bright and the interested and the more able students, to achieve at the level they were capable. They were also concerned that students would find it difficult to progress academically because the science content was split up and learning concentrated mainly on skill learning. The teachers' perceptions of student learning and progression were such that they believed transfer of learning and skills should take place. It may do, but they felt they did not know for sure.

Students understood progression in a different way. To most students progression and progress were the same thing and meant the rate at which they worked through the sets. Two thirds (66%) thought they were working at an adequate rate and were satisfied with their progress as specified in the questionnaire. Progress also meant satisfaction with the results they gained. As mentioned in chapter 6, this may indicate the students have an internal fail/success barrier to which they relate their level of achievement.

Ramsden(1992) said the grading system is all-powerful to the students. They will learn any strategies that will gain them high grades even if they do not understand the material.

How do the students learn to judge themselves against this level? Most full time students have had experience of the academic levels of work in conventional schools. Students in the Secondary School group are currently experiencing teaching at conventional face to face schools and would be able to make a judgment on the academic level of the course.

Home Schoolers may have been to other schools but now they are home schooled they may also take on their standards of their school work supervisor. Adults students also have had experience of school level teaching and with their experience outside the classroom they too could make valid judgment on their perceived academic level of the Correspondence School course.

Another question that could be asked is how does the Correspondence School teachers know what the current academic level of teaching at year11 is? All

teachers at the Correspondence School are experienced classroom teachers. Some have been out of the conventional class room situation for several years, but they have practical experience of the academic levels expected of students through school days and seminars. From these types of contact Correspondence School teachers are able to judge what can be expected of the students even though there is a widely held assumption that it is not only the students who are isolated when they learn by distance education but their teachers are as well. Overall there is no perceivable difference between the expectations of distance teachers and classroom teachers of their students.

(ii) How are the science process skills taught?

The second part of the research question asks how were the science process skills taught by the Correspondence School level 6 science course. In distance education, as practiced by the Correspondence School in 1995, the teaching of science process skills was initially done at the planning and writing stages. The teachers who mark the student's work can only respond and give, what is termed by the Correspondence School, second phase teaching support. This second phase teaching support consists of extending students' understanding as seen necessary from their answers to the practical activities or re-teaching science concepts that have been misunderstood or completely missed the first time round. In doing this, the teachers who mark can only respond to the results of the initial teaching. Section 6.2.3 reports on what the students did when they received their marked work back from the teacher. The results of the questionnaire show that the students thought the comments and letters from the teachers useful to their learning.

Teachers who mark the work do not have the opportunity to negotiate the type of teaching given in the course. The students also are unable to negotiate any part of the course content or contexts and are not in the position of setting their own goals. This is in contrast to the intentions of the *New Zealand Curriculum Framework* (1993a). Of the various enrolment groups the adult students have the greatest freedom in that they can choose whether to do the course or not, and at what level they want to enter into the school system, depending on how they rate their prior knowledge. Their choice of science is often job related, or so that they can take an interest in or support their children's education.

Most secondary school-aged students are often placed into level 6 courses as a result of social progression through the education system based on age. The teachers of the level 6 science course do not know much about the prior knowledge or experience of the average student. There are no diagnostic tests at the beginning of the course to check reading age or the capabilities of the students. It is assumed the students have progressed through level 5 and are ready to build on that knowledge when they are enrolled into the level 6 science course. Cognitive learning theories emphasizes exiting cognitive structures and the prior knowledge of the learner that will influence the way in which new learning will occur (Jones and Mercer, 1993). Dewey (1942) wrote about the importance of the ability to understand an idea expressed in words for estimating a student's potential for handling new tasks. He said it was important to evaluate the student's domain (science) specific knowledge prior to learning new material by diagnostic pre-testing. His ideas are still important and are supported by practicing classroom teachers who are able to test and then adapt their teaching to their students' learning quickly. Print based distance education courses find diagnostic testing difficult to do because of the time factor. What is the student to do while the diagnostic tests are sent to the school for marking and decisions made? Modern technologies can speed this process up if they are available to the students. The level 6 Correspondence School course was completely print based and did not have any diagnostic testing built into it. It was written at a reading level that most students could cope with, even though that reading level did not match those of relevant textbooks or the School Certificate Science Examination paper. The results of the reading levels of these different documents that the students have to deal with are shown in section 4.3.2. The difference in reading levels of student work brings up the debate of whether schools should teach the student at the level they are at, or teach to the assessment programmes against which the students (and the schools) are measured.

There was a wide range of opinions from the teachers on how science process skills are taught in the level 6 Correspondence School course. Four teachers described the teaching approach as basic and minimal, producing a very uniform and bland course. Other teachers described the teaching approach as superficial, but opposite views were expressed and the teaching approach was described as varied and usually stimulating so that it communicates the basics

well. Meanwhile, other teachers expressed their ideas in a different way saying the teaching approach was reassuringly similar throughout the course to help students gain useful routines.

Teachers also said the writing style used in the booklets was mainly guided didactic conversation (see 2.5.1 and fig 2.10). None of the teachers thought the writing style gave enough scope to demonstrate the depth of the subject matter but most thought the science process skills were taught successfully.

### **8.3.2 Research question 2**

How well do Correspondence School students achieve in the skills taught through the level 6 Correspondence School science course when analyzed by gender, ethnicity and enrolment.

#### (i) What was expected of the students?

Students were expected to work through the booklets of the level 6 Correspondence School science course, complete the practice activities, the teacher-marked exercises and the various assessment activities. It is also expected they would progress in their subject and science process skill learning which would be seen as an improvement in their work and the development of science process skills to facilitate the transfer of these skills to other situations.

Assessment in the level 6 Correspondence School science course provides feedback to students and caregivers and is directed towards individual student progress. It sees its main aim is to improve teaching and learning by diagnosing students' strengths and weaknesses and measuring students' progress against the achievement objectives of the National curriculum statements.

#### (ii) How were students assessed?

The skills and their applications were assessed in several ways ranging from teacher marking of student reports of practical experiments they carried out, to self-marked activities and teacher marked activities and tests. Most assessments of skills were based on the written word but a few solid products from chemical experiments were sent in for the teacher to actually see. The

methods of assessment were limited due to the isolation of distance students, and because direct observation and discussion could not take place.

(iii) How well did the students achieve?

Various enrollment groups performed at different levels. This is partially illustrated by the analysis of performance of the level 6 Correspondence School science course according to ethnicity and gender groups. Evidence of student performance was collected from the logsheets. in the form of a score between 1 and 8 marked on an interval scale. This score did not differentiate between skills and tasks or the mastery of skills and tasks. It was an overall score for the skills tested in each booklet (appendix 3A, fig 3.1). In studying the average scores for booklets 2 to 7 this would appear so, but the lower average scores for booklets 4 and 6 may indicate that the students found the chemistry skills and tasks a little more difficult to manage. As the year progressed the proportions of the different groups changed. The higher average scores seen in booklets 8, 9, 10 may show that the students who stay with the course and complete more sets achieve better.

(iv) Ethnicity, gender and student performance

In this study there are two declared ethnic groups to which the students belong, Non Maori and Maori. To see if there were any differences in student performance that may be due to gender or ethnic origin the mean score for booklets 2 -9 of of assessed student work were tested for significant difference Female and male mean scores are seen in table 5.6 and indicate the female students mean scores were significantly different to the male students' mean scores as female students perform better on this particular distance education course..

To find out how well the level 6 Correspondence School science course suited these groups, Maori and Non Maori, male and female, the following pairs of categories were investigated:

- (a) non-Maori and Maori females
- (b) non-Maori and Maori males
- (c) female and male Maori
- (d) female and male non Maori.

In summary it was shown that female students perform better on this particular

distance education course than males. There was a smaller difference between non-Maori and Maori female performance but between non-Maori males and Maori males there was a significant difference in performance. Non-Maori females perform better than all the other groupings and Maori females perform better in several booklets than non-Maori males. The achievement of Maori males is lower than any other grouping.

This problem of unequal achievement was recognized by the *Science in the New Zealand Curriculum* (Ministry of Education 1993b) developers and writers. They emphasized the need to encourage science learning in Maori, girls, students with special abilities and special needs (*Science in the New Zealand Curriculum*, p11-13). It was also recognized by Jones A. (1990) who described educational and systematic factors that have impacted on girls, especially Maori girls, that some schools do make a difference to the inequalities. Perhaps the Correspondence School offered Maori girls something they lack in conventional schools, such as more individual attention and less competition so that they could move towards their potential.

It appears the level 6 Correspondence School science course caters for the needs of girls well, as both Maori and non-Maori girls achieve better Maori and non-Maori boys. (See Fig 5.1) Contributing factors to the poor achievement of boys, and Maori boys in particular, could be that they were unsuited to distance education and needed personal guidance and supervision to do the work. Collectively their reading skills may not be developed enough to learn by printed matter alone and that they did not persist at the course long enough to achieve the objective of the course. Also it may be a male and/or cultural response (not cool to achieve) or they may have seen the course as irrelevant to their lives and futures. From the responses to questions 4 and 6 and 8 it appears between 18 -24% of the students that replied to the questionnaire also thought the self marked exercises were not of use to them even though they did them. A lot more research is needed in these areas.

#### (v) Enrolment groups

The enrolment categories, home schoolers, adults and the secondary school students' performances were compared with that of the full time students of the the Correspondence School. The comparative performance of the home schoolers is shown in table 5.1. Their performance although varied, measured

significantly above the mean score of the full time students for booklets 1, 3, 4, 5, 6 and 9 but significantly lower in booklet 7.

The adult student performance, however, was significantly above the mean for the full time student group for all booklets. Their performance data is shown in table 5.1 as well.

The secondary school students, also had their performance compared with the fulltime group as seen in table 5.1. Their performance was significantly lower than the average for the full time student group in booklets 1, 3 through to 9.

In summary the adult students gave evidence that they could perform the skills at a higher level than the rest of the students. Of the compulsory school-aged students, the home schoolers obtained the highest scores, followed by the full time students and lastly the secondary school students.

The full time students were further categorized into enrolment sub-categories of distance, medical, psychological, suspension, itinerant, pregnant schoolgirls and overseas students and further analysis of this group was undertaken. Table 5.2 shows the mean scores for the full time student group and this is used as the basis for comparing the subgroups. The results show that each enrolment sub-group achieved differently.

The distance students performed in a very similar way to the whole of the full time student group but their scores were significantly higher in booklet 2 (biology), booklet 4 (chemistry), and booklet 9 (geology).

The mean scores of the medical enrolments (table 5.2) were higher at the beginning of the course. The mean scores were significant in booklets 1 (biology), 2 (biology), 3 (geology) and booklet 6 (chemistry) but physics booklets 5 and 7 proved more difficult for them.

The psychological group mean scores were below the fulltime group mean scores throughout the level 6 science course. Their mean scores were significantly lower as shown in table 5.2.

The suspended students mean score was significantly lower than the mean

score of the fulltime students for booklets 1, 2, 3, 4 and 5. Very few suspended students sent in work from the rest of the level 6 course as highlighted in table 5.2.

Itinerant students mean score was significantly higher than the fulltime students' mean score, except for booklets 9 and 10. This is also shown in table 5.2, as are the pregnant girls' mean scores. When the pregnant girls' mean scores were compared with the fulltime students' mean scores it showed they were very similar even though the pregnant girls had to overcome many unfamiliar situations during the time they studied.

The overseas students' mean scores were significantly higher than the fulltime students' mean scores for booklets 4, 5, 6 and 7, but there were very few students in this group as highlighted in table 5.2, so that the results may be misleading.

In summary, the analysis of the mean scores of the sub-enrolment groups showed that the groups achieved at different levels when compared with the mean scores of the whole fulltime group. The distance, medical, itinerant and overseas groups were comparable or better than the whole fulltime group, while psychological and suspended students did not do as well. This may indicate the single course was not suitable for all the enrolment groups.

### **8.3.3 Research question 3**

What skills are transferable from one task to another when taught through the level 6 Correspondence school science course.

The term 'transferable skills' is the application of skills across different contexts allowing people to succeed in a wide range of different tasks and jobs. When teachers assess students on their skill ability the teachers usually depend on some hierarchical structure by which they can rank student achievement. The issues raised in the debate about transferability has been dealt with in the literature review but the education and science philosophy held by the teachers influences the ways assessment take place.

The position taken by *Science in the New Zealand Curriculum* (Ministry of Education 1993 b) is that students pass from one level of achievement to a higher one. The science teachers at the Correspondence School also hold this developmental view of skill transfer in which students are positioned along a continuum of increasing competence in a skill. However, the New Zealand Qualification Authority takes the other view of science process skill assessment in which students either possess the skill or do not possess it. However, the authorities hold the views of teachers as unimportant even though the teachers have to work with both systems.

The level 6 science Correspondence School course was written to be compliant to the *Science in the New Zealand Curriculum* (Ministry of Education 1993 b) document with the developmental view of transfer dominant and multiple measurements of the same skill were taken which was thought to increase reliability of the skill assessment compared with a single measurement. Also it should increase the validity of the assessment tasks and show progression in student achievement. There was very little evidence for science process skill transfer when student performance scores were examined. This is not surprising when some students did not recognize skills as being different from knowledge content of the level 6 science course or indeed did not perceive them to be. (One student asked what was a skill after successfully completing the course). 69% of the students who answered the questionnaire thought the science process skills would be of use in the future and 68% thought they would be able to use them in other science exercises (near transfer and context bound). However, 48% (question 26) thought they would be of less use in other subjects such as mathematics, economics or geography and considered the skills were not fully transferable.

Only 39% of respondents thought the science process skills may be useful in everyday life with the adult group expressing most doubts about the skills being useful. The Correspondence School science teachers were also unconvinced of the possibility of transfer occurring. According to Tamir (1989) transfer is only possible when explicitly addressed and the contexts were close but these were not the conditions found in this study. It is the opinion of the researcher that transfer of skills can occur if the skills are very general or simple, discrete in nature and are repeatedly used. The more complex skills in the

Correspondence School level 6 science course are context bound and are less likely to show transferability.

Many researchers think transferability is doubtful. Their views have been described previously and can be summarised as saying student success in one area of learning is not enough to enable the student to transfer the ability to another. This research showed student performance in interpretation was low when students were asked to apply science skills in contexts other than the one in which it was taught. Even so, the practical skills of planning, performing and interpreting are assumed to be transferable, especially when the new context is closely related to the first, giving a horizontal application of the skills.

There is continuing controversy over the implicit or explicit nature of skill learning, skill teaching and whether hierarchies of skills should be developed across or within skills. It is thought students could learn to apply skills to problems similar to those used in their training, but in most cases the skills disappeared over time and did not transfer to problems of a different nature. Only one teacher thought skills could be transferred across the science strands but only with difficulty because of the distance education aspect. The other seven expressed serious doubts but hoped it was possible, however, it was not obvious to them.

As a general conclusion to this part of the study, is that the skill of performing an investigation is transferable from one situation to another but the other skills of processing, interpreting, and using information are more context dependent. In these situations the science skills may take on different characteristics depending on the context of the different science strands (Lock 1990). This would mean a change in context and mode for assessment would make the distance between the two tasks too great for transfer to occur giving low assessment scores. Some students who answered positively about the use of the skills thought they may be able to use them in different contexts, but less than half of them thought the skills would be any use in everyday life. When transposed onto the full sample population approximately 18% would have thought them useful. This is at odds to the New Zealand Curriculum Framework and the Science in the New Zealand Curriculum documents, which expects everyone to find them useful.

### 8.3.4 Research Question 4

How does the performance of Correspondence school students compare with student performance from conventional schools?

As each school develops their own teaching programmes the only comparison of student performance that can be made between Correspondence School students and those in conventional school is with the National Qualification Authority School Certificate Examination in Science.

The students taking this level 6 Correspondence School science programme were prepared to take the *School Certificate in Science Examination* (NZQA 1995) based on the *Science in the New Zealand Curriculum* (Ministry of Education 1993b). Part of the preparation for the *School Certificate in Science Examination* (NZQA 1995) was an internal practice examination.

The performance of the students in this study was followed through their attempts at the Correspondence School science internal examination and the *School Certificate Science Examination* (1995) and then compared with the national results.

The 1995 *School Certificate Science Examination* took into account the new prescription. It was composed of resource material that gave the context and problems that tested various science skills.

Not all Correspondence School School Certificate students' results were available to The Correspondence School in January 1996 This has been explained in the chapter of student performance . The mean score percentage indicates there is no significant differences between Correspondence School students and those students from conventional schools (table 5.12).

Further investigation into the published results showed that Home Schoolers received the highest number of grades A - C, followed by adults, Secondary School Groups and Fulltime Students (table 5.13).

The percentage of grades A -C awarded to non-Maori students was 58.5% and to Maori students was 26.7% (the number of Maori students was small). The

distribution of grades shown can be explained by the absence of the unknown student results which may have enhanced the level of the grades awarded.

### **8.3.5 Research question 5 - Students' perceptions**

Some of the students' perceptions have been reported in answers to previous research questions. 64% of those who answered the questionnaire thought science process skills were easy to learn by distance education methods. They were not worried by the lack of differentiation between the skills (cf. Lock, 1990 and Kok-Auntoh and Woolnough 1994) but were able to say that they found the skills of processing, interpreting and communicating information, carrying out an investigation and using information more difficult to use in chemistry than biology or physics. They judged their success at using skills on the scores they received for their work. As previously reported, Ramsden (1992) said the assessment system used was the most important indicator students had to judge how well they were doing.

To achieve the learning objectives of level 6 Correspondence School science course students needed to have some support structures in place that supplemented the written course. Those available were science boxes, teaching notes, personal letters from teachers and phone calls when appropriate. Teaching notes were composed of model answers to teacher-marked written exercises and were intended to give the student opportunity to go over their work again and check their learning. The teachers' letters are structured to comment on something positive and that the student has done well, followed by comments or instruction on how to improve two or three teaching points. These support systems were all reactive rather than proactive. The proactive support was supposed to be embedded within the course writing that aimed to motivate the students to do the work in the course.

Student perceptions of the teacher support was on the whole very positive and most students appreciated the time teachers took to correspond with them personally. Just over half of the students thought it worthwhile to go over the formal teaching notes. Other students said they would if they got their work back quickly. This may indicate that a long response time between sending and

receiving the work back deterred students from revising work they had already finished with. However 90% of the respondents read the teachers' letters addressed to them personally and found all personal contact helpful (see questions 11 and 13).

### **8.3.6 Research question 6 - Teachers' perceptions**

As with the students' perceptions, many of the teachers' perceptions have been used to answer previous research questions. Although some answers given by teachers lacked detail and specificity they expressed some general concerns about the intended curriculum, the implemented course and student achievement that stemmed from the language used.

Language was a problem for everyone. With move to the New Right philosophy the government had changed the type of language used in official science education documents, discussion papers and assessment to that of the 'language of process'. This made it difficult for schools and teachers to know exactly what was required. It stemmed from documents where the language of process was used to justify a change from knowledge led science to process science. It was used in policy statements to describe processes as sequences of events that are followed when scientists undertake scientific investigations. This use of language also suggested that the processes represent a hierarchy in levels of intellectual ability. From that point it was assumed teachers and students could understand the language of process and could use it to learn skills and transfer them across subject areas.

The New Zealand Curriculum Framework used this language of process and intermingled it with the languages of several educational theories. It was from this base that the Science in the New Zealand Curriculum was developed and where the interpretation and transcription of the official language began. It was then passed along a line from government policy to school policy, subject departmental policy, to the teacher to implement in the classroom for the student.

In distance education the writing and editing processes further complicate this line of interpretation. The Correspondence School level 6 science course was

written to a plan that was developed from a consensus interpretation on the part of all interested parties (See fig 4.4). It was expected that the students would be able to understand the language used as it was aimed at the 'middle of the road' of the diverse student population studying science at year 11. Most students (80%), who responded to the questionnaire, thought the level of language used was about right. The language used tended to be non-scientific in order to encourage the poor language skills of lower ability students. The majority of student responders did not complain about the language used, however, some of the Correspondence School teachers surveyed said the scientific language was probably too difficult for some students who were doing the course. Student performance results show this was probably true for students who were enrolled in the psychological and suspension student groups (tables 5.6 and 5.7 respectively) and for many male students. (fig 5.1).

The lack of scientific language used by New Zealand students was commented on in the Chief Marker's report of the 1995 School Certificate science examination. The report said it was expected students would use scientifically correct language and choose the most appropriate form when answering questions. It is difficult for teachers developing science courses to know how much and what form the teaching of scientific language should take when there is so little guidance or indication in the government policies and curriculum statements.

The distance education environment compounds this difficulty where the printed word is permanent. Any change in interpretation is difficult to implement because of length of time of course production and costs. In the Correspondence school level 6 science program any extra teacher input, for example using different words to re-teach a concept, comes after students have committed themselves to an idea and have put their answers on paper. Change to student learning does not occur during the processes of negotiating understanding but as a correction to what is already in place.

The lack of scientific language use by students is also related to whether the skill of using scientific language learnt in school science courses is transferable to a different context such as that of a national examination setting. As Halliday and Martin (1994) pointed out, scientific terminology is frequently not

understood when scientific words are used in a different grammatical form or strung together in a description. This difficulty may be one of the reasons why many Correspondence School students do not attempt the internal examination and even less the School Certificate Science Examination (table 5.1). Students may fear scientific language because of lack of practice and use at appropriate reading levels.

The comparison of reading ease indices and grade levels of the Correspondence School level 6 science course, classroom textbooks and the School Certificate Science Examination (table 6.8) shows that there is a disparity between them. The reading ease index of the School Certificate Science Examination indicated that the Correspondence School students would have to overcome quite a large language gap from their course work to reach the examination level. Nevertheless, the teachers' perceptions were that the achievement of the students was as they expected, considering the many types of students who studied with the Correspondence School.

#### **8.4 Summary**

This study involved different research methods and different views about science skills, science process skills, teaching and learning. It has investigated how these differences have affected the way students have learnt to use the skills and the transference of skills. Through distance education courses such as the level 6 Correspondence School science course, students get very few choices about what they are taught while the teachers who mark the students' work can only respond to what is sent into the school. Teachers respond with what is called second phase teaching, consisting of encouragement, support for the student and pointers for future learning improvement. The teachers do not know very much about the prior knowledge or experience of the average student but try to give the student appropriate guidance to achieve the learning objectives of the level 6 science course. The students who responded to the questionnaire had positive perceptions of the teacher support. Science process skills were emphasized throughout the course but it is not clear if each skill was defined clearly. This would have an affect on the determination whether the skills were transferable from one science situation to another. The conclusions from this study are listed in the next chapter.

## 9 Conclusions and recommendations

Specific issues have been discussed in the previous chapter that arise from the literature review, document analysis and the investigation into skills and skills transfer of level 6 Correspondence School science course. The conclusions stemming from these issues can be grouped into the effects of the (a) distance education mode, (b) level 6 Correspondence School science course and (c) student characteristics on the teaching and learning of science skills. Caution must be taken however, as the conclusions refer to a science course designed by the Correspondence School for a particular set of requirements as laid down by the *The New Zealand Framework* (1993a) the *Science in the New Zealand Curriculum* (1993b) and the *School Certificate in Science Prescription* (1994) and the research data refers the time period of the academic year of 1995.

### ***The effects of the distance education mode on science process skill learning***

1. Distance education affects how the curriculum is delivered to students and how the learning outcomes are assessed.
2. Successful learning with distance education is dependent on the language and reading abilities of the students.
3. Science process skills can be taught and assessed by distance education but they need to be continually practiced to be maintained.
4. The establishment of science process skills is partly due to the students' prior knowledge but due to the mode of distance education information on students' prior knowledge is not fully known.

### ***The effects level 6 Correspondence School science course on science process skill learning***

1. A single level 6 science course does not suit all the different types of students enrolled in the course. An individualized science course with alternative booklets at different achievement levels and the addition of some alternative media presentations would help hold the interests of the different types of students.
2. The needs of individual students must not be overlooked in that some may need remedial work while others would welcome some extension work.

3. Dependence on a single print-based course limits some students who have a different preferred style of learning.
4. Maori needs and expectations may not be met with a single course.

### ***The effects of student characteristics on science skills learning***

1. Students' prior knowledge is the recognized starting point for learning science process skills successfully so that each piece of new information is related to previous experience.
2. Students' language and reading ability has a bearing on how they learn and maintain science process skills and is related to their understanding and ability to use scientific information
3. Students' expectations in regard to success and failure are important because they affect the students' motivation to learn and the amounts of effort students are willing to spend on task. Students who have experienced repeated failures may become passive learners and believe their failure is due to lack of ability.
4. Students' levels of motivation and persistence influence their progress through the course and the standard of their work.
5. The value the student and their families place on education influences the success the student experiences.

### ***Recommendations for future skill-based distance education courses***

1. There is a need to develop multi-level courses to suit individual student needs and find ways to involve all enrolled students in learning.
2. Provide adequate resources for distance education to meet the *Science in the New Zealand Curriculum* requirements.
3. Develop courses that acknowledge the multi-dimensional requirements of assessment at the senior school levels, such as formative assessment for the *Science in the New Zealand Curriculum* and summative assessment for School Certificate Science Examinations and unit standards of the National Qualification Framework.
4. Continue research and development of multi-media course presentations. This is linked with the development of the multi-level courses.

5. Develop diagnostic tools to assess students' prior knowledge and reading ability so that the progress students are making through the course can be mapped.
6. Find ways of increasing reliability of assessment of student performance by reducing sources of inconsistency in teacher marking and the authenticity of student work.
7. Investigate further use of practical science activities to motivate students without all of it being linked to assessment.



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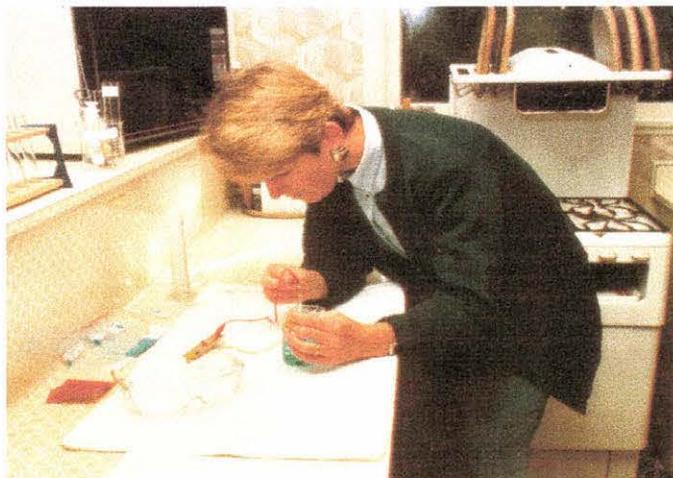
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# Appendix

## Correspondence School science students

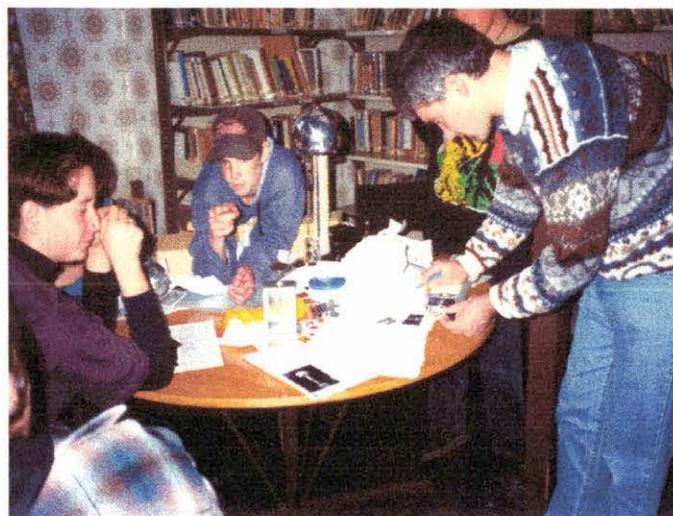
The Correspondence School science students study and do practical experiments in many different environments, at home, in school laboratories and in parks and gardens.



Adult student working in her kitchen on a practical science activity.



A fulltime distance student experimenting on the kitchen bench

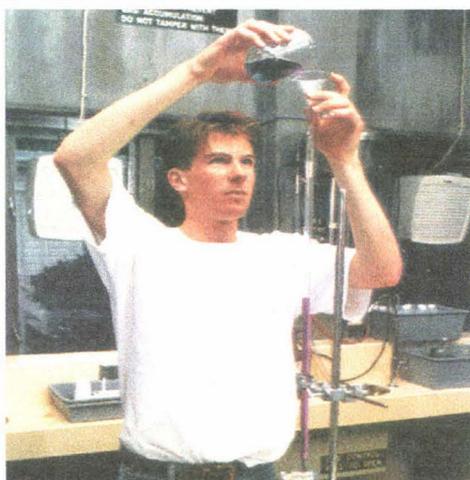


Science students working with a visiting teacher on the dining room table.





Secondary school student observing snails in their natural habitat.



Correspondence School student working in a local secondary school laboratory



Fulltime students working in the Correspondence School science laboratory during a school day.



|             |
|-------------|
| <b>MEMO</b> |
|-------------|

To: Margaret Latimer, Science Department  
Copy: Hal Morgan, HOS Science  
From: Mary Rae, Principal Secondary  
Date: 13 December 1994

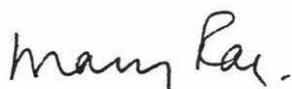
### Research and development portfolio

Dear Margaret

Thank you for your research proposal and letter of 29 November 1994 regarding your proposed Master of Education thesis "An evaluation of distance education skill-based science course for level 6 of the New Zealand Science Curriculum".

It appears to me that it will form a very useful assessment as to whether elements of new curriculum are inappropriate for distance education which services students in the compulsory education sector who have no alternative access to the New Zealand curriculum.

Best wishes,



Mary Rae  
Principal Secondary

Margaret Latimer  
Science Department

The Principal of the Secondary School  
Research and Development Portfolio  
The Correspondence School  
Wellington  
24 July 1995

Dear Mary

The preparation of my thesis on the evaluation of the level 6 science course for the fifth form is at the stage where I would like to use some of the student data the Correspondence School has collected.

This data will be used in conjunction with data I have collected this year on the assessment of science skills and a survey of students' opinions.

It is intended that the students' privacy will be safe-guarded at all times by coding in the information about each student so that only global conclusions and trends are reported.

I would like permission to use these school records so that I can proceed with this study.

Yours sincerely

*Margaret Latimer.*

*Permission granted.*  
*mRae*

*31-07-95.*

July 1995

## Survey of Correspondence School Science Course, SC500

Dear Student

You are invited to take part in an evaluation study of the Level 6 of the New Zealand Science Curriculum (SC500) provided by The Correspondence School. This evaluation is being carried out by Margaret Latimer, a post graduate M.Ed student working under the supervision of the Department of Education, Massey University and the Research and Development Committee of The Correspondence School.

As a part of a sample of the students studying the SC500 course you are asked to complete the attached questionnaire which seeks your views about the teaching and learning methods used in the SC500 course. When you have completed your questionnaire please mail it to The Correspondence School in the pre-paid addressed envelop included in this package.

The confidentiality of your answers is guaranteed (the coding is for statistical purposes only). Please answer the questions as fully and as accurately as you can. There are no right or wrong answers to the questions. Whatever you say, your answers will be of great value in helping us improve the teaching we provide. The information from the questionnaire will be strictly confidential and used for research purposes only.

Your cooperation in this research is very much appreciated.

Please complete the questionnaire now as you sit down to do study, and return it immediately to The Correspondence School. Thank you.

If you would like any further information, please contact Margaret Latimer, Science Department, The Correspondence School, ext 8692.

Yours sincerely

## The Correspondence School Board of Trustees Policies Privacy

Approved: October 1997 Category: Miscellaneous

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The Correspondence School Board of Trustees will recognise its obligations under the Privacy Act.

The Privacy Act imposes requirements on The Correspondence School in the way it collects or holds information about any individual. The principles of the act cover

- how, why and from whom personal information can be collected
- the rights of access to and correctness of that personal information
- the accuracy, completeness and relevance of that information
- the use and disclosure of any personal information
- the safe keeping, storage and disposal of all personal information collected or held

The Correspondence School Board of Trustees will recognise its obligations under the Act by:

- ensuring that staff are provided with training in the requirements of the Act.
- developing written procedures for staff to follow in dealing with privacy related matters.
- examining all school procedures related to the collection, storage and disposal of personal information to ensure they meet the relevant principles of the Act.
- ensuring that all forms used for collection or transmitting personal information include a statement of confidentiality.
- having a procedure for handling complaints under the Act.
- appointing three Privacy Officers to oversee and monitor compliance with the Privacy Act (Personnel, Secondary, Primary / Early Childhood).

April 1995 REVISION

New Zealand Council for Educational Research

## ETHICAL STATEMENT

### Responsibilities

The welfare of research participants takes precedence over the self-interest of researchers and over the interests of colleagues, employers, and other agencies.

Researchers are sensitive to cultural and social diversity. They recognise that there are differences among people, such as those that may be related to age, gender, or socioeconomic and ethnic backgrounds and, when necessary, they obtain training, experience, or advice to ensure competent and sensitive research.

### Informed Consent

Researchers obtain the informed consent of participants except where its exclusion can be justified by the research methodology. Informed consent means agreement to participate in the research, or where necessary, agreement by those authorised to represent the interests of any person judged to be incapable of giving informed consent. When children are involved in a study informed consent should be obtained from their parents or others who are responsible for them. Informed consent includes:

- a) Being informed of the purposes, nature and procedures of the research;
- b) Being informed of any research procedures that might have harmful effects on them;
- c) Being informed of the right to withdraw from a research project at any stage and, if they have been paid to participate, the conditions of withdrawal;
- d) Being informed of the right to knowledge of the use to which the data may be put and of the outcome of the study.

Researchers take all possible steps to protect participants from physical and mental discomfort, harm, or danger. Care should be taken not to disturb or cause anxiety to participants by the research procedures that are used or by the details in the research report. Researchers do not use research procedures if they are likely to cause serious or lasting harm to participants.

Where methodological requirements of a study involve the use of concealment or deception a researcher has particular responsibilities. These include justifying the use of such procedures to an appropriate ethical committee, demonstrating that other non-deceptive procedures could not be used, obtaining the consent of participants to waive their right to prior information on the nature and purpose of the study and ensuring that all participants are given full explanations as soon as practicable.

### **Obligations of Research Personnel**

Researchers must ensure at all times that research carried out by others under their supervision conforms to this Code.

Researchers should ensure that their proposals, and all aspects of their research, are consistent with the requirements of the Privacy Act, 1993.

Research assistants, external research collaborators, and members of advisory committees should have the relevant parts of these ethical guidelines drawn to their attention, including the requirements regarding anonymity and respect for privacy.

### **Additional Obligations**

Consultation re the terms of reference and membership for an NZCER Ethics Screening Group will be completed during 1995. Thereafter, researchers should submit their research proposals to the NZCER Ethics Screening Group for review. In the event that the proposal contravenes NZCER policy, the researcher is obliged to revise the proposal as recommended by the Ethics Screening Group.

### **Note:**

This Ethical Statement is a 1995 revision, prepared in consultation with the Director and staff of NZCER. The original NZCER statement, prepared by Val Podmore in consultation with the Director and Staff of NZCER in April 1991, was based on models from the N.Z. Psychological Society and the NZARE.

## Appendix 1

The *New Zealand Curriculum Framework* (1993a) has identified the essential learning areas and skills, defining the national achievement aims, objectives and assessment procedures. It also indicates the place of attitudes and values in the school curriculum and states that schools have the freedom to develop programmes which are appropriate to the needs of their students.

| Essential Learning Areas<br>Nga Tino Wahanga Ako | Essential Skills<br>Nga Tino Pukenga     |
|--|--|
| Language and languages<br>Te Korero me Nga Reo   | Communication skills                     |
| Mathematics Pangarau                             | Numeracy skills                          |
| Science Putaiao                                  | Information skills                       |
| Technology Hangarau                              | Problem-solving skills                   |
| Social Sciences Tikanga-a-iwi                    | Self-management and competitive skill    |
| The Arts Nga Toi                                 | Social and co-operative skills           |
| Health and Physical Wellbeing<br>Hauora          | Physical skills<br>Work and study skills |

Table 1 Essential learning Areas and essential skills of the New Zealand Curriculum Framework, adapted from the Ministry of Education (1993) *The New Zealand Curriculum Framework* p 5..

*The New Zealand Curriculum Framework* (Ministry of Education 1993a) recognizes that all students should have the opportunity to undertake study in the essential areas of learning and to develop essential skills. Science is one of the Essential Areas of learning that helps to develop the essential skills. The skills are to be developed in scientific contexts, which reflect the 'everyday world' of the students so that science can be seen by the students as relevant, meaningful and useful to them.

*Science in the New Zealand Curriculum* (Ministry of Education 1993b) describes science as a process of inquiry and a body of knowledge with all the strands interwoven and linked by the achievement objectives and the learning experiences. Teachers are expected to obtain specific learning outcomes from the achievement objectives and put them into contexts that are appropriate for their students' needs. There is a range of learning contexts suggested for each of the eight levels in the Science Curriculum document and suggestions for the assessment of students' work. This means the only requirements all schools have in common are the prescriptive objectives and the obligation to monitor every student's learning.

## Appendix 2

A comparison between the characteristics of conventional schooling and distance education.

| Face-to-face Education   | Distance Education  |
|--|---|
| Immediate, personal contact between teacher and learner  | Contact through communications media  |
| Teacher can readily adapt to learner's immediate behaviour                                     | Adaptation is delayed   |
| Learner's environment is primarily designed to support learning activities                     | Learner's environment is designed to serve other purposes (distracters)             |
| Metacommunication between teacher and learner is possible                                      | Metacommunications is difficult   |
| Personal relationships can moderate learning   | Personal relationships are of little importance                                     |
| Direct control of learner by teacher is possible   | Teacher's influence is indirect   |
| Learning materials can be of low didactic standard   | Learning materials must be of high didactic standard (well organized, clear etc)    |
| Learners experience limited degree of freedom  | Learners experience a high degree of freedom  |
| Wide opportunities exist for imitation and identification learning                             | Few opportunities for imitation/identification learning                             |
| Communication need not be planned to the last detail   | Communication is usually highly planned   |
| Information is provided by a mixture of cues (personal, content-related, organization-related) | Information is mainly provided by content and organization                          |
| A high degree of evaluation and feed-back from the teacher is possible                         | A comparatively low degree of evaluation and feed-back from the teacher is possible |
| Internal motivation, self-direction, self-evaluation, planning etc. can be low                 | Internal motivation, self-direction, self-evaluation, planning ability must be high |
| Willingness and ability of learner to work without direct supervision may be low               | Willingness and ability of learner to work without direct supervision must be high. |

Fig 2.11 From Cropley and Kahl (1983) cited in Keegan (1986).

## Appendix 3A

Table 3.1 Student group code numbers

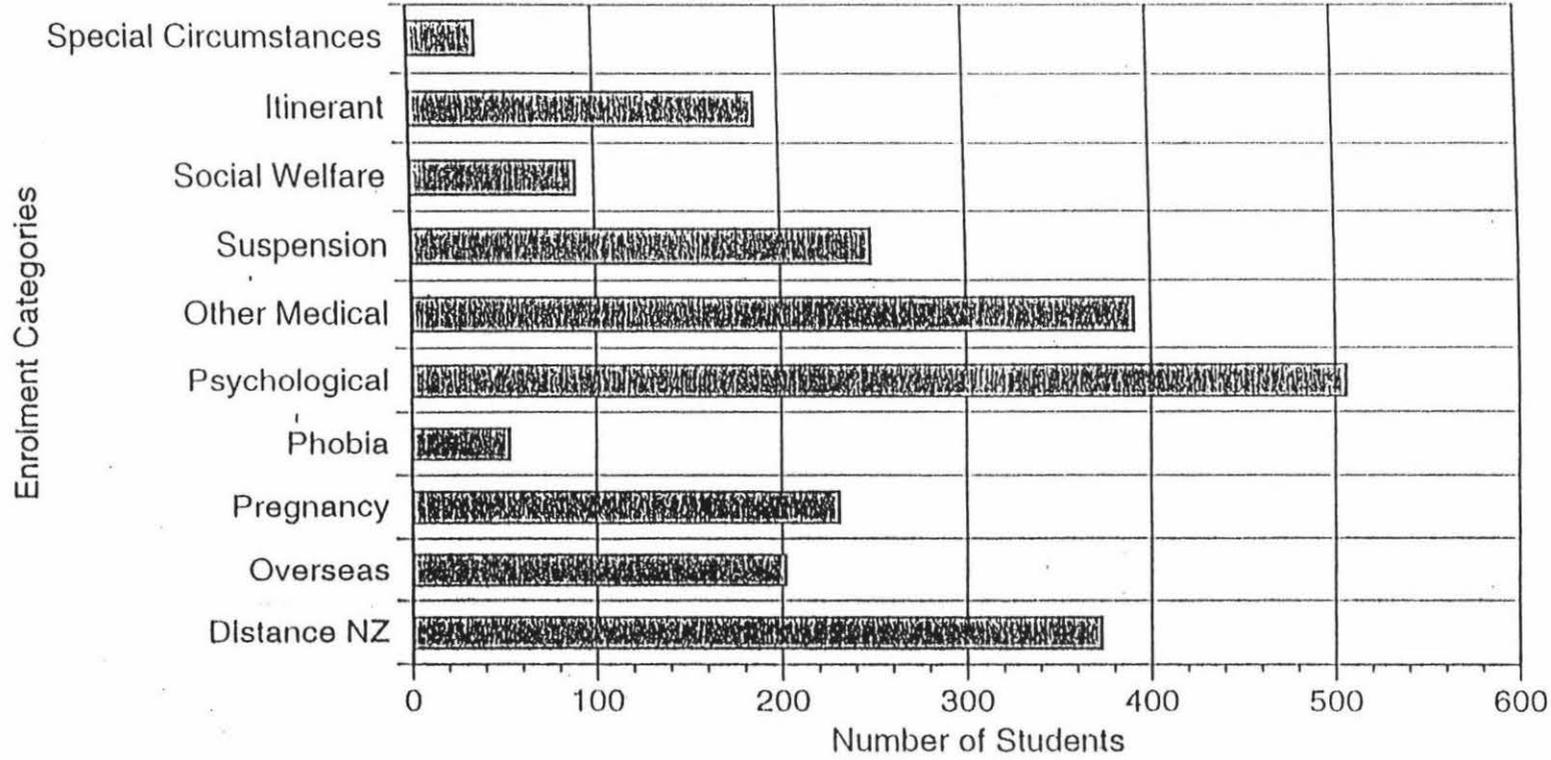
| <b>Student Groups</b>   | <b>Code number</b>    |
|-------------------------|-----------------------|
| Adults students         | 18                    |
| Home Schoolers          | 28                    |
| Secondary schools group | 38                    |
| Fulltime students       | 48 (general grouping) |
| •distance               | 41                    |
| •medical                | 42                    |
| •psychological          | 43                    |
| •suspension             | 44                    |
| •itinerant              | 45                    |
| •pregnant school        | 46                    |
| girls                   |                       |
| •overseas               | 47                    |

Table 3.2 Variables, value labels and code numbers.

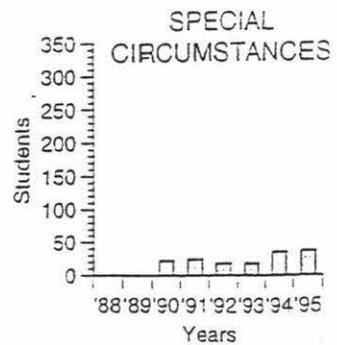
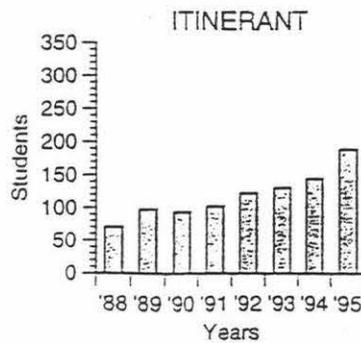
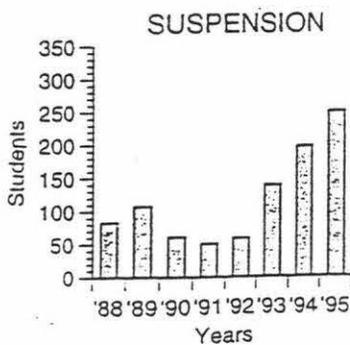
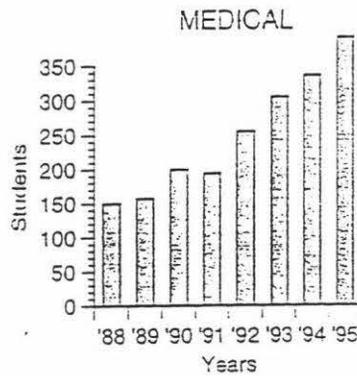
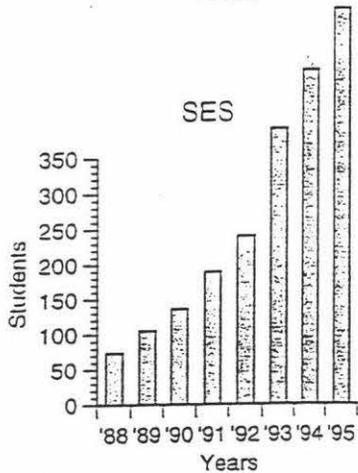
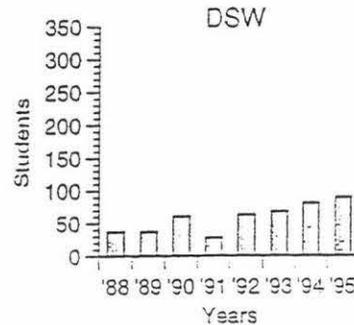
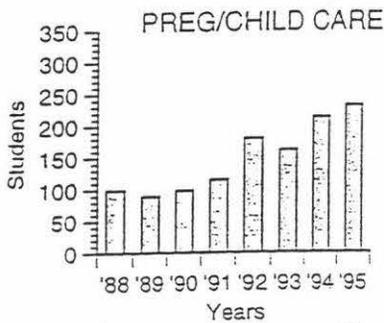
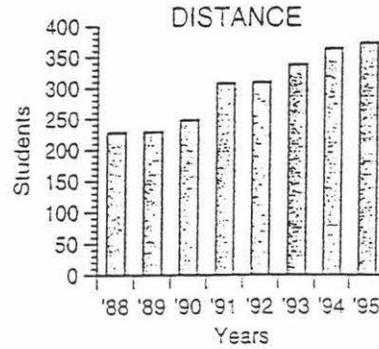
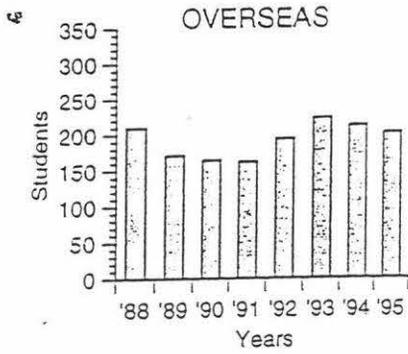
| <b>Variable</b> | <b>Value label</b> | <b>Code numbers</b> |
|-----------------|--------------------|---------------------|
| Gender          | female             | 1                   |
|                 | male               | 2                   |
| Ethnic groups   | Non Maori          | 1                   |
|                 | Maori              | 2                   |
|                 | Others             | 3                   |

Fig 3.1 Example of teacher records from student log sheets.

# FULL TIME SECONDARY STUDENTS BY CATEGORY - 1995



## Policy Entitled Students by Enrolment Category Secondary Fulltime 1988 to 1995 (mid October)





## Student Questionnaire

# SC500

The following questions seek your responses to the various methods of teaching used in the course named above. You are asked to give your responses on a rating of 1 to 5.

- if you strongly disagree about what is being asked, circle '1'
- if you strongly agree circle '5'
- if you feel less strong either way, circle one of the numbers in between.

### THE LEARNING IN LESSONS

Each lesson contains

- Learning content: where the knowledge and skills you need to learn is set out and explained;
- Practice (self marked) activities: to practise your understanding of the work in the lesson and where you learn further from the self-marking.

| Show the extent to which you agree or disagree with each of the following statements. |  | Strongly Disagree |   |   |   |   | Strongly Agree |  |  |  |  |
|---|--|-------------------|---|---|---|---|----------------|--|--|--|--|
| 1   | The words used to explain what you have to learn are clear and easy to understand. | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |
| 2   | Explanations of what you have to learn are easy to follow.                         | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |
| 3   | The amount of learning in each lesson is right.                                    | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |
| <b>Practice (Self-marked) Activities</b>  |  |                   |   |   |   |   |                |  |  |  |  |
| 4   | I can do the practice exercises  | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |
| 5   | I do not take a lot of time to answer the practice activities.                     | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |
| 6   | The practice activities are easy to mark.  | 1                 | 2 | 3 | 4 | 5 |                |  |  |  |  |

| Indicate how helpful each of the following have been in your learning of the work in your course. |   | Not very helpful to learning |   |   |   |   | Very helpful to learning |  |  |  |  |
|---|---|------------------------------|---|---|---|---|--------------------------|--|--|--|--|
| 7   | Working through the explanations in the lessons.          | 1                            | 2 | 3 | 4 | 5 |                          |  |  |  |  |
| 8   | Completing practice activities and marking them yourself. | 1                            | 2 | 3 | 4 | 5 |                          |  |  |  |  |

Please turn over

## TEACHER MARKED WORK

When your marked work from each set is returned you would receive:

- your marked work;
- Teaching notes, which set out and explain the correct answers;
- A letter or general comments on your progress from your teacher.

| Indicate how thoroughly you would normally read through each of them. | Don't read much |   |   | Always read thoroughly |   |
|---|-----------------|---|---|------------------------|---|
| 9 Your marked work.   | 1               | 2 | 3 | 4                      | 5 |
| 10 The teaching notes.  | 1               | 2 | 3 | 4                      | 5 |
| 11 Letters and general comments from your teacher.                    | 1               | 2 | 3 | 4                      | 5 |

| Indicate the extent to which you agree or disagree with each of the following.  | Strongly disagree |   |   | Strongly agree |   |
|---|-------------------|---|---|----------------|---|
| 12 The teaching notes are understandable and instructive.   | 1                 | 2 | 3 | 4              | 5 |
| 13 Letters from my teacher are understandable and helpful.  | 1                 | 2 | 3 | 4              | 5 |
| 14 Being in contact with my teacher as I am first learning the work would be more helpful than the letters and comments with my completed work. | 1                 | 2 | 3 | 4              | 5 |

## GENERAL COMMENTS ON THE COURSE

The following asks about your progress and how you would rate different aspects of the course as a whole to date.

| Indicate the extent to which you agree or disagree with each of the following.  | Strongly disagree |   |   | Strongly agree |   |
|---|-------------------|---|---|----------------|---|
| 15 I am satisfied with my progress to date in terms of the number of sets I have completed and the results I have gained. | 1                 | 2 | 3 | 4              | 5 |
| 16 I am satisfied with the results I have gained  | 1                 | 2 | 3 | 4              | 5 |
| 17 The amount of reading and work I am expected to cover in the course is about right.                                    | 1                 | 2 | 3 | 4              | 5 |
| 18 The amount of time I need to spend working on the course is about right.   | 1                 | 2 | 3 | 4              | 5 |
| 19 The difficulty level of what I am learning is too difficult?   | 1                 | 2 | 3 | 4              | 5 |

| Indicate the extent to which you agree or disagree with each of the following. | Strongly disagree |   |   | Strongly agree |   |
|--|-------------------|---|---|----------------|---|
| 20 The layout, presentation and look of the sets is clear and attractive.      | 1                 | 2 | 3 | 4              | 5 |
| 21 The writing style used in the sets is clear and understandable.             | 1                 | 2 | 3 | 4              | 5 |

| Processing and interpreting information, planning an investigation, carrying out an investigation and communicating information are important skills in SC500. Indicate the extent to which you agree or disagree with the following | Strongly disagree |   |   |   | Strongly agree |
|--|-------------------|---|---|---|----------------|
| 22 The topics chosen to explain the skills were easy to follow.  | 1                 | 2 | 3 | 4 | 5              |
| 23 The examples of the skills were easy to follow  | 1                 | 2 | 3 | 4 | 5              |
| 24 I believe these skills will be of use to me in the future   | 1                 | 2 | 3 | 4 | 5              |
| 25 I find I can use these skills in other science exercises  | 1                 | 2 | 3 | 4 | 5              |
| 26 I find I can use these skills in other subjects eg maths, economics or geography  | 1                 | 2 | 3 | 4 | 5              |
| 27 I find I can use these skills in everyday life  | 1                 | 2 | 3 | 4 | 5              |
| 28 It is easy to learn these skills by correspondence  | 1                 | 2 | 3 | 4 | 5              |
| 29 There were enough practice opportunities to develop these skills  | 1                 | 2 | 3 | 4 | 5              |
| 30 I think this course will prepare me for next year's science course such as biology, chemistry or physics.   | 1                 | 2 | 3 | 4 | 5              |

31 Name any specific skill you have a problem learning in this course

---



---

32 Name any specific skills have you found difficult to use

---



---

33 I spend about ..... hours working through each set.

Please use this space for any other comments you would like to make.

Please post this immediately.

Thank you for your co-operation.



## Teacher Survey

### Form 5 - level 6 Science Course

Please comment on the following aspects of the SC500 course. (If your comments fill the space provided please continue on the other side of this sheet).

1 Teaching approach

2 Learning styles

3 Choice of learning contexts used

4 Course contents. Please consider the following points in your comments and give explanations of your views where appropriate.

In your opinion was the SC500 course

- to the expected fifth form level *eq School Certificate*.
- to a level suitable for the majority of the students taking the subject

- using scientific language and technical terms  
at the level fifth formers in New Zealand are generally expected to understand and use

appropriately

consistently

5 How do you view the teaching of skills in this course?

Do you think it was successful in that

skills could be taught within the content of the course

students could use the skills in other situations than the one they were instructed in

skills can be transferred across the science strands with ease

skills were assessed separately?

6 Do you think this course fulfilled the curriculum expectations that students would be prepared for

further science education in levels 7 and 8

the skilled workforce New Zealand needs in the future

Thank you for your help and the time you spent replying.

## Appendix 4A

### *The principles of learning*

#### The New Zealand Curriculum

1. establishes direction for learning and assessment in New Zealand schools
  2. fosters achievement and success for all students. At each level, it clearly defines the achievement objectives against which students' progress can be measured.
  3. Provides for flexibility, enabling schools and teachers to design programmes which are appropriate to the learning needs of their students.
  4. Ensures that learning progresses coherently throughout schooling.
  5. Encourages students to become independent and life-long learners.
  6. Provides all students with equal educational opportunities.
  7. Recognises the significance of the Treaty of Waitangi
  8. Reflects the multicultural nature of New Zealand society.
- Relates learning to the wider world.

#### **The seven essential learning areas**

1. Language and languages
2. Mathematics
3. Science
4. Technology
5. Social Sciences
6. The Arts
7. Health and Physical Well-being

#### **The eight essential skills**

1. Communication skills
2. Numeracy skills
3. Information skills
4. Problem-solving skills
5. Self-management and Competitive skills
6. Social and Co-operative skills
7. Physical skills
8. Work and Study skills



## Appendix 4B

Achievement Objectives level 5 - 6. Developing skills and attitudes.

| Achievement Objectives                  | Students will be achieving at curriculum Level 5 and 6 when they can;   |
|---|---|
| Focussing and planning                  | <ul style="list-style-type: none"> <li>• ask a series of questions of themselves, their group, and resource people and refine questions to make them suitable for scientific investigation</li> <li>• integrate their scientific ideas and personal observations with scientific ideas of others to make testable predictions or to identify possible solutions for trailing</li> <li>• design 'fair test', simple experiments, trials, and surveys, with clear specification and control of likely variables.</li> </ul> |
| Information gathering                   | <ul style="list-style-type: none"> <li>• select and use measuring instruments to make qualitative and quantitative observations and standard measurements with appropriate precision</li> <li>• systematically record observations and measurements</li> <li>• locate information through catalogues, indexes and computers</li> <li>• use information- processing techniques to process information related to the purpose</li> </ul>  |
| Processing and interpreting information | <ul style="list-style-type: none"> <li>• identify trends, relationships and patterns, in recorded data using statistical and graphing procedures as appropriate</li> <li>• set their findings or possible solutions against established scientific theory to draw and justify conclusions</li> </ul>  |
| Reporting                               | <ul style="list-style-type: none"> <li>• present well reasoned, complete reports supported by relevant data in ways and forms appropriate to nominated audiences.</li> </ul>  |

(Ministry of Education, 1993, p44-47).



