Thinking and learning in junior high school: an evaluation of some enhancement strategies

Grahame William Wagener
University of Wollongong
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THINKING AND LEARNING IN JUNIOR HIGH SCHOOL:
AN EVALUATION OF SOME ENHANCEMENT STRATEGIES.

A Thesis submitted in partial fulfilment of the requirements for the
award of the degree

DOCTOR OF EDUCATION

from

UNIVERSITY OF WOLLONGONG

by

Grahame William Wagener
B.A., M.A., M.Ed. Admin.,

School of Education

January

1997.

Volume 1
DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

G.W. Wagener

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have been many ‘lost’ weekends and, on occasion, strong words spoken regarding peace and quiet. Now that the study is completed we can all say that we managed to ‘survive’ and can now look forward to catching up on some of the things we missed out on along the way.
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Through an understanding of learning and thinking strategies an attempt is made to examine whether certain cognitive and metacognitive strategies can enhance student learning and thinking skills. The debate referred to is between the advocates of domain-specific techniques and the advocates of domain-independent, generalisable thinking skills, to consider whether one technique is more effective in enhancing students' thinking skills and learning. Indications are identified in the cognitive and metacognitive literature that some students' thinking and learning might be enhanced by the adoption of certain strategies, and that these strategies might lead to successful outcomes in other learning activities. This study evaluates the effects of general cognitive and metacognitive programs which are reported to enhance student thinking and learning.

An examination is made of de Bono's ten-lesson CoRT -1 Thinking Skills Program, which has been reported to have successfully enhanced student thinking across a range of aptitudes. Case studies and research reports are analysed and the use of thinking skills to enhance learning is placed in an historical and contemporary context. The effect on student thinking and learning through developing an understanding of how students' think, learn, and how the brain functions, is also investigated.

Based on the foregoing, the problem investigated here is: Whether the teaching of general cognitive and metacognitive thinking skills strategies enhances year-seven students' thinking and learning.

A sample of 184 year seven students from a South Coast Comprehensive High school was studied in a program conducted over a total
of 30 weeks. The data from two instruments were analysed using independent $t$ tests, paired-sample $t$ tests, and analysis-of-variance procedures. Additionally, an analysis of questionnaire and interview data was conducted.

The analyses of the quantitative measures did not reveal a significant improvement in the constructs of the Otis-Lennon School Ability Test or the Learning Process Questionnaire. While there was statistical significance, it is argued that there might have been a trend favouring the treatment group. Interview and questionnaire data analyses revealed a positive belief, generally held by the students, that CoRT-1 strategies and metacognitive strategies assisted them with their in-class thinking and learning. There was not strong evidence that the students' transferred the strategies to out-of-class thinking and learning situations.

The study has led to certain recommendations regarding cognitive and metacognitive intervention strategies: that provision should be made for students' to practice thinking skills across the curriculum; that students' should be given every opportunity to explore their own thinking and learning processes; that more opportunities should be made available for teacher development in current cognitive and metacognitive strategies; that schools should encourage open discussion, throughout the entire school community, on thinking and learning skills and strategies; and that educators should be given every opportunity to explore cognitive and metacognitive strategies and be encouraged to use as full a range as possible in order to meet the individual needs of all students.
INTRODUCTION.

There is no doubt that the teaching of thinking, an understanding of learning processes and the ability to solve problems are high on the national educational agenda. In 1993, 1994 and 1995 several national and international conferences were held in Canberra, Townsville, Sydney, Brisbane and Newcastle as well as many other locations in Australia. The one key theme for the conferences was Learning: 'Learning about Learning', 'Leading the Learning Community', and 'Leadership for Learning'. The conferences were organised by professional associations, such as the New South Wales Secondary Principals' Council, the New South Wales Deputy Principals' and Leading Teachers' Association, the National Board of Employment, Education and Training, and the Australian Curriculum Studies Association. In 1993 the Incorporated Association of Registered Teachers of Victoria published a Seminar Series entitled 'Learning How to Learn' (Munro, 1993); in 1994 the Australian Council for Educational Research published four research articles on thinking and learning (Perry, 1994; Nuthall & Alton-Lee, 1994; Archer, 1994; Rowe, 1994). Also in 1994 the National Board of Employment, Education and Training published Commissioned Report No.28, 'Developing Lifelong Learners through Undergraduate Education' (Candy, Crebert & O'Leary, 1994) which was followed by a publication of conference papers in 1995 (Candy, 1995), which discussed amongst other things, the economics of learning, and emphasised schools were not alone in the teaching of learning, thinking and problem solving.

The New South Wales Department of School Education published a support document in 1994, entitled 'Quality teaching-Quality learning'. This
document lists the characteristics for teachers of quality teaching and outlines when quality learning is most likely to occur for students. Under Quality Learning, Point 4 states that quality learning is most likely to occur when students "believe in their own ability to learn and are able to reflect on their own learning" (p. 15). The document goes on to give examples of how quality teachers are able to facilitate this aspect of quality learning. For example, the document states that this aspect of quality learning can take place when teachers "help students to know how they learn best" and give opportunities for learners to "discuss and reflect on their learning" (p. 19). The document also states that another aspect of quality learning is facilitated when the processes of problem solving are taught (p. 17). This document was followed by a discussion paper, issued to schools in March 1995, called 'Schools as Learning Communities'. The two documents 'Schools as Learning Communities' and 'Quality teaching-Quality learning' are seen as being complementary. In 'Schools as Learning Communities' (1995a) it is stated that "in a knowledgeable society people need to learn how to learn" (p. 4). The paper goes on to comment that schools need to reconsider "current understandings of learning, the learning process and learner,..." (p. 5).

Further, Unicorn, the journal of the Australian College of Education, devoted an issue (1995) to Teaching Thinking; Time magazine had a lead article entitled 'Glimpses of the Mind' (Lemonick, 1995) and International Directions in Education (1995), a publication of the Commonwealth Council for Educational Administration, reflected on 'Restructuring Schools for Learning' in many countries around the world, not least in Singapore, where investigations are currently under way to "incorporate core thinking skills into the learning of subjects" (1995, p. 3).
In 1995/1996 the New South Wales Department of School Education Training and Development Directorate has been developing an inservice training module called 'Leading the Learning Community' (1995b). This module is being developed and trialed by a small group primary and secondary principals’ and is intended to be used as a training module across the State. Within the module there are units on learning, thinking, learning organisations, and metacognition. In addition, the Department’s School and Leadership Development Division has produced a teaching and resource module for the Certificate of Teaching and Learning entitled ‘The Learning Continuum’ (Hill, Mc Allister & Pettit, 1995). Within the module there are units on: 'Me as Learner'; 'School of Thought'; 'Learning Models'; 'Tools to Enhance Learning'; and 'Learning Organisations'.


A view of persons as active constructors of meaning gives a good basis for seeing learners as managing much of their own learning.

There is much talk of lifelong learning and of schools needing to ensure that their students ‘learn how to learn’. (p. 56)

The report suggests that a new pattern of classroom practice is needed along the lines of the pattern suggested by Middleton (1993), and Norman (1994), who remarked that
students are encouraged to understand their own learning; students are given enough time to achieve the intended learning outcomes; and processes are designed to facilitate success for all students and a growth towards autonomous responsibility. (p. 56)

In September, 1996 the Australian College of Education and the Australian Council for Educational Administration jointly held a conference of international significance in Perth. The conference theme is 'Leading the Learning Community' and topics explored include: School as a Community of Learners; Teachers as Learners; Administrators as Learners; Best Classroom Practice reflecting Advances in Curriculum, Teaching and Learning and Connecting the Home and the School.

Also in 1996, the New South Wales Secondary Principals' Council (1996) is holding its Annual Conference on the theme of “Schools As World Class Learning Organisations”. At the Annual Conference keynote speakers and workshops will be presented on: Learning Communities; Schools as Learning Communities; and Leadership of Learning Organisations.

Schools are being asked to accommodate the notions of 'multiple ways of knowing', 'metacognition', 'critical thinking', 'creative thinking', 'reflective learning', 'thinking skills' and to be places for 'learning how to learn', 'lifelong learning' and 'self-directed learning'. The process of accountability asks schools to ensure that student learning and thinking is effective, and to measure the 'success' of the teaching, and the improvement over time, through analysis of basic skills tests, School Certificate grades and Higher School Certificate outcomes. While trends in education point towards greater teacher accountability, so too are there changes indicated for
students. Students are increasingly being asked to understand their learning, to challenge their thinking and to be more critical and creative.

There is little doubt that, in the past, educators have been concerned about the quality of student thinking and have worked hard to improve it. Some such attempts, however, have been unsuccessful because of the pressure of syllabus coverage and the increasing accountability required to show quality teaching and learning through high standardised achievement scores. This dual problem has recently been noticed in New South Wales with some schools coming under public scrutiny for not teaching directly to the prescribed syllabus, and with the publication of students' and schools' Higher School Certificate results in rank order. The heavy emphasis on ranking schools and students according to supposed future tertiary ability is increasingly coming under question. What is quietly being asked is how well students are able to think, to learn, to understand, and to be good creative and critical thinkers. Sergiovanni (1996) commented that:

there is a growing acceptance of the idea that general improvements in student academic performance and social and moral development will occur only when classrooms become learning communities and teaching becomes more learner centred (p. 42).

If recent conference and publication events are a reliable gauge of educational trends, then this quiet discussion is likely to erupt into a noisy debate.

One of the most important aspects of a teacher's work is to provide an environment in which students can think and learn. For a teacher to be effective in carrying out this challenge there is an expectation that the
teacher would have a practical knowledge of thinking and learning processes. A teacher's knowledge about learning can be developed in a variety of ways, but there is little doubt that experience plays an important role. The decisions taken with regard to the classroom environment are often based on what seems to have worked in the past rather than on what may be supported by specific thinking and learning investigations. For the implementation of effective teaching, learning and thinking, it is necessary to mould together personal experience, a teachers' personal educational philosophy and current theories of thinking and learning, that can be investigated in practice.

Certain studies (Edwards & Marland, 1982, 1984a, 1984b) have shown that student in-class thinking was quite different from the expectations of the teachers. Other studies (Gunstone & White, 1980; Brumby, 1982) have shown that there was a dearth of quality thinking happening in schools. The 1980s research combined with the 1990s concern for, and drive towards, quality thinking and learning in schools, has awoken an interest in theories and programs that claim to enhance student thinking and learning. However, many of these theories and emergent programs have not been adequately researched in the practical setting. The researcher or teacher wishing to examine and apply these theories or programs is left with the difficult task of deciding which to choose.

Consequent on the foregoing, this study proposes to investigate the major theoretical proposition regarding whether general thinking skills can be taught directly to students and to what extent the teaching of these general skills enhances student thinking and learning. It is proposed to enquire, through the implementation and evaluation of general thinking and learning skills, whether student thinking and learning can be enhanced.
A program to enhance general thinking and learning skills in the present study comprise a combination of CoRT-1 (Cognitive Research Trust) Thinking Skills Program (de Bono, 1973), learning strategies and metacognition. Each will be evaluated separately; some will be evaluated through the use of quantitative procedures, and some will be evaluated through the use of qualitative procedures.

This present study also examines some theories of thinking, learning and metacognition in response to the issues that appear to be growing in the National education agenda, and, more importantly, to add to the store of knowledge that teachers can use to enhance student thinking and learning. This challenge will be met in this study through the investigation of certain research questions and hypotheses that relate to whether certain cognitive and metacognitive intervention strategies are likely to enhance student thinking and learning.

Chapter Two will investigate cognitive theorists whose work relates to this study and will consider the relevance of their theoretical propositions to the present enquiry.
CHAPTER TWO

THEORETICAL BACKGROUND.

A theoretical basis for the enquiry is to be found in the work of several theorists. These include, first, theorists of the behavioural school, and then cognitive theorists such as Ausubel and Bruner, followed by some contemporary theorists, such as Sweller, Edelman, and de Bono. A further exploration of the work of some of these theorists is conducted in Chapters 3 and 4.

2.0 Behavioural Theories.

a) Thorndike.

The study of learning is a relatively new phenomenon. In a scientific way, the study of learning did not really commence till the late nineteenth century. Researchers began using techniques borrowed from the physical sciences to gain an understanding of how humans learned. Amongst the early researchers were Pavlov, Thorndike and Skinner. These researchers are regarded as belonging to the behavioural school of learning. One of the most important, and obvious, principles of the behavioural learning theories is that behaviour changes according to the immediate consequences. According to Thorndike (1922), pleasurable consequences strengthen elements of behaviour (the Law of Effect), while unpleasant consequences weaken them.

Pleasurable consequences are referred to as reinforcers, and positive reinforcers are those activities used by teachers to encourage certain actions. Often, positive reinforcers are combined with Premack's principle
Premack’s principle applies when activities favoured by the subject, identified on the basis of the frequency of their occurrence, are used to reinforce participation in less favourable activities. For educators, the most useful, and simple, principle of behavioural learning is to reinforce those behaviours that the class teacher most wishes to see repeated.

From his observations Thorndike developed a theory of thinking which became the basis of what is now referred to as the associationist theories of thinking (Mayer, 1991, p. 20). The associationist view holds that “thinking is the trial-and-error application of pre-existing response tendencies called ‘habits’” (Mayer, 1991, p.22). This learning theory has become known as associationist. In any given situation there is a number of possible responses. The associationist theory of thinking has three elements: the stimulus, the response and the association between a particular stimulus and a particular response. The responses can vary in strength and can be placed in a hierarchical order. This phenomenon has been termed by Thorndike (1922) the law of exercise. The law of exercise states that responses which are more frequently used within a given situation are more likely to be continued to be used when that situation next arises, or that practice increases the specific stimulus-response link.

b) Skinner.

Skinner (1953) argued that behaviour is to be accounted for in terms of the present stimulus and the past history influencing the particular situation and the reaction to it. The past history provides the individual with a large amount of information, skills, and values which are learnt and influence present reaction. For Skinner, a neurotic person’s behaviour is learnt and can be ‘unlearned’ or, more precisely, replaced. The way to do this is to
ensure that undesirable behaviours cease receiving rewards and desirable behaviours begin receiving rewards. The undesirable behaviours tend to disappear by 'extinction'.

Skinner (1953) believed that intelligence tests might be useful for educational decisions, since they sample the problem-solving skills they purport to measure. Skinner (1953) argued that problem-solving typically involves labelling the problem situation properly, then activating an appropriate rule or response sequence leading to problem solution. Solution to the problem is to be explained on the basis of similarity of the present problem to one solved earlier, or to the simplicity of the problem. The technique of problem-solving is essentially one of manipulating variables which leads to a response. Skinner (1953, pp. 252-56) believed that it is possible to teach people to “think” or “be creative” by these methods.

c) Bandura.

Bandura (1969) developed social-learning theory, which is a development of the behavioural learning theories. Social-learning theory accepts most of the ideas of the behaviourists, but tends towards a much greater emphasis on modelling. Modelling is the process of learning from observing others and, in Bandura's theory, there are four phases to the process. The initial phase is the attention-getting phase and this is followed by the retention phase. After gaining the class's attention the teacher then models the behaviour the teacher wants from the students. The third, reproduction phase is when the students attempt to match their behaviour to that wanted by the teacher. The final phase is the motivational phase, where students model the behaviour because they now accept it as what they want. This theory has also been referred to as learning by observing.
d) Green.

Green (1995) argues that experiments using animals, in animal learning laboratories (i.e. maze learning), to describe "completely, precisely and unambiguously" (p. 119) what the animal has learned at any given time, are based on the assumption that the 'habit' learned constitutes the animal's intelligence. The animal's behaviour, as shown by the learning curve data, is only a "rough indication of what the animal has learned" (p. 119). Green (1995) states:

To say that learning tends to generalise to all stimuli sufficiently similar to the stimulus situation involved in the original learning may be true, but the problem of describing completely, precisely and unambiguously just what 'sufficiently similar' amounts to remains untouched. (p. 121)

Commenting on the theories of conditioning, Green (1995) points out that the conditioned response is occasionally not the same as the unconditioned response. If the experimental conditions allow it, the conditioned response is often made in anticipation of the unconditioned stimulus, which has then become a new feature of the unconditioned response, "something that theorists of classical conditioning have had little to say about" (p. 129).

Chapter 4 further explores the relationship between aspects of this cognitive theory and the present study.
2.1 Ausubel's Cognitive Theory.

One theory on the nature of learning is the work of Ausubel (1967, 1968; Ausubel & Robinson, 1969). Ausubel (1967) describes meaning as a conscious experience, "clearly articulated and precisely differentiated" (p. 10) where certain potentially meaningful pieces of information are incorporated into an individual's cognitive structure in a nonarbitrary way. This nonarbitrary connection to existing knowledge in cognitive structure is what differentiates meaningful learning from rote learning.

This theory also distinguishes between receptive and discovery learning. Receptive learning is relatively passive (by which it is meant that the new learning is incorporated into the structure at the appropriate place and level of generality, as compared to rote learning, which is not), while discovery learning is active and largely self initiated and is thought to be by nature meaningful. Rote learning can take place when the learner arbitrarily internalises the information, when the learner does not act on the information to make it potentially meaningful; thus receptive and discovery learning "can each be rote or meaningful depending on the conditions under which learning occurs" (1967, p. 17). Meaningful learning presupposes that there occurs within the learner a disposition to relate a new learning task to information which is already known, making the new learning task potentially meaningful. Regardless of how much potential meaning there may be in a new learning task, the learning process and outcome will be meaningless or rote if the new learning task is accepted by the learner in a non-substantive or arbitrary way, and not subsumed within the cognitive structure. Meaningful learning can take place in the classroom when expository teaching is conducted. Ausubel (1967) contends that "good expository teaching can lead to meaningful receptive learning" (p. 18). It is thought that much of the learning that takes
place in schools is of a receptive nature, whereas a good deal of the learning which takes place outside of school is discovery (Ausubel, 1967, 1968).

Ausubel (1967) noted that it is important to be aware of the difference between rote learning and meaningful learning, as there frequently appeared to be confusion over the two concepts (1968, p. 24). Rote learning occurs if the task involves associations only, or if the learner is interested only in internalizing in an imitative way. Meaningful learning occurs if the task is related to what the learner already knows in a substantive way. Ausubel considers that learning must be an active process in order to be meaningful, and that this can lead to more discovery learning experiences in schools. Ausubel states that most meaningful learning involves the assimilation of new information with pre-existing knowledge. This process is what Ausubel and Robinson (1969) have termed 'assimilation theory' (1969, p. 115). In assimilation theory progressive differentiation occurs when new information is linked to existing cognitive structures and both are modified to meet the new state. The modification means that the new information will take on a new meaning. This process has been termed integrative reconciliation (1969, p. 169). Integrative reconciliation "refers to the explicit attempt to point out significant similarities and differences . . . between successive ideas presented in a sequential arrangement" (p. 169). When integrative reconciliation does not take place excessive cognitive strain is involved in the attempt to search for an explanation. Also common features can be ignored, previously learned information is not adequately recalled and significant differences between related concepts are not utilised thus giving the perception that they are identical. The active nature of meaningful learning means that students will have a greater awareness of their abilities.
Greater awareness of learning ability, or metacognition, is arrived at through an understanding of where existing ideas are situated in relation to the individual's knowledge structure, through the reconciliation of existing with new ideas, through the reformulation of new ideas so they adapt to an existing structure, through the revision of existing knowledge and through the search for further knowledge. Metacognition results in the move from declarative knowledge to procedural knowledge, that is, the move from knowing about an activity to being able to carry out the activity. These processes are regarded as higher-order procedures and when undertaken allow the individual to gain a greater awareness of learning. These higher-order procedures "appear to be implicit, automatic and unconscious" (Evans, 1991, p. 59-60). Some of the issues raised here are further explored in Chapters 3 and 4 with the work of Marton and Saljo (1976a, 1976b); Ramsden (1979, 1985), and Biggs (1988a, 1988b).

2.2 Bruner's Cognitive Theory.

As further background to the development of contemporary cognitive theories explored later in the study, the theories of Jerome Bruner will be investigated.

In 1960, Bruner made a major contribution to the American education system through the publication of *The Process of Education* (1960). This publication is now (Hotchkis, 1996) seen as an attempt to improve the American education system as a consequence of the Soviet success in launching Sputnik. In 1971 Bruner published a document outlining the reasons why this initial venture failed. Bruner (1971) stated
... there was also a great emphasis on active learning, poking into things yourself, an emphasis on active discovery rather than upon the passive consumption of knowledge. . . . Some enthusiasts ran away with the idea of the 'discovery method' . . . (p. 22).

Bruner (1966a, 1966b, 1968, 1973) developed an alternative theory to that of Ausubel. Bruner (1966a, 1966b, 1973) conceives of efficient learning as a matter of acquiring general coding systems within which new information is categorised. Once the general code has been retained the specifics can be forgotten since they can be reconstructed from the general code. Ausubel (1967) would agree with Bruner, in that Ausubel classifies this as derivative learning where one general principle encompasses all the necessary details. Ausubel contends that most school learning is not of this sort but, rather, the more common type of reception learning in the classroom is correlative learning. Correlative learning is an elaboration of previous knowledge. It may be related to other learning, but the meaning is not implicit. If most learning is correlative rather than derivative, then the main reason for learning generic concepts is not so much to reconstruct, as it is to provide an anchorage for, new material. Bruner (1966a, 1966b) and Ausubel (1967) have a further point of disagreement in their attitude to discovery learning. Bruner praises discovery learning as the best learning method, while Ausubel believes that reception learning is more common and efficient (Ausubel, 1967, p. 11).

Bruner (1966a, 1966b) does not perceive there to be any distinction between perceptual and conceptual processes. Perceptual and conceptual processes result from the categorising of stimuli from the environment. Bruner notes that it is not possible for our mental processing to respond to every stimulus as if it were unique. There are determining factors which
assist in the narrowing down of our perceptions. One of the determining factors is our natural concentration towards those stimuli that are in accord with our present needs and interests.

A second determining factor is our natural tendency to ignore individual differences in stimuli. Bruner (1960) believes that all perception is generic, in that meaning is achieved from a class in which a stimulus has been placed. The process of categorisation is unconscious and can be capable of revision, or the categorisation can be accurate, or it can possibly be mistaken, depending on the cues that were available. It is through this process that we narrow down our perceptions to manageable proportions, and as part of the process, build up our perceptions of the world around us. The perceptual model of the world around us is a system of categories that have varying degrees of accessibility depending on need and interest. The advantages of the categorising process are considerable. These advantages relate to our ability to reduce the complexity of our environment, our ability to readily identify new objects and events, a reduction in our need for continual learning, our ability to respond appropriately to a wide range of stimuli, and our ability to make generalisations between categories.

Bruner sees two ways of explaining the categorising procedure. First, there is the learning of the defining properties of the class of objects that are functionally equivalent. Once an understanding has been made of the critical attributes of a stimulus, then given certain cues, the stimulus is immediately invested with meaning; Bruner (1966b) referred to this process as intension (p.154).

Secondly, according to our previous learning experience, we are able to make assumptions about what stimuli are grouped together. This process
of grouping stimuli is referred to by Bruner (1966b) as extension (p. 154) or as coding (p. 323). Coding includes both the single category and the network of categories by which we deal with information. The English language is a coding system which enables us to make sense of words and which enables us to make intelligent guesses at new words. A coding system enables us to make predictions about numbers in a series, about word meanings where there are gaps in the letter sequence, and to make assumptions about problem solution.

   Bruner (1966b) contends that transfer is maximised when students access the appropriate generic coding system (p. 323). The network of arithmetic relationships, the generic coding system of arithmetic, when induced, can assist beginning mathematics students to understand the work better. Bruner believes that there exists a comprehensive coding system within each subject. The learning that a student has acquired in a subject allows the student to relate further learning in a meaningful way. Transfer to out-of-school learning situations is made easier when the initial learning is related to a structured pattern. Bruner argues that learning is enhanced when students are given an understanding of the fundamental structure of the subject being taught (Ausubel's 'advance organisers', 1968, p. 149).

2.3 Information-Processing Model.

Over the last twenty years, one learning theory has become prominent (Hunt, 1962; Ausubel, 1967; Atkinson & Shiffrin, 1968; Edelman, 1989; Evans, 1991; Biggs & Moore, 1993). This theory is called the Information-Processing Model (I.P.M.). The I.P.M. is a cognitive learning theory that describes the processing, storage and retrieval of knowledge. The processing stage begins with the sensory register (Atkinson & Shiffrin, 1968).
The sensory register receives large amounts of information from all our senses and holds this information for a very short period of time. If nothing is to happen with this information then it is rapidly lost. Sperling (1960, 1963) has conducted several experiments on the effect of information on the sensory register.

The importance of the sensory register for educationalists is that people need to pay attention to information if they are to retain it and it takes time for all the information received to be consciously acted upon. Cognitive-load theory (Sweller, 1988) states that if people are exposed to too much information at any one time, without being informed which information they should pay attention to, then it is possible that very little, if any, learning will take place. Within the sensory register once the stimuli have been received, the mind begins to process them. Gestalt and related theorists (Ausubel, 1968; Mayer, 1991) suggest that we perceive whole units of stimuli, rather than many small elements. Closure is that part of the mental processing system that allows us to perceive things as simply and logically as possible. Thus, an important part of the gestalt theory is the process of making form out of what we perceive or, said another way, is the tendency to organise our perceptions so they are integrated and meaningful.

The second component of the memory system is short-term memory or working memory (Atkinson & Shiffrin, 1968; Case, 1985; Biggs & Moore, 1993). Short-term memory is an information storage system that can hold a limited amount of information for a short period of time. It is the place in the mind where information currently being processed is held. Once we stop thinking about the information in short-term memory, the information disappears. Information can enter short-term memory from two sources. One is the sensory register and the other is long-term memory. Most
frequently, both things happen at the same time. An object is registered in the sensory register and an individual will try to make sense of it as simply as possible, while long-term memory calls on all our past experience of the object to assist us in placing the object in its proper perspective.

Information can be retained in short-term memory through rehearsal; that is, by repeating the thought over and over in the mind. Rehearsal is important, because the longer an item remains in short-term memory then the more likely it is to be retained in long-term memory. Rehearsal is important in the teaching process. It gives students an opportunity to reflect on what they are being taught and to remember it.

Long-term memory is that part of the mind where information is kept for long periods of time (Atkinson & Shiffrin, 1968; Biggs & Moore, 1993). I.P.M. theorists suggest that long-term memory can be very large, and that, in fact, information is not forgotten but rather the ability to recall the information is lost. Some theorists suggest that long-term memory can be divided into three parts: episodic memory, semantic memory and procedural memory (Tulving, 1985). Episodic memory is our memory of personal experiences, semantic memory contains the 'facts' and general information that we know, and procedural memory is knowing how to carry out a procedure.

Episodic memory (Atkinson & Shiffrin, 1968; Biggs & Moore, 1993) contains the images of when and where a certain event happened. An individual's ability to call on the image of what that individual was doing when an especially significant event occurred, comes from episodic memory; but it can also be confused, so that not all memories remain clear. Episodic memory does tend to jumble up some of the more common happenings, thus making episodic memory harder to use.
Semantic memory (Mayer, 1991) is organised in schema or networks. These networks of concepts enable individuals to understand and incorporate new information. Schema theory states that individuals access information, held in the semantic long-term memory, by following pathways of connecting information. The more a pathway is used, then the easier the access. The significant point for educators is, the better developed the schema pathways, the easier new information can be retained.

Procedural memory (Mayer, 1991) is the ability to recall how to do something. Theorists suggest that this memory system works on a series of stimulus-response groupings. The individual responds to the stimulus in a natural way from accessing previous learned experience. Once the individual has learnt how to ride a bike, it takes little procedural memory to be able to do it again.

Chapters 3, 4 and 5 explore aspects of I.P.M and the relationship of this cognitive model with the present study.

2.4 Contemporary Theories.

a) Constructivist Theory.

A more recent theory of learning is the constructivist theory (Biggs & Moore, 1993; Hotchkis, 1996). The main platform of the constructivist approach is the concept that learners individually transform knowledge to make it their own. Constructivist theory believes that learners are always checking new information against old information and then making revisions. The constructivist view draws deeply from the Piagetian and Vygotsky theories. Both Piaget and Vygotsky believed that old knowledge went through a process of change in the light of new knowledge and both
emphasised the social nature of learning and the use of mixed ability groups to facilitate learning. The constructivist approach has students working on complex problems and then discovering the skills needed to solve the problems. The constructivist approach advocates the use of co-operative learning, because of the belief that students will more easily comprehend complex problem solution if they can talk to each other about the problems.

b) Bartlett's Cognitive Theory.

Bartlett (Norman, 1976, p. 137) suggests that learning takes place when new experiences are organised within the framework of past experiences. The organisation of stored material is referred to by Bartlett as a schema. Bartlett believes that various schemas are interconnected so that learning takes place when the relevant schemas are activated. New material is not learnt by itself, rather the schemata of past associations are activated relating the new material to something that is already known. Norman calls Bartlett's concept of schema a rule. Thus, Norman concludes, learning behaviour is governed by rules.

c) Sweller's Cognitive Theory.

Sweller points out (Sweller, 1991, p. 80-81) that rules could be automatically applied. If rules were applied automatically then problems could be solved more rapidly than if the rules required conscious consideration. According to the research conducted by Sweller the automatic application of rules can be facilitated through practice. Practice is most effective when using worked examples.
Ward and Sweller (1990) argue that learning can be facilitated by having students working through many completed examples of problems rather than solving problems by themselves. The findings of Ward and Sweller (1990) are supported by Sweller and Cooper (1985), Cooper and Sweller (1987) and Zhu and Simon (1987). Ward and Sweller (1990) believe that a schema is a cognitive construct that categorises problems according to known solutions. They state that when the correct schema is applied automatically, as it is in the case of experts, then more cognitive resources are able to be utilised in solving the problem. This automatic process, utilised particularly in the case of experts, is referred to as rule automation.

Sweller (1993) points out that schema acquisition is a fundamental learning mechanism and that the automation of intellectual processes occurs in skilled intellectual performance. When schemas are not available in problem solving, then a strategy called means-ends analysis is used. According to Ayres and Sweller (1990) means-ends analysis as a strategy is demanding on cognitive resources and can be detrimental to the learning process.


Edelman (1989) proposes that a general theory of learning across species, as shown on studies performed by Thorndike, Pavlov or Skinner, "is not tenable" (p. 293). A number of studies are cited (p. 293) which point towards 'special evolutionary' features as strongly influencing learning and that conditioned-stimulus studies do not make clear the process being observed and interpreted. It is not the impact of the stimulus which is the major issue in learning, it is the knowledge of a particular learning situation on the basis of what is expected.
Edelman (1989) holds the view that special evolutionary features influence the learning of individual species. An animal in a species acquires knowledge about a learning situation through the influence of past associations that are characteristic of that species. These past associations give a positive or negative outcome of events and so serve as signals for future reference. Edelman (1989) points out that learning is specific to a context (p. 295), which consists of the animal's brain state as it responds to certain objects and events. A stimulus is a specific event impacting upon the brain state making a change to both the response and the new state. This means there is a very strong connection between learning and memory and that 'true' learning occurs often when an element of surprise is present (p. 296). An animal recognises certain objects and events, and thus is able to behave accordingly, through perceptual categorisation (p. 26), a feature of the animal's neural state which existed epigenetically. Edelman proposes that "the ability to learn thus requires that the means for perceptual categorisation first be in place" (p. 296). Perceptual categorisation becomes adaptive to time, place, chance and cause through learning: it is learning which makes categorisation within the brain state adaptive. Perceptual categorisation, according to Edelman (1989), is "limited by evolutionary means into the structure of the brain and nervous system before the events of learning take place" (p. 297).

Staddon (1983), as presented in Edelman (1989), proposes that there are four repeating stages to learning: (1) novelty or surprise - (2) "inference" - (3) action - (4) new environmental situation - surprise (p. 299). This pattern is repeated until the response becomes "automatic" and is part of the animal's categorisation of places and events. It is in this way that species-specific learning takes place. Edelman (1989) expands the Staddon theory to present a developmental model for learning (p. 304) based on neuronal
groups classified within global maps. Fundamentally, this developmental theory investigates the evolutionary basis of species-specific learning and how the process of learning adapts evolutionary neural pathways and global maps. In its restricted form the theory does not allow for a "consideration of the basis in brain function of higher-level concepts, thinking, or other related cognitive matters" (p.328).

e) De Bono’s General Theory of Learning and Thinking.

De Bono (1990) has presented, in The mechanism of mind, the overall model of how he believes the brain operates. The fundamental construct of the model is based on the concept of 'triggering' (p. 111), or the need for the memory-surface to be given a 'clue' from the environment so that the established pattern in the brain can be activated upon (p. 152). The 'trigger' commences the process in which a message moves down a neural pathway which has been formed in the brain because of previous experience. The process is a 'biological' one, as opposed to a 'physical' one, and is made up of a combination of experience and emotion. It is a 'biological' process because the neural pathways, referred to by de Bono as 'd-lines' (p. 133), are established in the brain, and thinking is the flow across these pathways. Each pathway can be altered, and the CoRT thinking-skills program is de Bono's theory of how existing thinking pathways can be improved. De Bono's way of communicating the complexity of the brain is through the use of mechanical objects and mechanical descriptions.

The mechanical model provides de Bono with a mechanism to show how ideas are organised in the brain and how ideas can be generated. De Bono describes the theory in The mechanism of mind as a "self-organising
The operation of the brain is represented by de Bono (1990) through the model of the special memory surface (SMS). The SMS is believed by de Bono to be "similar to the one operating in the human brain" (p. 266). It is a passive system where information is organised into patterns. The SMS is made up of memory paths, each of which forms a discrete pattern. A reactivation of the pattern will recreate a particular event recalled. Each memory path is affected by previous experience and by emotional states. The chemical process involved in an emotional state can have an effect on the memory path and thus the formation of the unique pattern. In this way a particular memory path may not be recalled exactly as a past experience recorded the event but as the emotional state allows aspects, or dominant parts, of the pattern to be recalled. Not only is it logical that more dominant memory paths can be recalled much easier, it is also de Bono's argument that this process can lead to a certain rigidity in thinking.

De Bono (1990) argues that present experience is processed in the SMS by the memory of past experience: the past experience pattern is the one that processes the new experience pattern. Within the SMS only a limited amount of a pattern can be activated at any one time. If there is a large area of connecting patterns in the SMS then the new memory path will follow that path which is most familiar. Some aspects of new information could be ignored for some time. This limitation on the SMS has the effect of dividing a large pattern into smaller, more specific patterns. These smaller, more specific patterns are impacted upon one at a time so that there is an increase in space used in the SMS and also an increase in the information-processing time taken. As each pattern is activated a decrease in the
importance of that pattern occurs, but only for a short period of time. The level of activation soon increases and eventually remains permanently above the original level of activation. This short-term memory effect means that as each pattern is activated, after a short period of time, that pattern becomes the preferred part of the SMS and subsequently the easiest part to activate. The short-term memory holds the patterns long enough for them to be organised into connecting units, thus forming a new composite pattern, and eventually leaving a memory pattern in the long-term memory (p. 115-120).

De Bono uses this model as the basis for the theory behind the CoRT thinking skills program. The SMS is made up of existing patterns, where attention is directed towards the area with the lowest level of activation, and this is believed to be a cause for rigidity in thinking and problem solving. The CoRT program gives the student a set of general thinking skills which can impact upon the SMS and change the existing rigid pattern of thinking.

In *The mechanism of mind* (1990) de Bono outlines the characteristics of the broad system of the SMS, as follows:

1. A memory system which records things.
2. An iterative memory system which means that changes are cumulative.
3. A self-organising system which enables it to produce its own patterns.
5. A two-stage memory system which gives it a combining function.
6. An internal bias which gives it individuality and adaptive behaviour (p. 271).
De Bono (1990) believes that the effectiveness of the SMS is based on the ability to select or ignore information; to be able to fragment whole pieces of information and to make whole patterns from fragments; to be able to make sense of confused and abstract information; to be able to represent a complete pattern with a symbol and to make a symbol into a complete pattern (p. 129). The SMS also has certain limitations (p. 218), prominent amongst which is the tendency for the patterns to lead to rigidity in thinking. The pattern formation can tend towards information being altered by the pattern rather than information altering pattern formation and/or expansion. As de Bono comments,

"(T)he system is one that creates order out of chaos but imposes an old order rather than becomes aware of a new one. Recognition of a new order must inevitably lag behind the availability of such a new order in terms of information (p. 219)."

The way the SMS functions, de Bono (1990) believes, makes new ways of thinking difficult because of the fixed process of pathways and patterns. The SMS, through its operating process, has difficulty changing from the old patterns to the new pattern formation. It becomes difficult, for example, for a student to think about a problem in a new way and it becomes equally difficult for a teacher to present problem-solving and thinking strategies to students in a new way. De Bono (1990) argues that the natural thinking process is directed by existing patterns and that there is little, or no, alternative considered. The rigidity of the SMS also gives rise to the polarity of thinking, where a new idea can be ignored because of its 'newness' or an idea affected by emotion can cause dominant patterns to assert themselves. The CoRT program brings an overlay of flexibility to the SMS.
In Chapters 3, 4 and 5 a further exploration of cognitive theory will investigate the relationship between some other theories to be examined and the present enquiry.

Having considered some major propositions of cognitive theorists whose work relates to the present enquiry, we now turn to an examination of ways in which such theorists relate to pegagogy in the context of this study.
3.0 The Nature of Learning.

a) Atkin.

Atkin (1994) posed the following question, "what is the nature of the thinking which has taken place during learning?" (p. 202). The answer lies, according to Atkin (1994), partly, in an analysis of two classrooms. In classroom one, Atkin (1994) suggests that meaningful learning has taken place despite the pedagogical efforts of the teacher. In this type of classroom some of the students have "learned to learn in ways which are relatively mindless" (p. 202). Atkin goes on to suggest that some students have learned in ways which have actually been modelled by mindless teaching strategies used by many teachers. Mindless learning has also been rewarded by assessment practices which value 'the one right answer'... . Yet these very same teachers lament that students don't think, don't estimate, don't challenge, don't understand and can't transfer learning from one situation to another (Edwards, 1994, p. 202).

The second classroom is one where thinking has been deliberately encouraged and learning experiences have been designed to be infused with thinking. This classroom was one where the teacher utilised a wider variety of resources, had a structure which facilitated individual learning styles as well as small-group techniques and, overall, appeared to be a more challenging experience for students. Contemporary discussion on the issue
of thinking and learning could lead to the conclusion that some educators feel the first classroom traditionally dominated pedagogy (Johnson, 1995; Splitter, 1995; Edwards, 1995a, 1995b, 1995c).

Atkin (1994), using extensive workshop experience as a guide, is able to give a non-teaching view of what learning means to over five thousand adults and students over the age of twelve. The responses typically fall into five categories:

- Gaining information, facts
- Making connections, understanding
- Being able to do
- Feelings, emotions
- Result or impact

Atkin reports that the dominant images and analogies for learning which emerge are:

- Growth (learning is like the change from seedling to plant)
- Light bulb (learning is like illumination)
- Journey
- Transformation
- Puzzle solving

These descriptions of learning have, according to Atkin, a close relationship with Kolb’s (1984) model of experiential learning. As Kolb views it,

... learners have immediate concrete experience, involving themselves fully in it and then reflecting on the experience from different perspectives. From these reflective observations, they engage in abstract conceptualisation, creating generalisations or principles that integrate their observations into sound theories as guides to further action, active experimentation, testing what they have learned in new more complex situations. The result is another concrete experience, but this time at a more complex level. Thus experiential learning theory is best thought of as a helix, with learners having additional
experiences, and then using them as guides to further action at increasing levels of complexity (Edwards, 1994, p. 204).

b) Bawden.

Bawden (1989) describes experiential learning in graphic form. This model of learning is described as:

the nature and process of human learning we experience (in) the world around us. We reflect on these experiences and construct mental maps or patterns for making sense of our world. The effect of this mental pattern making, or map-making feature, is to simplify the bewildering array of stimuli that we face every moment we are alert. Our 'maps' give us our 'window on the world'. Our 'world processing' system is equipped to distinguish contrasting features and to form, and later recognise, patterns. As we distinguish elements which do not fit the pattern, we continually adjust and refine our pattern. In addition to developing patterns for making sense of our world, we develop skills (our 'bag of tricks') which enable us to act, to do. In a spiralling fashion, further experiences and reflection lead us to refine and change our mental patterns and to fine tune and hone our skills (p. 10).

c) Influences on Learning.

Not only within the classroom was there a belief that thinking and learning would occur as natural phenomena at some time during the process of teaching.

It was a matter of conventional thought that certain study habits would improve thinking and learning and, if followed, would go a long way to ensuring academic success (O'Neil & Child, 1984). These study habits were thought to be effective across all learning contexts, for all students and in all situations. This concept came under strong question (Biggs, 1970, 1978,
1988a, 1988b; Entwistle, 1981; Watkins & Hattie, 1981; O'Neil & Child, 1984). It was thought that this conventional view had failed to take into account the complexity of student learning and the many interrelated variables that had an effect on the quality of learning outcomes.

There are many factors which have an influence on learning (Entwistle, 1981; Kolb, 1984). Student motivation has been emphasised as a determinant of success (Entwistle & Kozeski, 1985; Biggs, 1987a, 1987b; 1988a; 1988b) as has the individual characteristics of each student (O'Neil & Child, 1984; Biggs, 1987a, 1987b, 1988a, 1988b; Thomas & Harri-Augstein, 1985). The individual characteristics of each student include ability level, age, personality, prior knowledge, experience in the subject area and experience in the type of learning encountered, environmental factors which may have impacted upon the students' development, and possibly attitudes held by prominent adults towards learning. Other considerations include the orientation of the teacher and the school towards learning, and raising students' awareness of learning (Biggs, 1987a, 1987b, O'Neil & Child, 1984).

d) The complexity of Learning.

The complexity of the learning process can be shown using the Lewinian theory on behavioural outcomes (Biggs, 1978). The equation, \( B = f(P,E) \), where \( B \) refers to the learning outcome, \( P \) to the variable which relates to the individual and \( E \) relates to all the contextual variables, has established that learning can only be viewed in terms of the complex interaction of many variables (Hunt, 1975a, 1975b).

There is research on student learning which has been directed towards the general approach in educational psychology called nomothesis.
(Biggs, 1987a). This research approach emphasises that, in the learning process, general laws are formed. Within these general laws there are rules which are governed by the behavioural approach to learning known as the stimulus-response (S-R) equation. This equation refers to the way the material is presented to the learner as being of most influence to the learning process.

Other research work has been guided by the premise that learning cannot be measured quantifiably. This research refers to the 'qualitatively distinct ways in which students go about learning' (Biggs, 1987a, p.1; Edwards, 1995a, 1995b, 1995c). There is alternative research that has been influenced by a more cognitive approach to learning (Weinstein & Mayer, 1986). This research attempts to understand how information is processed and structured in the memory, the emphasis tending to be on mental structures and processes, and the active nature of learning. Consideration is given to several issues: the way that learning varies according to contextual situations, the way in which students perceive a task, the importance of the task, the students' role in the learning situation, and what constitutes different levels in student achievement.

Kolb (1984) believes that experience has a role in the development of learning. Kolb (1984) argues that learning is not an innate feature of each individual's mental process, but is a changing process according to the interaction of the individual with the environment. Cognitive functioning and style are developed within the individual through on-going experiences with the immediate environment.

Learning, as a result of experience, should be conceptualised in terms of processes. As a result, learning is a continuous process, as noted in the
theory of assimilation (Ausubel, 1967). Learning involves the resolution of conflicts between opposing ways of dealing with problems that arise. Lewin was concerned with the conflict between concrete experience and abstract concepts, and between action and observation. Kolb (1984) studied learning as a process involving reflection on, and action about, all experiences.

e) Kolb's Theory of Learning.

Kolb (1984) believes that there are four modes to experiential learning:

1. concrete experience - the ability to become involved in new experiences;
2. reflective observation - the ability to reflect on and observe a number of experiences from a number of different perspectives;
3. active participation - the ability to integrate observations and make deductions on theory;
4. abstract conceptualisation - the ability to use theory to make decisions about learning processes and to assist in solving problems.

Learning results from the interactions of these four modes. The interactions also reflect a particular individual's learning style. This learning style does not relate to an individual's ability, but relates to the particular learning process inclination that is unique to each individual. As Kolb (1984) points out, in this area of learning theory there are several components. Some of these components will now be explored.
3.1 Learning Styles.

a) An Historical Perspective.

Some cognitive style theorists (Kavale & Forness, 1987) believe the learning style movement originated with the ancient Greeks, others start the movement with the work of Cronbach (1958) whose original model was influenced by the theories of Thorndike (1906) and Thurstone (1938). Thurstone (1938) and Thorndike (1906, 1922) believed intelligence was the product of multiple interconnected but distinct abilities. These abilities were seen to be partly independent, to be able to develop at an uneven rate, and, once measured, could identify an individual's strengths and weaknesses. Cronbach applied these ideas to an educational context, and believed that it might be possible to enhance the learning of students by concentrating instruction on the student's strongest ability area.

Thorndike and Thurstone's original ideas have lost favour, as have Cronbach's early conceptualisation of learning styles and associated pedagogy (Arter & Jenkins, 1977; Kavale & Forness, 1987; Kampwirth & Bates, 1980). However, Cronbach's theories did ignite general enthusiasm for the study of learning styles.

There is a current widespread enthusiasm for the concept of learning styles, which Howell (1995) notes is due to, at least in part, its accessibility. Knight (1996) states that the "basic logic of the approach is similarly appealing" (p.2). Knight (1996) believes that if there are differences in the way people learn, and if there is broad enough variety of pedagogical styles to accommodate these differences, then "opportunities should exist for improving student learning outcomes" (p.2) through matching learning style
with instructional method or by extending teaching strategies to cater for all learning styles.

b) Models of Learning Styles.

Since the 1970s there has been a significant growth in the variety and number of suggested learning styles. Amongst the proposals are shallow or deep processing (Marton & Saljo, 1976a, 1976b), surface, deep and achieving (Biggs & Moore, 1993); learning models (Kolb, 1984); successive or simultaneous processors (Das, 1988); and learning style approaches, such as Accelerated Learning (Rose, 1985), and Integral Learning (Atkin, 1992). Some of these learning style theories will now be explored.

c) Model 1. Student Approach to Learning.

Schmeck, Ribich and Ramanaiah (1977) identify four factors which they find to be distinctive in the ways in which students approach learning situations: synthesis-analysis, study methods, fact-retention and elaborate processing.

Students who are oriented towards synthesis-analysis favour organisation, evaluation, extrapolation and discrimination in their learning. The study-methods-factor students are characterised by systematic study routines with a large amount of dependence on organisation of time and attention to the specifics of what is to be learned. The fact-retention student tends towards content and the ability to retain it. Students who favour elaborative-processing are usually skilled at visualising, summarising, forming relations, applying information to problems and relating information to previous knowledge.
Schmeck et al. (1977) indicate that students who operate on the level of synthesis-analysis and/or elaborative-processing are able to process information in more depth than those who rely on the other two factors. Greater understanding of the presented information can usually be achieved by the synthesis-analysis and/or elaborative-processing styles, and thus learning is thought to be more intrinsically meaningful.

d) Model 2. The Four Mode Model of Kolb.

According to Kolb (1984), a person's learning style is determined by “consistent patterns of transaction between the individual and his or her environment” (p.63). These patterns involve some combination of the use of the four modes of the Kolb model (1984, p. 42) of the learning process. The first involves modelling, adopting approaches shown by another person, or repetition of a previous technique, a combination of ‘reflective observation’ (the ability to reflect on and observe experiences from many perspectives) and ‘concrete experience’ (the ability to become involved in new experiences). The second, a combination of concrete experience and ‘active experimentation’ (being able to create concepts that integrate observations into theory), where a student would rely on intuitive feeling. The third, a combination of ‘abstract conceptualisation’ (the ability to use theory to make decisions and solve problems) and concrete experience, which mainly involves the use of induction. The fourth combines abstract conceptualisation and active experimentation. Kolb (1984) believes effective learning takes place when these strategies are combined.

From these strategies, and from the use of the Learning Style Inventory (1984, p. 42), Kolb concludes that there are four basic learning styles: convergent, divergent, assimilation and accommodative.
The convergent style relies primarily on abstract conceptualisation and active experimentation. Students with this style are thought to be adept at problem-solving, decision making and the application of ideas. These students tend to do well in traditional intelligence tests and focus on the specifics of a problem. They are usually emotionally controlled, and are better with technical tasks as opposed to tasks of a social nature.

The divergent style emphasises concrete experience and reflective observation. Students with this orientation are thought to be more imaginative, relying on observation rather than active involvement. They do well when alternative ideas are desirable, and can tend towards being more emotional.

The assimilation style is dominated by abstract conceptualisation and reflective observation. Students with predominantly this style tend to be more inductive in their reasoning and attempt to assimilate information into an integrated theory. They tend to be ‘ideas people’, rather than actively involved in the practical aspects of implementation.

The accommodative style relies on concrete experience and active experimentation. Students of this type generally become involved in new experiences and tend to be actively involved in doing things. They look for opportunities and take risks. They adapt to circumstances around them, and often use trial-and-error methods of solving problems.

e) Model 3. Field Dependent - Field Independent Learners.

The learning of some students is benefited by a structured learning environment (Hunt, 1975b). These students are sometimes referred to as
more field-dependent (Witkin, 1976) than others, implying that they are less able to separate information relevant to a topic from irrelevant information without guidance. Those students with more intrinsic motivation, who are recognised as being able to learn better within a less structured mode, are regarded as being more field-independent (Witkin, 1976). Field-independent individuals are characterised as analytical and introspective, while field-dependent individuals are described as "global", being less strategic and more reliant on social cues (Witkin, 1976).

f) Model 4. Holistic - Serialistic Learners.

Pask (1976), Entwistle (1978, 1981) and Laurillard (1979) conclude that students could have one of two orientations toward learning: holistic or serialistic. In terms of strategies, serialists are those who follow a step-by-step procedure in learning. They concentrate on one thing at a time and work towards one goal. Holists can assimilate information from many topics and relate it to an overall goal or objective. They tend to work with a global frame of mind, have a number of ideas about a number of topics and are creative in their interpretations. The concepts of serialist and holist are mutually exclusive: a student applies only one or the other at any given time.

Pask (1976) originally used the terms holist and serialist to describe both learning strategies and learning styles, but later clarified the distinction between the two (Entwistle, 1978). In learning style, Pask (1976) thought that those who behave "like holists" (p. 133) are comprehension learners, and those who are "like serialists" (p. 133) are operation learners.
g) Model 5. 'Levellers and Sharpeners'.

In terms of the underlying principle, known as cognitive style (Ausubel, 1968, pp. 170-172), some students have been labelled within the research on learning theory as being 'levellers' (one example of cognitive style) and other students have been labelled as 'sharpeners' (the opposite example of cognitive style). Both terms are called "Gestalt phenomena" by Ausubel (1968, p. 97) and can be reinterpreted in terms of assimilation theory (1968, p. 97). Levellers are those students who tend to make decisions based on the influence of known criteria, and sharpeners are those students who are recognised as being able to evaluate each new situations on its own merit.

Biggs and Telfer (1981) consider that this taxonomy of cognitive style, including those cognitive styles that have already been outlined, is not exhaustive. However, the labels used by various researchers are very similar and do tend to concentrate on what observers have regarded as being the opposite poles of human cognition.

h) Model 6. 'Conceptual-level Theory'.

Hunt (1975a, 1975b, 1977, 1982) has researched the cognitive complexity involved when an individual makes a decision, and has labelled it 'conceptual-level theory'. This theory particularly relates to an individual's interaction with the environment. The degree of structure within a learning environment is matched with the individual's cognition level, and the particular learning style is matched with the amount of structure each individual needs. There is a developmental process involved in a manner which means that cognitive style alters according to this developmental process.
i) Model 7. Schema Acquisition

Gick and Holyoak (1983) found that the closer a past-experience schema (called by them an ‘induced’ schema) approximates to a present schema (called a ‘convergence’ schema), then the more likely an answer will be provided for a problem. Gick and Holyoak (1983) refer to the complex nature of schema acquisition as something not easily explained. The ready acquisition of schemas is implicit in the problem solving of experts. In the case of students however, through the teaching process, specifically through the use of selected examples, the knowledge can be conveyed implicitly.

j) Model 8. Rehearsal

Thorndike (1922) suggests that a process called rehearsal assists the student to learn material. Rehearsal is a form of inner speech through which information is maintained in limited amounts in the memory. The information appears to be stored in the memory according to the way it is spoken; thus rehearsal is especially beneficial to the learning of verbal material.

k) Model 9. Practice

VanLehn (1989) describes several mechanisms that are thought to assist a student to become a better learner through practice. Compounding is a process where two problem-solving operations can be formed into one operation called a macro-operator. The best operators to use in problem solving will be decided by a process called tuning. Two of the most common forms of tuning are generalisation and specialisation.
'Strengthening' is also a learning mechanism, says VanLehn (1989). As the name implies, there are thought to be certain stronger learning processes that are preferred by the learner over weaker ones. The learning process involved here is for regular practice to take place building upon the strength.

3.1.1 General features of Learning Styles.

Reid (1995) states that an individual's learning style is the "natural, habitual and preferred way(s) of absorbing, processing, and retaining new information and skills" (p. 58). An individual's learning style persists, regardless of pedagogy, and regardless of content.

Giorcelli (1995) believes that there are some fundamentals of learning styles which should be considered:

Every person, student and teacher alike, has a learning style and learning strengths and weaknesses;
Learning styles exist on wide continuums, although they are often described as opposites;
Learning styles are value-neutral; that is, no one style is better than others;
Students must be encouraged to 'stretch' their learning styles so that they will be more empowered in a variety of learning situations;
Often, student's strategies are linked to their learning styles;
Teachers should allow their students to become aware of their learning strengths and weaknesses (p. 10).

Reid (1995) argues that instead of more "traditional conceptions of teaching-learning, in which learning progress was largely teacher-centred and instructive in mode, linear in progression, and didactic in character" (p. 13), there is a growing realisation that learning is 'not the same' for all
learners in a particular age group, and that learning is not necessarily linear.
Reid (1995) asserts that it is becoming more widely accepted that more
efficient learning occurs when students are involved in monitoring their own
learning progress.

3.1.2 Learning Styles in the School setting.

Resnick (1987) has described the types of school organisation that
can promote independent, problem-solving learning styles. The first part of
this type of organisation involves the internal programs. The features of
school programs that promote problem solving and learning how to learn are:

- Involvement in socially shared intellectual work
- Organisation around joint accomplishment of tasks
- Building competence step by step
- Encouragement given to student observation and commentary (p. 3).

The second part involves the features of the schools that teach problem
solving and learning how to learn. These features are:

- Focus on the development of thinking skills
- Assessment integrated with teaching
- Students work as teams
- Skills learned in context of real problems
- Learner-centred; teacher directed
- All students learn to think (p. 3).

Resnick (1987) suggests that these features are not common in schools
today, but Bartlett (1995) argues that changes are possible, with a whole-
school commitment to improving learning and thinking.

Ipswich Grammar School has been conducting a whole-school
development program on learning entitled "The Learning How To Learn"
project. Ipswich Grammar school is a boys'-only school of about 1100 students, has a stable staff, some scholarship students, good academic results, a strong sporting tradition and operates traditional as well as enrichment and remediation classes. Bartlett (1995) reports that the project started with a small group of student volunteers being given instruction on learning theory, learning styles, and thinking skills. According to Bartlett (1995) there was an immediate and noticeable change (as reported by anecdotal evidence of teachers) amongst the student volunteers, enough of a positive change to encourage the project to expand. The project is based on four fundamental issues:

1. That students who appear to learn do not always retain what has been learned,
2. That students who know how to learn ... learn better,
3. That it should not be assumed that students know how to learn ... without direct teacher assistance, and
4. Developing students as independent and critical learners will impact on the teachers’ philosophy and practice of teaching.

The conceptual framework for the project involved three parts, namely:

1. Personal epistemology
2. Strategic development - What is happening in the classroom? How do students learn? How transferable is this learning across the curriculum?
3. The teaching-learning paradigm.

The approach that is used is based on the concept of "top-level structuring" (Bartlett, 1995). This is a concept that targets "the integration of literate behaviour, language and learning both as an instrument of instruction, and as a developmental outcome of instruction" (Bartlett, 1995, p. 6). The approach has four theoretical components. They are:

1. Scaffolding,
2. Modelling,
3. Active involvement,
4. Appropriate strategy selection and use.

Bartlett (1995) states that "top-level structuring" has a research base. For example, it has been found to be a powerful predictor of memory and comprehension performance, it is teachable, and it is associated with achievement across the range of content areas taught in high schools (p. 5). It is not known if an evaluation of the project has yet been conducted.

As Entwistle (1981) has also observed, there is little doubt that the learning process is complex and that the individual's perception of learning is influential upon the actual learning taking place.

3.2 Learning Strategies.
   a) Background. The Relationship between Learning Styles and Learning Strategies.

An individual's learning strategy, according to Derry and Murphy (1986), is "the collection of mental tactics employed by an individual in a particular learning situation to facilitate acquisition of knowledge or skill" (p. 2). Learning strategies are those external skills that can be consciously or automatically used by students to improve their learning. These strategies take many forms and can to be taught to students. They build upon the learning processes that are inherent in everyone. A student's preferred learning style is enhanced through the use of preferred learning strategies. Learning strategies are thought to allow individuals a greater awareness of their learning through monitoring, evaluating and making choices amongst different possible ways of approaching problem situations (Evans, 1991, p. 51). Learning strategies come under the umbrella of cognitive strategies in
which an individual's intellectual skill permits some control over how the individual thinks.

Weinstein and Mayer (1986) believe that learning strategies are techniques that

... can be defined as behaviours and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process. Thus, the goal of any particular learning strategy may be to affect the learner's motivational or affective state, or the way in which the learner selects, acquires, organises, or integrates new knowledge (p. 316).

O'Malley, Chamot, Stewner-Manzanares, Kupper and Russo (1985) describe learning strategies as "any set of operations or steps used by a learner that will facilitate the acquisition, storage, retrieval, or use of information" (p. 557).

Rubin (1975) states that strategies are "techniques or devices which a learner may use to acquire knowledge" (p. 43). Pask believes a learning strategy refers to the procedure a student uses in working through a well defined, structured section of subject matter, where the strategy can be characterised by reference to the ordered sequence of component topics being selected by the student (Laurillard, 1979, p. 396).

Entwistle (1978) states that there is a definite connection between students' achievement and the corresponding use of appropriate learning strategies (p. 257).

It would appear that students can adopt two orientations to learning: deep-level and surface-level processing. Students using a surface-level
style are more interested in learning the material as it is presented. Ramsden (1979) points out that such students see the material as an "isolated, elemented phenomenon" (p. 422). These learners are regarded as being passive, and they give little thought to what they are doing. Marton and Saljo (1976a, 1976b) refer to deep-level learning students as those that are focused on the significance of the learning material. These students relate the information to other knowledge that they have, and they are able to retain the knowledge for longer periods of time. Ramsden (1979) states that these students are able to relate the knowledge to personal experience, and use this association to make assimilation and associations quickly.

Marton and Saljo (1976a, 1976b) stress the relationship between selected strategies and the nature of the task. They concentrate on the flexibility students have in being able to determine which orientation is suitable for each task. Students can and do choose which level on which to operate, use it exclusively during the task, and are capable of switching orientations if the nature of the task deems it necessary.

Svensson (1977) agrees with the classification of deep-level and surface-level functioning. However, in order to avoid making a distinction between process and outcome, as in the work of Marton and Saljo, and to unite the knowledge and skill components, Svensson distinguishes two approaches labelled atomistic and holistic.

The atomistic approach is identified by such strategies as making specific comparisons, being sequential, and through the memorisation of material. The holistic approach is typified by attempts to understand the overall meaning of a text, to discover underlying intentions, to look at the wider context, and to form judgements on the available information.
Svensson's labels closely parallel those of Marton and Saljo. Svensson also believes that there is a definite relationship between cognitive approach and the outcome of the task. A holistic approach is seen as essential in order for a student to achieve a deep level of understanding.

Laurillard (1984) states that the use of deep-learning strategies by students, as opposed to the use of surface-learning strategies, does not occur consistently. Students employ a particular learning strategy in response to a given task. Laurillard believes that the students examine what is required, decide on priorities and act. Laurillard's analysis is supported by Marton and Saljo (1976a, 1976b), but not by Biggs (1988a, 1988b).

Biggs (1988a, 1988b), however, holds the view that students are consistent in their approach to learning. Along with Entwistle (1981) and Kolb (1984), Biggs concludes that students do have a tendency to adopt either a deep or surface approach, and that this tendency is consistent over different situations. Biggs (1987a) states that "the approaches to learning that students say they typically use are in fact stable over time and situations" (p. 93). Biggs believes that students change learning strategies according to the demands of the task, but that this change nevertheless operates within the broad limits of a particular approach. Biggs (1987a) expresses concern with "the extent to which the change that does occur, is affected by the student's predisposition to change" (p. 93). Biggs (1987a) comments:

It would be simplistic to insist that approaches to learning are specific to the particular situation in which a performance occurs. The evidence is quite strong that students are consistent in their approach to different learning situations. That consistency must, however, be
however, be viewed within the framework of the student's own metacognitive processes: priorities change and hence motivational patterns shift, task relevant knowledge increases, people become tired, the context and external pressures change, and hence so do the approaches to learning (p. 93).

Biggs' learning-style model may have been influenced by the work of Das (1979), who proposes three dimensions which were labelled as successive processing, simultaneous processing and planning. Due to the similarity of the conclusions to which a number of researchers were arriving, Biggs (1985, 1987a, 1987b, 1988a, 1988b) changed the original labels of his learning-styles model, to those of surface-level processing, deep-level processing and achieving.

The strategies which students employ in both surface-level and deep-level are ways in which the student becomes involved with the content of the task. Achieving strategies are ways in which students organise themselves and the environment in which the task is carried out. Therefore, students are thought to be able to operate using a surface-achieving or deep-achieving approach, a conclusion which relates to the present enquiry.

3.3 Learning Intervention Strategies.

a) Introduction of two broad categories:- Declarative Knowledge and Procedural Competence.

Learning interventions, as intentional learning management strategies, tend to fall under two broad categories. The first concentrate on changing cognitive activities mainly through the process of changing declarative
knowledge about such activities. The second seek to improve learning management capabilities, either by increasing declarative knowledge about management strategies, or by enhancing procedural competence with such strategies.

The majority of learning-enhancement programs fall into the first category, in that they concentrate largely on the teaching of declarative knowledge (also called propositional knowledge) (Evans, 1991, p. 58). Declarative knowledge ensures a student knows 'about' a particular activity but does not guarantee that the student will be able to carry out such an activity (procedural knowledge). However, as Evans points out, the propositional aspect of learning:

is the ability to continue to use propositional knowledge to monitor or evaluate performance. (It) is an important way of controlling actions and learning, even for automatic actions (p. 58).

b) Traditional cognitive-based interventions.

Learning interventions teach about cognitive activities and the factors that affect cognitive outcomes. The teaching of these cognitive activities has not usually been associated with assisting the learner to select activities that will assist in achieving learner-identified goals. Traditionally, cognitive-based interventions have been conducted as activities detached from school subject matter, with the outcome expected that students would be able to learn general strategies and skills that could be applied in a variety of general contexts.

There appear to be three distinguishing characteristics of such learning interventions. First, they are conducted in a manner in which the
students are expected to utilise them without question; secondly, the information on them is provided solely by the teacher, and thirdly, the teacher becomes the technical expert. Weinstein (1988) points out that this highly structured approach to learning intervention relies upon the adaptability of 'successful' learning strategies' being readily imparted to the less successful learner.

In the second category there have been a number of learning strategies whose authors have attempted to investigate learning management through the improvement of declarative knowledge about cognitive strategies and the conditions under which it is appropriate to employ them (Marton & Saljo, 1976a, 1976b; Gibbs, 1981). The emphasis in the non-directive programs was on talking about cognitive skills and activities. The emphasis was on the doing rather than on the control. Researchers studied students' approaches to learning (Ramsden, 1985), students' motives in learning (Biggs, 1986) and students' conceptions of learning (Marton & Saljo, 1976a, 1976b). In both categories, the prescriptive and the non-directive, it was reported that the learning intervention programs were only able to help students achieve desired limited learning outcomes.

Other learning intervention strategies have incorporated cognitive processes as well as the management of those processes. These strategies can be classified according to whether they target strategies as well as address the conditions under which those strategies can be used. Alternatively, the classification can be based on whether the intervention strategies target learning management through declarative knowledge and also attempt to improve procedural competence through recognising the existence of appropriate conditions for the strategies, as can be seen in the following study by Edwards.
c) Examples of Learning Intervention Strategies in school settings.

Edwards (1985) introduced a learning intervention strategy with Year 11 high-school students. Edwards' program focused on declarative knowledge about strategies and learning management. Edwards used the Study Habits Evaluation and Instruction Kit (SHEIK). The program's effectiveness was assessed using the Learning Process Questionnaire developed by Biggs (1987b). The evaluation showed that, when compared with the control-group scores, the treatment-group scores increased on three of the sub scales. However, the treatment group did not increase their use of deep-level learning strategies. The evaluation was not able to show whether an improvement of understanding had occurred.

Graham and Harris (1987) and Nist and Simpson (1987) studied the use of the teaching of learning-intervention strategies without conditions and with practice in learning management, and found that there was an improvement in surface learning but not in student understanding or deep learning. Paris and Oka (1986) believe that teaching students declarative knowledge about cognitive strategies and providing practice exercises is not enough to ensure self-regulated learning. They suggest that students need to understand the beneficial nature of a particular strategy and why that strategy promotes learning. Pintrich, McKeachie and Lin (1987) describe a learning intervention strategy that enquired into the conditions of use as well as declarative knowledge about strategies. They taught the what and how of learning strategies in fairly traditional ways, but (in order) to foster the acquisition of conditional knowledge (i.e. when and how to use the strategies) we teach students about the cognitive
psychological theory and research underlying the strategies (1987, p. 82).

The evaluation of this learning intervention found that, while changes were made in the student learning, these changes were not significant. The evaluation of changes in learning was not sufficiently focused for the researchers to make an evaluation of any changes in understanding (deep learning). Derry and Murphy (1986) applied a similar learning-intervention strategy. Training in declarative knowledge and knowledge about conditions of strategy use were given. At appropriate times, teacher prompts were given to the students to assist them to utilise learning skills. These prompts decreased as students became more proficient in learning management. Two problems were found with this strategy: first, the selection of the strategy was made by the teacher not the student; and secondly, an evaluation of the strategy was not reported.

Some enquiries have approached learning intervention through the use of heuristics. Sweller (1991) refers to a heuristic as a 'rule of thumb, a general problem-solving strategy' (p. 75). There appear to be two types of heuristic intervention: the use of prescriptive questioning and the use of guided questioning. Hynes (1986) reported on the effect prescriptive questioning had upon students. In this study, students were required to answer a series of questions in a diary they were to bring regularly to class. The questions would enable the students to reflect on their learning and the diaries allowed them to record their thoughts. This heuristic intervention proved unsuccessful for a number of reasons:

a) the students regularly forgot their diaries (White & Baird, 1991, p. 75),
b) diary entries did not indicate reflective thought on learning,
c) students did not clearly understand the purpose of the exercise,
d) students struggled to find an answer to all the questions,
e) the learning stopped at the completion of the questions (follow-up was not thought to be necessary),
f) there was little scope for comment and feedback by the teacher.

Baird and White (1984) and Baird and Mitchell (1986) analysed guided heuristic interventions conducted in Australian high schools. Students from the participating schools were asked a series of specific questions which were to act as guide questions on topic areas. During the course of the lesson, the students would ask themselves the guide questions which would then facilitate reflection on learning up to that point. While the evaluation did not report any change in student understanding, it was claimed that, if the students were given greater control over their learning, this would lead to greater understanding of content. This was thought to be the case because, amongst some other factors, teacher dominance was recognised by the researchers as being a restrictive influence on student learning. Sweller (1991) comments on the use of heuristics:

Contrary to expectations, we do not have a systematic body of empirical evidence based on testing many students that teaching heuristics has any positive effect... In principle, it should be relatively simple to compare groups of students who have been taught heuristics with groups who have not and, if the theory is correct, find superior problem-solving performance on the part of the heuristics students. Such evidence is not available (p. 76).

Nickerson, Perkins and Smith (1985) comment that the use of heuristic analysis is of specific advantage over approaches which involve no such analysis. In evaluating heuristic-oriented approaches, Nickerson et al. (1985, pp. 190-226) include the following strategies: Patterns of Problem Solving (Rubenstein, 1980); Schoenfeld's Heuristic Instruction in Mathematical Problem Solving (Schoenfeld, 1980); A Practicum in Thinking (Wheeler & Dember, 1979); the Productive Thinking Program (Covington, Crutchfield,
Davies & Olten, 1974); Problem-Based Self Instruction in Medical Problem Solving (Barrows & Tamblyn, 1980); and Lateral Thinking and CoRT (de Bono, 1968, 1970).

d) Cognitive-apprenticeship intervention strategy

Another group of learning-intervention strategies have been labelled cognitive-apprenticeship interventions. These intervention strategies are so called because of their close association with apprenticeship learning, where the learning process is embedded in a functional context. Schoenfeld (1985) found that students who used the textbook pattern for solving problems were unable to solve problems that were presented out of that context. Collins, Brown and Newman (1989) argue that conceptual and problem-solving knowledge acquired in school might remain unintegrated for many students. They believe the evidence points to the use of apprenticeship learning where modelling and coaching are used more extensively. Modelling, as one would expect, involves the student in observing a task being performed (Bandura, 1969). The student then performs the task with assistance and guidance where necessary. Skill introduction is graded and assistance diminishes with time and practice. Evans points out that modelling could be regarded as a higher-order procedure (Biggs, 1991, p. 59). Modelling approximates Sweller's (1984, 1993) and Sweller and Cooper's (1985) concept of using worked examples to enhance learning. In the case of modelling the student uses the teachers' worked examples as a guide to carry out other problem-solving tasks.

One of the first studies of the cognitive-apprenticeship approach was by Brown (1981). The results of Brown's work, comparing able learners and less able learners, showed that the more experienced learners needed less
explicit instruction in order to improve performance. For the less able learners, explicit training in the use of rules was needed. The best performance for the less able learner occurred where learning management and practice of skills processes were used. The weakest performance was in a self-management-only situation. The results pointed out that a better performance in surface learning occurred when students were taught declarative and procedural knowledge about strategies and their use as well as being given practice in implementation. Brown's work was followed up by that of Palincsar (1986), who argued that students need to have a repertoire of strategies to match the vast array of learning situations.

Palincsar (1986) developed a cognitive-apprenticeship model of 'scaffolded' instruction. Studies of how mothers scaffolded the learning of language by their infants (Bruner, 1978) have suggested ways in which modes of thinking might be taught in the classroom. In the cognitive-apprenticeship model of scaffolded instruction, the teacher and student participated in dialogue designed to jointly construct meaning. Over time, this dialogue would be less teacher-initiated and more student-initiated. The research demonstrated that the active involvement of students in learning cognitive-intervention strategies improved learning (Moore, 1991, p. 181).

However, while the strategy was shown to be effective in raising students' comprehension scores, there were some limitations. In terms of learning outcomes, a limitation was that surface, rather than deep, learning was targeted. Students were not being encouraged to search for meaning, but to recall facts that would assist in an examination situation.

Lawson (1991) discusses the importance of teaching cognitive strategies:
Knowledge of such strategies is not an automatic consequence of their (students') involvement in reading and writing. They may concentrate only on the content of the task itself and neglect the methods and conditions of operation on the task. These students do not spend time considering whether a task can be done in different ways, or whether there might be more than one way to solve a problem, and it is unlikely that they will give much attention to the answer they generate (p. 133).

Toomey (1995) presents a model of learning called the Cognitive Apprenticeship model (see Table 1). This model maps certain characteristics of learners, as seen by Toomey, to be the key features of that particular learning mode.

**Table 1: Cognitive Apprenticeship - A model of Learning.**

Please see print copy for image
Studies by Biggs and Rihn (1984) and Edwards (1986) argue that students can be trained to think more about their learning, and that improved metacognition has implications for improved academic performance. It is important to note, however, that the students researched in both studies were
implicitly motivated and were receptive to the learning strategies applied. Without the motivation it would appear that the teaching and learning strategies would not have received as good a reception (Biggs, 1991, p. 179).

White (1993) comments that the development of cognitive strategies should not be left to chance. White gives two examples of strategies: namely, self-directed questioning and the active search for links between new knowledge and old knowledge, and White believes that students who lack skills such as these will have a poor understanding of content. These students will inevitably be labelled as lacking in ability, but they can reverse this trend with the assistance of good teachers. White states that good teachers provide cognitive training unconsciously, while superior teachers do so deliberately. White realises that the development of cognitive strategies takes considerable time, placing such development at odds with content teaching. White also points out that the structure of many secondary schools, horizontally in years and vertically in blocks of time and specialist teachers, prevents one teacher from providing effective cognitive training for all students. It is noted here that this structure might be improved by a co-ordinated approach across the whole school and a release of the external pressure for state-wide comparative assessment on content.

Bawden (1989, p. 10) advocates an understanding of experiential learning through the use of a model of the learning process. Our understanding of the world around us is a result of the construct of mental models or patterns. These mental models have the effect of simplifying the enormous array of stimuli that we face. The mental maps become our 'window on the world' which is continually adjusted and refined. We each develop our personal 'bag of tricks' which enable us to perform tasks, and through continual refinement our skills are developed and fine-tuned.
3.4 The effect of Learning Intervention Strategies on the Learning Outcome of students.

a) Background.

Edwards (1995) strongly argues that the use of qualitative assessment alone, as the basis of gauging the success, or otherwise, of whether a learning intervention strategy has enhanced learning, does not give a true picture of the influence of a strategy on student thinking and learning. Yet a recurring weakness, as expressed in evaluations of the learning-intervention strategies investigated in this chapter, has been cited as the lack of qualitative assessment, as the major investigative tool, of changes in learning outcome. This situation exists in spite of taxonomies that have been developed expressly for this purpose. Edwards (1995) argues that the influence of measurement alone is decreasing and that a better way to gauge how students think, and the influences on how they think, is to ask the students themselves.

Marton and Saljo (1976a) in attempting to classify learning outcomes qualitatively, examined students' understanding of certain concepts within a text. Through this study, they were able to identify three categories of learning outcome:

a. The first category of subjects were conclusion-orientated in the comments on the topic, in the sense that they included the most important aspect of the discussion in their recalls, namely causes or consequences of the problem and the conclusions that can be drawn,

b. The next level consists of students who more or less fully describe what the author said about the ... problem without including causes, consequences or conclusions,
Levels of outcomes were described on a dimension of surface to deep according to the quality of the answer given. A deep-learning outcome required the identification of the underlying concept ('level a' in Marton and Saljo's study). A surface-learning outcome was indicated by the presence of the individual facts or examples mentioned in the passage without reference to the central theme (levels 'b' and 'c' of the Marton and Saljo study). The taxonomy is based on the belief that students learn different material in stages of increasing difficulty and that it is possible to identify, in broad terms, the stage at which a student is operating. Collis and Biggs (1979) postulate that the taxonomy allows for identification of high-order processes without the need to resort to extensive phenomenographic research. It is through the use of the taxonomy that teachers are able to make more use of qualitative evaluation without having to rely on a subjective view.

b) SOLO:- Structure of Observed Learning Outcome-

Collis and Biggs (1979) developed an index of learning outcome called the SOLO Taxonomy. SOLO is an acronym for Structure of Observed Learning Outcome. This taxonomy consists of five levels of answer which may be given by a student after a learning task. These levels were summarised as being:

1. Pre-structural. The response has no logical relationship to the display (e.g. the text given in the learning task) being based on inability to comprehend, tautology or idiosyncratic relevance.
2. Uni-structural. The response contains one relevant item from the display, but misses others that might modify or contradict the response. There is a rapid closure that oversimplifies the issue.

3. Multi-structural. The response contains several relevant items, but only those that are consistent with the chosen conclusion are stated. Closure is selective and premature.

4. Relational. Most or all of the relevant data are used, and conflicts resolved by the use of a relating concept that applies to the given context of the display, which leads to a firm conclusion.

5. Extended-abstract. The context is seen only as one instance of a general case. Questioning of basic assumptions, counter examples and new data are often given that did not form part of the original display. Consequently a firm closure is often seen to be inappropriate.

(Biggs & Moore, 1993, p. 68-75).

Levels 1 to 3 are classified by Collis and Biggs (1979) as surface-level learning outcomes, and levels 4 and 5 as deep-learning outcomes.

c) SPELT:- The Strategy for Effective Learning and Thinking.

The Strategy Program for Effective Learning and Thinking (SPELT) is a learning intervention strategy which attempts to teach students to become active learners and problem solvers (Mulcahy, 1991, p. 197). In this cognitive program, the students' learning strategies are viewed as a set of tools that activate and regulate cognitive activities. The teacher is a mediator who structures the learning environment and provides the opportunities to improve learning behaviour. Using socratic dialogue as a catalyst, SPELT aims to guide the student towards control and generation of thinking and learning strategies. A summary evaluation of SPELT reported that the
teaching of learning and thinking should be made an integral part of the school curriculum (pp. 205-211).

3.5 Conclusion.

This review of learning theory, learning styles, learning management, learning intervention and learning outcome has attempted to assess which, if any, learning interventions are likely to be effective in enhancing student learning. It would appear, from the review, that interventions which provide:

a. information about strategies useful in achieving learning goals;

b. information about the context in which the use of the strategy is appropriate;

c. explicit contextual practice in strategy use;

d. explicit contextual practice in implementation;

are those that offer the most opportunity for enhancing learning.

Learning interventions that concentrate on cognition rather than management appear to be restricted in their inappropriateness to be able to be self-selected by students to achieve learning goals. Interventions that concentrate on management either provide general-skills intervention out of specific context, or provide contextual practice without other goal-directed strategies. Theoretically, the most effective learning intervention strategy should be one which combines general skills, management skills, declarative knowledge and procedural competence, and is placed in an appropriate context.

Candy, Crebert and O'Leary (1994) in the Report on Life Long Learning Through Undergraduate Education, comment that:

we receive many comments from students, graduates and teaching staff themselves on the adverse, and in some instances, highly
constraining effects of the 'traditional' approaches upon the students' potential to learn (p. 127).

This study revealed that learning outcomes that resulted in lifelong learning skills were most likely to come from:

- self-directed and peer-assisted learning
- experiential and real-world learning
- resource-based and problem-based learning
- reflective practice and critical self-awareness
- open learning approaches
- assessment directed towards learning rather than ranking

(p. 7).

The report noted that there seemed to be an "obsessive" focus (p. 97) on content in the curriculum at the expense of learning to learn. The report gave an emphasis to learning-to-learn programs, stating:

Another key element is 'learning-to-learn programs'... Very few of the courses profiled included any formal means of teaching students how to go about learning... Learning-to-learn involves more than learning how to study. It involves the higher-order skills of analysis, synthesis and evaluation, the ability to think critically, to construct meaning and reconstruct understanding in light of new learning experiences. Courses where reflective practice is central inevitably help students develop into independent learners much more readily than those whose focus is on the acquisition of a large body of knowledge. Most students are unaware of how they learn... Few recognise the need to understand how and why they learn and unless they are confronted with a particular problem or issue that requires such understanding, are likely to leave university with no more interest in the learning process than they had when they arrived (p. 100-101).

There is little doubt that contemporary researchers of student learning agree with the fundamental importance of instituting effective learning
strategies in the teaching and learning process. One of the key issues explored in this chapter is not whether one contemporary view is better than another, but rather, that the purpose of an enquiry such as the present one, is to gain an understanding of the range of strategies that research suggests can enhance student learning. Having explored some theoretical and empirical findings central to discovering the nature of learning, we now turn, in the next Chapter, to examine ways in which thinking skills might successfully be taught, utilizing some of the major principles identified in this Chapter.
4.0. Teaching Thinking in an Historical Context

a) The Historical Perspective as background

Mann (1979), presents an historical perspective of teaching thinking, and places ancient Greek philosophers, such as Plato and Aristotle, amongst the first proponents of the teaching of generalisable thinking skills. Socrates and Plato believed, Mann says, that the function of general thinking-skills training was to develop, within the individual, the ability to reason and contemplate. The philosophical discourse involved the contemplation of knowledge within the soul, or the contemplation of knowledge before an association with the imperfect body. The questioning, advocated by Plato as a dialectic, encouraged students to be more effective in their contemplation and reasoning skills. This approach is one still favoured by programs such as Lipman's 'Philosophy for Children' (Lipman, 1985).

According to Mayer (1991, p. 12), Aristotle expressed three laws of learning and memory:

Doctrine of association by contiguity - events or objects that occur in the same time or space are associated in memory, so that thinking of one will cause thinking of the other;
Doctrine of association by similarity - events or objects that are similar tend to be associated in memory;
Doctrine of association by contrast - events or objects that are opposites tend to be associated in memory (p. 12).
Aristotle's concepts of associationism were reformed, according to Mayer (1991, p. 12), by Hobbes and Locke in the seventeenth and eighteenth centuries. Their theory on thinking contains four main characteristics:

Atomism - The unit of thinking is the association between two specific ideas. All mental life can be analysed into specific ideas and associations.

Mechanisation - The process of thinking or of moving from one idea to another is automatic and based solely on strength of associations.

Empiricism - All knowledge, that is, all ideas and associations, comes from the sensory experience. The mind begins as a 'blank slate' and is filled by reproducing the world exactly as it is received through the senses.

Imagery - Thus thinking is merely the automatic movement from point to point along mental paths established through learning, and since each point is a sensory experience, thinking must involve imagery (or some other sensory experience) (Mayer, 1991, p. 12).

Associationists (Mayer, 1991, p. 22) describe thinking as the trial-and-error application of responses called 'habits'. The word is coined from the belief that for any problem situation, there are strong links, or associations, to many possible responses. There are three elements to this associationist theory:

1. the stimulus (the problem-solving situation)
2. the response (the problem-solving behaviour)
3. the association (between the stimulus and response).

(Mayer, 1991, p. 22)

Thorndike identified two laws of learning to describe the solution process: the law of exercise and the law of effect (Mayer, 1991, p. 22). The law of exercise states that the more a response to a given situation is practised, then the more likely that response will be utilised if the same
situation were to arise. The law of effect states that responses that do not assist in problem solution are more likely to decline due to lack of use, while problems that do assist in problem solution are more likely to rise in prominence. Associationists would regard problem solving as the trial-and-error application of an individual's 'habit' hierarchy (Mayer, 1991, p. 22-25). Associationists assume that for any problem there are links to possible solutions with the links forming a family of possible responses. Within the family of possible responses the links vary in strength, some being weaker than others, thus forming a hierarchy of 'habit' responses to a given problem. Thorndike's law of exercise and law of effect have a resemblance to the neural-pathways concept as expressed in schema theory and in the special memory surface as described by de Bono in *The mechanism of mind* (de Bono, 1990).

Pavlov (1955, 1957) has had a major impact upon learning theory. Pavlov noted that there existed something called a reflex. A reflex involved a neural path within the brain, that connected incoming sensory information with impulses leading to movement. Pavlov suggested that these reflexes are innate and that identical paths can be formed. The forming of these new paths, connecting a stimulus with a response, constituted learning. According to the behaviourist view, all learning reflects the physical event of stimulus and response. The behavioural school argues that we do not say and do what we do because of ideas in our heads, but because stimuli have been connected in our past learning and this has lead to appropriate responses being activated.

Guthrie (1934) argued that Pavlov's was an artificial form of learning, and what was needed was a more general principle. Guthrie (1935)
developed one law of learning form which all learning would be made comprehensible, namely:

A combination of stimuli which was accompanied by a movement will on its recurrence tend to be followed by that movement (1935, p. 26).

Guthrie (1935) believed that learning was a gradual process: any one movement may be learned in any one trial, but practice is needed to learn a number of movements in a number of different circumstances. Guthrie differed from Thorndike, in that Thorndike was interested with the total scores of subjects, while Guthrie was interested in the number of movements and whether they led to success or error. Guthrie (1935) believed that skill represented a population of habits, and that learning accumulated with repetition. If a desired behaviour was required in a given situation then that behaviour would need to be practised in that situation. If a desired behaviour was required in a variety of situations then that behaviour would need to be practised in a variety of situations.

According to Damasio (1994), the French philosopher Descartes conceptually separated mind and body and allowed for the mind to be studied as a separate process. Damasio (1994) challenges Descartes’ view holding that

... feelings are a powerful influence on reason, (and) that the brain systems required by the former are enmeshed in those needed by the latter, and that such specific systems are interwoven with those that regulate the body (p. 245).
From this beginning emerged the first attempts to quantify the ability of the mind through psychological tests, such as intelligence tests (Mann, 1979). Mann says, Descartes thought of intelligence as the ability to respond appropriately to any stimulus taken from an infinite set of different stimuli. Green (1995) argues that intelligence is much more than the ability to respond appropriately to any one of a number of different stimulus possibilities. Intelligence, according to Green (1995), also includes

... the ability to benefit from past experience in such a way as to respond more appropriately, and to be able to do so in a wider variety of situations, than hitherto (p. 117).

Wundt (Mayer, 1991, p. 12-13) influenced the study of thinking by dividing psychology into two classes of processes of enquiry. One class involved processes that could be studied by direct experimental methods; the other class would not reveal anything through the use of such experiments. It was Wundt's contention that the higher-order mental processes could not be scientifically studied: thinking and learning were not for the scientists' laboratory. Wittgenstein (1953) agreed with this view, stating

The existence of the experimental method makes us think we have the means of solving the problems which trouble us; though problem and method pass one another by (p. 232).

Challenging the view put forward by Wundt and casting doubt on the tenets of the associationists, a group of psychologists from the German city of Wurzburg, found, by experiment, that:

Elements of thought change as they combine;
thought is directed and guided by some human motive or purpose;
experience is not reproduced or copied in the mind exactly as it occurs in the world; there is evidence of general and abstract thought and also of "imageless thought" (Mayer, 1991, p. 14).

Throughout the nineteenth century the dominant view was that the mind was made up of a number of 'faculties'. Herbart (1776-1841) (Biggs & Moore, 1993, p. 346) challenged this view with the thesis that the mind acts upon each new stimulus and, in turn, existing stimuli are acted upon by each successive new stimulus item. Herbart termed this process 'apperception' and its lasting application can be seen in the work of Ausubel, who developed the concept that new ideas are subsumed into existing structures.

Herbart held the view that the mind acted upon each new stimulus received and the existing content is restructured by each new item of stimulus. Herbart believed that the mind was in constant motion and was subject to the same mathematical laws as were heavenly bodies. Information changed in strength, some information remaining active while other information declined in consciousness. Information was not lost; it was simply not being activated upon. The process that lead to the decline of the strength of the information could however, be reversed. When new stimuli act upon the brain all the associated stimuli come to the surface to be acted upon (this process is called 'vaulting') (Mayer, 1991, p. 30); but, over time, information relevant to existing structures is kept at a conscious level while less relevant information declines in strength (a process called 'tapering'). As this interaction happens constantly, some information is reinforced and the differences are decreased, thus making concepts more fixed in the conscious. Herbart believed there were four major factors involved in thinking:

- the strength of the impression,
the degree of opposition to the existing structure,
the openness to impressions,
the degree to which the mind was occupied.

Herbart was an associationist and would be regarded as an advocate of domain-specific learning.

In the late 1860s Bain introduced the concept that the mind had motor components as well as sensory components (Watson, 1963). This approach was favoured by many psychologists because it was felt that the combination of psychology with physiology gave a certain scientific respectability to the emerging discipline. One of the problems associated with the move towards scientific respectability was the tendency to reduce analysis to that which can be measured. The work of researchers such as, Binet, Spearman, Thurstone and Burt gave credence to the use of tests and established a continuing emphasis on measurable changes (Edwards, 1991).

But some researchers do not advocate sole reliance on cognitive measurement. Notable amongst them is de Bono (1983a), who states:

In the end, this type of soft data may be the most significant data of all for they reflect thinking in an actual situation rather than an artificial test (p. 126).

Tripp (1979) also argues that objective tests may simply be too insensitive to measure what is happening when students are being taught generalisable thinking skills.

Baldwin (1896) suggested that ..."a great want of the world is thinking teachers capable of educating a race of thinkers" (p. 185). This critique of teaching, including such a wide range of influences as: the neglect of reason
in favour of memory; spoon-feeding in lectures which worked against thinking; poor modelling of thinking; failure to develop programs of thinking; not enough reliance on direct experience; and too much hurrying, could be regarded as the beginning of questioning what was happening in schools concerning thinking (Edwards, 1991).

In 1890 William James included a chapter on deductive reasoning in his textbook, a start for a subject which held a modest position in mainstream psychology (Mayer, 1991, p. 9). James described the two main processes of deductive reasoning: analysis and abstraction. As Mayer (1991, p. 117) points out, analysis is the process of breaking an object into parts and then substituting a part for the object. Abstraction refers to subsuming a specific property under a more general rule. This example is given:

As an example of analysis, to process the proposition 'Socrates is a man', a thinker must think of Socrates only in terms of one property... Analysis requires a 'mode of conceiving' - a way of referring to Socrates... . As an example of abstraction, the thinker, to process the proposition 'All men are mortal', must subsume Socrates as a man under the general heading of 'mortality' (Mayer, 1991, p. 117).

This modest position could be summed up in Humphrey's (1963) assessment: "Fifty years' experiments on the psychology of thinking or reasoning have not brought us very far, but they have at least shown us the road which must be traversed" (p. 308).
b) Transfer. Specific versus General Transfer. An Historical background.

The issue of transfer of training became dominant in education in the latter half of the nineteenth and into the twentieth century. The debate centred around specific versus general transfer, a very important issue in the formal discipline approach. Transfer refers to the effect of prior learning on new learning and Thorndike (1906) claimed that improvements due to transfer of training could be explained on the basis of identical elements in both the training and transfer situations. Thorndike stated:

One mental function or activity improves others... because it contains elements in common to them... . Knowledge of Latin gives increased ability to learn French because many of the facts learned in one case are needed in the other (pp. 243-248).

According to Mayer (1991), Thorndike (1906) based his theory on his ideas of how the brain worked. He argued that the mind is made up of thousands of particular independent capacities each of which must be developed by itself. These independent capacities are created on the basis of neural grooves along which reactions in the nervous system occur when practice takes place; thus the prior learning affects the new learning (Edwards, 1991). Similarly, de Bono (1990) believes that information is organised in the brain in discrete units which can be combined to form patterns. Every memory trace follows a unique pathway and reactivation of the pathway will bring forward a recreation of the event. Past experience and emotional state are two major forces that combine to have an impact on the ease of activation of each memory trace. Thorndike's view challenged the concept prevailing at that time, the doctrine of formal discipline. This doctrine (Thorndike, 1906, pp. 243-248) proposed that transfer was quite
general, learning in one discipline would assist learning in any other discipline. Thorndike's experiments largely laid the concept of general transfer to rest, but, in 1960, Bruner commented:

Virtually all of the evidence of the last two decades on the nature of learning and transfer has indicated that, while the original theory of formal discipline was poorly stated in terms of training of faculties, it is indeed a fact that massive general transfer can be achieved by appropriate learning... (1960, pp. 5-6).

Lashley (1929) had previously issued a challenge to Thorndike's neurological opinions:

There is no evidence to support ... belief in the identity of nervous elements. On the contrary, it is very doubtful if the same neurons or synapses are involved even in two similar reactions to the same stimulus. Our data seem to prove that the structural elements are relatively unimportant for integration and that the common elements must be some sort of dynamic patterns ... We cannot, on the basis of our present knowledge of the nervous system, set any limits to the kinds or amount of transfer possible ... (p.172-3).

Mayer (1991, pp. 22-43) believes the trial-and-error approach of Thorndike can be compared to the focus on perception, awareness, insight and structural understanding of the Gestalt psychologists. Gestaltists believe some problems seem to be hard to solve because some individuals are not able to perceive particular problems in different ways. To assist an individual in thinking about solutions, a Gestaltist would advocate giving a hint (direction), to assist in looking at the problem in a different dimension (insight) from the first dimension. If solutions cannot be found, the problem is left for a period of time (incubation). Wertheimer (1959) argues that in the
process of thinking it is change and improvement that is needed, not fixed patterns.

Kohler (1969) presents the Gestaltist case in this way:

Since, for the most part, we do not produce such sudden restructurings intentionally, but rather find ourselves suddenly confronted with their emergence, we are forced to conclude that, under the stress of our wish to solve a certain problem - and after our thorough consideration of various parts of the given material - sometimes brain processes tend to assume new forms or structures which, when reflected in our minds, suddenly make us see new relations and thus gives us new insights which tend to bring about the solution (p. 154).

The Gestaltists introduced some new ideas: productive and reproductive thinking and the idea that thinking occurs in stages. Productive thinking is based on creating a new solution to the problem, while reproductive thinking is where old behaviours are reproduced. Critics of the Gestalt view believe that the theory is too vague (the Gestaltists developed their propositions originally at an early stage in the development of neurophysiology), but do appreciate the contribution it makes to theory development. This position is best summed up by Dellarosa (1988) who states that they "simply did not possess the tools and techniques for building models of the level of complexity they required" but they "foreshadowed the cognitive revolution... carving out domains that would be explored later" (p. 7).

Otto Selz (1982) developed a theory of thinking which involved a complex set of relationships between thoughts necessary for the structure to
be complete. This theory opposed the notion of thinking's being a chain of associations. Selz's ideas included the following:

The unit of thought is the directed association (the forerunner of components of the information-processing system).
Understanding a problem involves forming a structure (the forerunner of schema theories).
Solving a problem involves testing for conditions (foreshadowing means-ends analysis).

Selz's work remained unfinished, but can be regarded as the beginning of contemporary approaches to teaching thinking.

The momentum behind the push for the direct teaching of thinking skills continues (Edwards, 1991), and is most noticeable through the public and professional focus occurring in the United States. As Edwards (1991) points out:

(re)ports such as *A nation at risk* (1983), calls from employers (e.g. Chatham, 1982), predictions by futurists (e.g. Naisbitt, 1982), and results of polls and surveys all point to the critical importance of thinking-skills training for the citizens of the twenty-first century (p. 90).

Chipman and Segal (1985) hold this practical view:

Because explicit instruction in thinking and learning skills has received little attention in the schools, it is likely that large improvements are possible. It is much easier to improve instructional outcomes in a new or neglected area than to achieve significant improvements in instructional methods that have undergone decades or centuries of evolutionary improvement by trial and error (p. 3).

Having explored the historical background and made an initial move into contemporary approaches to the teaching of thinking skills, the next
section of this Chapter expands on contemporary approaches developing further strategies and investigating alternative arguments.

4.1 Contemporary Approaches to Teaching Thinking

a) The Direct Teaching of Thinking Skills. A background.

In *Education and learning to think* Resnick (1987) lists the features that characterise 'higher-order' thinking. According to Resnick, higher-order thinking:
- is non algorithmic: that is, the path of action is not fully specified in advance;
- tends to be complex;
- often yields multiple solutions;
- involves judgement and interpretation;
- involves uncertainty;
- involves self-regulation;
- involves finding a structure in apparent disorder;
- involves considerable mental effort.

Resnick's concept of 'higher-order' thinking skills stems from an understanding of Bloom's taxonomy of educational objectives combined with Piaget's 'stages of cognitive development'. The implied assumption is that fundamental, or lower-level, knowledge is acquired first and that the levels of the hierarchy define limits for some children. This limitation has proved to be a stumbling block, to some educators, when they plan to improve students' thinking.

Willis (1992) believes that a resurgence of "interest and innovation" (p. 1) in teaching thinking has taken place in the 1980s, to the extent that the surge of interest has been labelled the "cognitive revolution" (p. 1). Willis (p. 1) points out that there are three approaches to teaching thinking that are regarded as being the most common. These are:
1. Creation of a classroom environment that fosters thinking, without
direct teaching of thinking skills;
2. Infusion of thinking skills into regular classroom instruction;
3. Separate courses for teaching thinking.

With approach 1 teachers may use Socratic questioning techniques; however, the direct teaching of thinking skills is not conducted. Approach 2 is regarded by Willis (1992) as the "most popular method of teaching thinking" (p. 1). Teachers using this approach teach thinking skills directly, within the context of subject-matter content. In approach 3 thinking skills are taught "outside the context of regular classroom content" (p. 1). Teachers using the first approach foster a thinking environment in the classroom; the teacher is careful to use questions that require higher-order thinking. The second approach advocates infusing thinking skills into regular classroom instruction, and there are those favouring this approach who believe that using de Bono's CoRT Thinking Skills program is the best way to achieve infusion (Willis, 1992, p. 4). Those who argue for the separate-program approach favour the use of programs such as Higher Order Thinking Skills (HOTS) developed by Pogrow of the University of Arizona-Tucson, or Philosophy for Children, developed by Lipman of Montclair State College (Willis, 1992, p. 4). While there are arguments which favour one approach over another, nevertheless, there appears to be general consensus that

(u)nless the curriculum embodies good models of thinking and students have plenty of opportunity to practise thinking, there is no chance that students will learn to think better (Willis, 1992, p. 4).
b) Arguments for and against the Direct Teaching of Thinking Skills.

Sweller (1988), using the assistance of artificial intelligence programs, developed cognitive-load theory. This theory argues that the cognitive load required to complete a task is determined by the way a task is presented. Many features within the task may be irrelevant to the task and cause cognitive overload in problem solution, actually inhibiting problem solution which takes place in the working memory which in turn, has a limited-capacity. Restructuring of the material to reduce unnecessary cognitive activity can facilitate learning and problem solving. Sweller (1991; 1993) believes that learning and problem solving can be facilitated through the restructuring of the material to enhance schema acquisition and automation. Schema acquisition and automation place the cognitive burden on long-term memory, and restructuring of the material to remove unnecessary cognitive activity takes the burden away from working memory. The combination of these two activities in instruction should ensure efficient learning and problem solving (1993, p. 7). Sweller (1993) describes two techniques that have been investigated where it assumes that cognitive load can be reduced by removing unnecessary cognitive activity and having learners directly engage in cognitive activities directed toward solving the problem (schema acquisition). The first strategy leads to goal-free problems and the goal-free effect (1993, p. 3). A goal-free strategy requires cognitive activity being directed only towards the single activity of the problem and solutions, not towards differences in problem states, or towards strategies used to reduce differences, or to previous sets of subgoals. The use of worked examples, rather than the process of solving many problems as a conventional teaching strategy, is believed by Sweller 1993, p. 4) to require less time, lead to an increase in learning and improve problem-solving performance.
Green (1995) argues that one of the lessons to be learnt from work in artificial intelligence is that complex problem solving (e.g. playing chess) requires complex information processing. Given that all the influences are the same, a computer program with more heuristics will generally play a better game than a program with fewer heuristics. The way to improve complex programs is to devise more complex programs, which will involve more complex information processing. Improvements in complex programs are limited by the extent that the sequence of information processing that contributed to the success or failure of the problem solving are able to be identified. The more complex the program the greater the ambiguity as to which of the heuristics is most responsible for the success or failure. Green (1995, p. 123) refers to this problem of ambiguity as the ‘ambiguity of reinforcement’ problem. Green (1995) believes that unless the ‘ambiguity of reinforcement’ problem is overcome “the development of learning programs which could enable other programs to be improved as a result of their actual successes or failures at solving problems would be ruled out” (p. 123).

Green suggests that a statistical attempt to work out which heuristics in a program are more successful could be made, but the harder the program the more difficult it would be to evaluate. A statistical procedure would not help identify the different permutations of the same heuristics which were used in tackling different problems. Green (1995) believes the ‘ambiguity-of-reinforcement’ problem does not exist in stimulus-response theory. In stimulus-response theory the ability of a stimulus to elicit a certain response is treated as something that depends on various conditions. Stimulus-response theory has failed at accounting for some behaviours where artificial intelligence has made progress (Green, 1995, p. 124). The number of different permutations in a game of chess does not allow the brain to mediate the number of stimulus-response connections. Green (1995) states
(w)e have on the one hand, then, information-processing theories of intelligence which fail to account for learning and, on the other hand, stimulus-response theories of learning which fail to account for intelligence. So long as intelligence and learning are treated separately, as independent phenomena, the incoherence in the idea of a mechanistic theory of intelligent learning remains hidden (pp. 124-125).

The cognitive architecture described by Sweller (1993) points towards cognitive load being reduced by schema acquisition and automation, since both reduce the load on working memory. Schema acquisition reduces the load by chunking pieces of information into a single piece, thus reducing the number of pieces that need to be cognitively processed. Automation allows information, to a large extent, to ignore or by-pass working memory while being cognitively processed. Sweller (1993) believes that certain characteristics of cognitive architecture result from this analysis:

Solutions to problems are domain-specific and general problem-solving strategies overload working memory.

Instructional activities which stress goal-free problems and the use of worked examples can facilitate learning.

Sweller (1993) comments that the enhanced understanding of higher-order cognitive processes will have a significant impact in altering "our preconceptions concerning instructional processes" (p. 8).

Splitter (1995) believes that the 'lower-order/higher-order' dichotomy has past its 'use-by' date. For Splitter the teaching of thinking involves an understanding of the complexity of thinking:
... It involves understanding that the kinds of characteristics offered by Resnick and others do not pick out a higher - as opposed to a lower or more basic - level of thinking. What they pick out is good thinking, desirable thinking, complex thinking, thinking that is so rich and enticing that it stimulates those who engage in it to do more, and do it better (p. 21).

Splitter, in continuing the argument, challenges the proposition that specific skills of thinking need to be taught. Lipman (1991) agrees with this view, stating:

we should teach directly and immediately for higher-order thinking. The skills will take care of themselves, and if they do not, this is a matter for subsequent remediation (p. 20).

It is in this regard that Splitter and Lipman find themselves opposed to the position of Anderson (1994), who believes:

One of the early (and, by implication, continuing) themes in the literature on teaching thinking is the notion that if we are to teach students to think, we need to identify specific skills of thinking, and then focus on how to teach those particular skills (p. 11).

Hart (1978) challenges the use of the word 'skill'. He believes that everyday activities, such as reading, speaking, writing and thinking, are made less important by the skills approach. Hart (1978) states:

... in order to be able to read properly you have to be able to bring something to your reading. But what you have to bring isn't skills; it's yourself (p. 207). ... (C)oming to have your say ... is coming to be a person in your own right, with outlook and interests of your own. And the richer the interests you have to bring to a conversation the more you have to say (p. 209).
Hart argues that certain activities in which we engage, such as thinking, influence our overall development. He believes that general thinking-skills programs provide a way in which individuals can decline to take responsibility for their own thinking; that general thinking-skills programs are an artificial replacement for the natural process of thinking, the development of which is each individual's responsibility. Taking this position, Hart places himself on the side of the Gestaltists, who stress the role of the individual in taking responsibility for the development of thinking. Hart advocates the view of Wittgenstein in which individuals are responsible for their own thinking in the same way that individuals are responsible for the type of person they are.

A second challenge issued by Splitter (1995), is the question of whether the teaching of thinking is domain-specific. Splitter (1995) argues:

We should be careful not to take the notion of domain-specificity too far. Whilst the strategies, tools and procedures associated with thinking and inquiry are, indeed, without meaning when they are applied outside any and every context, it does not follow that they are totally different in each context of their application. To the contrary, such strategies as are involved in constructing criteria, forming judgements, hypothesising, reasoning deductively, inductively or analogically, finding appropriate examples and counter-examples, are common to every discipline (albeit sensitive to the context of each) (p. 24).

McPeck (1981, 1983, 1990) has become a critic of the general approach. McPeck is of the view that "students cannot effectively be taught to 'raise and defeat counter arguments' in general, but only do so in contexts where they know and understand the specific subject matter" (McPeck, 1990, p. 56). McPeck (1983) argues that subject content gives powerful ways of learning about and thinking about the world. The knowledge already
possessed by teachers, McPeck contends, is worth directing attention to and
should not be undermined, as happens with general thinking-skills programs.
McPeck is supported by the work of Barrow (1987, 1990) who also contends
that it is a matter of conceptual truth that critical thinking is largely subject-
specific. Barrow states that it is "a matter of logic" (1987, p. 192) that there
are no significant general components of critical thinking.

Hager (1994, pp. 57-65) analyses McPeck's and Barrow's major
objections to the generalisability of critical thinking skills, and finds that each
theory is conceptually flawed and/or based on unwarranted conclusions. For
every example, in relation to the debate concerning 'logic of thinking', Hager points
out that, if McPeck's position, that critical thinking is always subject-specific,
were true, then there would be no such thing as general reading and writing
skills (p. 58). Barrow forcefully presents the argument that because someone
is a critical thinker in one subject area, '... as a matter of logical and empirical
fact', it does not follow that that person will be a critical thinker in another
field, where the individual's knowledge is minimal. Hager disagrees, he
states that this argument misses the point, because proponents of the view
that general thinking skills are largely generic do claim that, if one is
regarded as a critical thinker in one field, then if enough information is
acquired, the individual could become a critical thinker in another field.
Barrow and McPeck present a further argument, similar to that presented by
Wittgenstein, that there are different rules for different subjects which control
the different kinds of thought (p. 59). As McPeck comments:

... there are almost as many distinguishable logics, or kinds of
reasoning, as there are distinguishable kinds of subjects (p. 60).
Hager points out that McPeck's argument, because of its strong similarity to that presented by Hirst, should be subject to the same criticism (p. 62).

McPeck (1983) has directed some of the criticism to specific-general-thinking-programs, most notably the work of de Bono:

1. The CoRT thinking program is a superficial, heuristic device which entertains more than educates.
2. There are too many varieties of thinking for there to be one generalised skill.
3. The program deliberately uses artificial problems to avoid using content.
4. In life and academic study the real situation is more important than the number of alternative suggestions that can be produced.
5. CoRT problems do not provide sufficient contextual information for one to decide between the plausible and the logically possible.

The following responses have been made:

1. Nickerson, Perkins & Smith (1985) claim that CoRT can educate and is not just to provide entertainment.
2. De Bono (1986) does not claim a single generalised thinking skill but a group of executive strategies which can be generalised to other situations.
3. De Bono (1986) does see that a number of thinking skills, including traditional forms, have important roles to play.
4. De Bono (1986) believes there are two phases in developing thinking skills: first, the skills are learnt in content-free situations to ensure a direct focus on the thinking process; and secondly, the skill is utilised broadly in real-life situations.
5. Many of the CoRT processes deal with a wide range of processes: organisation of thinking, planning, focusing, consolidating, clarification, contradictions, informing analogies (de Bono, 1976).
Edwards (1994) reported on a series of research studies which indicated that:

student thinking can be improved in a range of respects through the direct teaching of the CoRT program. Improvements in scholastic aptitude scores, scores on creativity tests, on self-perceptions of use of CoRT-thinking approaches, and often improvements on heavily content-based school exams, were found for students taught the ten lessons of the CoRT-1 program when compared with control groups (p. 11).

Robert Glaser (1984) argues that thinking skills should be developed in the context of existing academic disciplines. Glaser stresses the essential role of knowledge acquisition in intellectual functioning and believes that heuristics-based approaches (such as de Bono's CoRT program) typically avoid the complexity of subject-matter information. He bases this belief on the view that general thinking-skills programs stemmed from the 'early' theories and research, which, for example, used relatively knowledge-free problems which offered limited insights into learning and thinking that require domain-specific knowledge. Glaser (1984) states:

The strong assumption, then, is that problem solving, comprehension, and learning are based on knowledge, and that people continually try to understand and think about the new in terms of what they already know. If this is indeed the case, then it seems best to teach such skills as solving problems and correcting errors of understanding in terms of knowledge domains with which individuals are familiar. Abilities to make inferences and to generate new information can be fostered by insuring maximum contact with prior knowledge that can be restructured and further developed (pp. 100-101).
c) Approaches to Teaching Thinking.

Some researchers (Costa, 1991; Perkins & Swartz, 1992; Mayer, 1991; Edwards, 1994) have recently identified three major approaches to teaching thinking. Perkins and Swartz (1992) have labelled these: ‘teaching of thinking’, ‘teaching for thinking’, and ‘infusion of thinking’. As Costa (1991), and Perkins and Swartz (1992) have pointed out there appears to be agreement on the meaning of ‘teaching of thinking’, yet there is a variety of definitions provided for the other labels. Ennis (1989) gives one clear account of the groupings under the general heading of critical thinking, namely:

- general
- immersion
- infusion
- mixed.

A general approach is about teaching thinking skills as a separate process apart from the teaching of content (Ennis, 1989). Advocates of the general approach include Sternberg (1984), Paul (1985), de Bono (1986), Feuerstein, Jensen, Hoffman and Rand (1986) and Edwards (1994). As the authors of the two most widely used programs, CoRT (de Bono, 1986) and Instrumental Enrichment (Feuerstein, Hoffman, Rand, Jensen, Tzuriel and Hoffman, 1980), de Bono (1985, 1986) and Feuerstein et.al. (1986) agree that thinking skills need to be taught directly. They have expressed their point of view as:

(a)ttending to content distracts from attending to the thinking tools being used. ... Whenever there has been an attempt to teach thinking skills and content together, the training in thinking seems to be weaker than when these skills are taught in isolation (de Bono, 1985, p. 206);
... (o)ne of the teacher's responsibilities is to determine which of the prerequisites for learning are missing and to provide them with direct instruction (Feuerstein et. al. 1986, p. 53).

The infusion approach is similar to immersion, in that thinking instruction is conducted within traditional academic disciplines, but the general principles of critical thinking dispositions and abilities are made explicit (Ennis, 1989). Proponents of the infusion approach include Glaser (1984) and Resnick (1987).

Infusion has been described by Perkins and Swartz (1992) as the "best-of-both-worlds approach" but they suggest that "stand-alone instruction and efforts to stimulate thinking during content may be valuable complements" (p. 58).

The mixed approach, as a multiple-strategy approach, complements that of infusion (Ennis, 1989). The mixed approach is a combination of both the immersion or infusion approaches (Ennis, 1989). Perkins and Salomon (1989) suggest that such an approach acknowledges that "there are general cognitive skills; but they always function in contextualised ways"... (p. 19). Proponents of the mixed approach include Brel (1990), Ennis (1989), and Perkins and Salomon (1989). It would appear that de Bono, an advocate of the general approach, is able to offer qualified support for the mixed approach, saying: "after the tool has been learned, then it is readily applicable to real problems" (de Bono, 1986, p. 38).

Several other classifications have been used to organise thinking programs. Brandt (1985) suggested nine general approaches, Nickerson et
al. (1985) suggested five categories, and Bellanca and Fogarty (1992) identified four categories. The Brandt (1985) schedule is shown as Table 2 and the Nickerson et al. (1985) schedule is shown as Table 3.

Table 2

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<th>Selected approaches to teaching thinking</th>
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(Brandt, 1985, p. 245)
Table 3
Approaches to teaching thinking

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(Nickerson et al., 1985, p. 144)
To illustrate the differences in the classifications, the following example shows the many ways a program, such as de Bono's CoRT, has been classified:

Heuristics approach - involving perception (Brandt, 1985),
Heuristics-oriented approach (Nickerson et al., 1985),
Divergent-production paradigm (Poison & Jeffries, 1985),
General approach (Ennis, 1989),
Macrological program (Adams, 1989),
Stand-alone approach (Perkins & Swartz, 1992),
Strategic-skills approach (Bellanca & Fogarty, 1992).

Nickerson et al. pointed out:

...any sorting of (programs to teach thinking) into a few categories has some degree of arbitrariness about it and requires some force fitting ... (T)he distinctions between categories are fuzzy, and the differences among programs that we have placed in a given category are, in some cases, very substantial (Nickerson et al., 1985, p. 144).

Poison and Jeffries (1985) have suggested, when one looks at approaches to general thinking skills, that the differences between information-processing and divergent-production approaches be considered. Poison and Jeffries (1985) regard information processing as the blue-print for thinking-skill programs. However, they see a problem:

Information-processing theories of learning and skill acquisition have not progressed to the point where one could make definitive statements on how to construct an instructional program to teach thinking and problem solving (p. 424).

As an advocate of information processing, Case (1985) believes the individual is the constructor of thinking strategies. Case emphasises the
roles of executive-processing space and automatisation in strategy construction. Cases's model stems from the concept of one working memory, which has a fixed capacity from a prescribed age, and is made up of short-term storage space and a processing space. As the individual develops, so too does the executive-processing space, which in turn decreases the amount of operating space required, leaving more room for short-term storage. Building on the work of Pascaul-Leone (1970), Case believes that simple strategies become automatic through use, and then these strategies become modified into more powerful strategies. As development continues, more information is kept in working memory. Through practice a strategy becomes more automatic and does not require as much attention. This means the individual can hold more items in memory, enabling a move on to more complex strategies. Increasingly, more sophisticated strategies are able to be used because the simple strategies become automatic. Developmental changes in performance are translated in terms of increasingly more complex strategies of information processing.

Klahr's (1984) work supports the idea that development involves the building of more sophisticated strategies. Klahr emphasises the individual's ability to learn how to extend a rule to a new situation.

Polson and Jeffries (1985) developed the divergent-production classification. Divergent-production is based on several assumptions:

Thinking is a skill,
Motivation and self-image are stressed,
Divergent thinking is emphasised; it is important that a large number of alternatives are generated (p. 426).
Polson and Jeffries place de Bono's general thinking-skills program, CoRT, in the divergent-production classification. They have also pointed out the common features of divergent production and information processing, in that both:

- believe thinking is a skill,
- are heuristically based,
- have a consistent theoretical base,
- were developed from the work of Polya and the Gestaltists,
- agree that understanding processes is important for successful performance.

There is also central disagreement between the two which concerns the role of domain-specific knowledge. Polson and Jeffries (1985) believe that all information processing involving perception and comprehension requires domain-specific knowledge. Proponents of divergent production believe domain-independent, perceptual and comprehension strategies can be taught, and that it is possible to teach general, domain-independent thinking skills. Simon (1980) comments:

> The evidence from close examination of AI (artificial intelligence) programs that perform professional-level tasks, and the psychological evidence from human-transfer experiments, indicate both that powerful general methods do exist and that they can be taught in such a way that they can be used in new domains where they are relevant (p. 86).

Polson and Jeffries (1985) point some of their arguments directly at the CoRT general thinking-skills program:

- the theoretical base of CoRT is difficult to specify,
- CoRT has similarities with the Gestaltist theory but does not have an historical base,
- sections of CoRT overlap with each other,
d) Comments on the Evaluations of General Thinking-skills Programs.

Commenting on the lack of evaluation studies of de Bono's general thinking-skills program, Polsen and Jeffries (1985) state:

We find the lack of adequate evaluation studies on the CoRT program to be both surprising and disturbing. The program has been in existence for over ten years and is claimed to be in wide use both in the British Isles and in Venezuela. Furthermore, de Bono makes strong claims concerning the effectiveness of the CoRT program. Yet after 10 years of widespread use, we have no adequate evidence concerning those claims and thus no support for the effectiveness of the program or the theoretical assumptions from which it was derived (p. 445).

Commenting about the evaluation of general thinking skills programs, Nickerson, Perkins and Smith (1985, p. 315) state that the effectiveness of teaching thinking programs is difficult to gauge as good evaluative data is hard to find. Chipman and Segal (1985, p. 6) appear to agree on the scarcity of evaluative data on thinking-skills programs and remain unconvinced that such programs are able to meet their claim of being able to develop cognitive skills.

A further comment on the difficulty of evaluating thinking-skills programs comes from de Bono (1976, p. 201) who understands that there would be an expectation that evaluative data on the ability of thinking programs actually to improve thinking should be available. However, the position is not an easy one in that an attempt to measure an improvement in
thinking is a very difficult process and the problems associated with any attempt may well be too great to give validity to the attempt.

In their evaluation of thinking-skills training programs Mansfield, Busse and Krepelka (1978) came to the conclusion that thinking skills, or more specifically creative thinking, can be taught. At the same time they identified a number of methodological problems with many evaluation studies of general thinking skills programs. A number of these methodological problems have also been raised by Nickerson et al. (1985).

Comparisons between evaluative studies of general thinking-skills programs have proven to be difficult because different studies have used different measures. Very few evaluations have taken place outside the classroom, which raises doubts about the transferability of general programs, and studies have tended to be over short periods of time, so longevity of program strength is in question. A test used could be open to many difficulties, amongst which are cultural bias, language problems, not meeting the stated objectives of the program or with student familiarity. A given program may be too situational-specific and needs testing across a broad spectrum of situations, and there may be a reliance on observations, as an evaluative measure, which can be open to distortion.

Sternberg and Bhana (1986) have also raised the issue of inadequacies of general thinking-skills program evaluations. The issues raised were not dissimilar from those of Nickerson et al. (1985) with a number of additional matters of concern. Sternberg and Bhana (1986) noted that many studies were sponsored by the program developers and that, in some instances, reporting was sketchy and inadequate. Many studies did not involve adequate control groups, and supporting documentation appeared
often to be little more than supporting statements or testimonials. The small number of published reports was in itself a cause for questioning the ability of the programs to achieve what they claimed across a broad spectrum and to have undergone rigorous examination.

e) Categories of thinking programs.

Nickerson et al. (1985) have developed five categories of thinking programs, namely:

Cognitive-operations approaches.
Heuristics-oriented approaches.
Formal-thinking approaches.
Symbolic-facility approaches.
Thinking-about-thinking approaches.

In the heuristics approach, Nickerson et al. (1985, pp. 190-226) include:

Patterns of Problem Solving (Rubenstein, 1980),
Heuristic Instruction in Mathematical Problem Solving (Schoenfeld, 1980),
A Practicum in Thinking (Wheeler and Dember, 1979),
Productive Thinking Program (Covington, Crutchfield, Davies and Olton, 1974),
Problem-Based Self Instruction in Medical Problem Solving (Barrows and Tamblyn, 1980),

Commenting on heuristic approaches in general, Nickerson et al. (1985) outline some of the difficulties associated with many programs. Nickerson et al. believe that heuristic approaches depend on the instructor's having a reasonable understanding of the skills to be taught and that there can be problems applying the approaches in unfamiliar contexts. Also one can
forget to apply heuristic approaches, but they can be useful when analysing complex tasks especially when compared with programs that do not suggest a process of analysis.

Langrehr (1995) believes that there are certain aspects which characterise good thinkers in "any subject, occupation, sport or interest" (p. 13). These aspects involve:

1. A good attitude or disposition to thinking.
2. Good pattern recognition.
3. Self questioning.
4. Mental mapping.
5. Tactical intelligence (as distinct from content and power intelligence).
6. Multiple intelligences.
7. Thinking styles.
8. Creative thinking.

These aspects which characterise good thinkers can be either taught or strengthened. Langrehr (1995) believes thinkers with good dispositions: clarify the issue, are open minded, are objective, and are loose or flexible. Langrehr states that these dispositions can be taught and modelled by the teacher so as to enhance better thinking.

Pattern recognition is regarded by Langrehr (1995) as an early and vital link in the thinking process. He states that students who have problems with pattern recognition usually have problems learning associated information. This pattern recognition problem can be overcome with better thinkers sharing the patterns they see in the information, with poor pattern recognisers.
Self questioning, according to Langrehr, assists in "connection building". Langrehr asserts that:

Too many questions in our classrooms are "content-building" questions that reinforce the memorisation, recall, and application of prescribed content (p. 13).

Students can be taught scaffolds or aids to help them with self-questioning. Some scaffolds that could be used are: Consequences - Assumptions - Meaning and main points - Prejudice and points - Examples - Relevance and reliability. Other scaffolds that could be used include: Combinations - Random input and reversals - Eliminations - Alternatives - Twists - Elaborations or extensions.

Langrehr proposes that good thinkers are also good at mental maps. Concepts in information are thought to be linked together in a particular shape. They may be organised hierarchically, radially, comparatively, cyclically and/or in a linear way. Poor thinkers, suggests Langrehr, can be taught how to select visual organisers that match the shape of the information. Core thinking processes, such as, categorising, comparing, summarising, ordering, decision making and problem solving, should be infused throughout the curriculum. Langrehr also suggests that educators need to make students aware of multiple intelligences, and with this awareness comes the need to ensure that multiple intelligences are being catered for in every classroom. Along with multiple intelligences comes an awareness of thinking styles and the interaction between temperament and personality which can affect the way in which we think. He contends that de
Bono's 'Thinking Hats' are a good example of how different styles of thinking can promote students' thinking about an issue in different ways.

Cammeray Public School in metropolitan Sydney is using de Bono's 'Six-Thinking-Hats' method in its creative and critical thinking programs K-6. In the School Education News, 19th July, 1995 it was reported that de Bono's program:

... raises the students' confidence and self-esteem, and promotes tolerance of ideas different to their own (p. 5).

Whimbey (1985) indicates that, when thinking skills are incorporated as an integral part of the curriculum, student test scores on academic procedures increase. When reading is taught as a strategy of thinking, students' comprehension increases (Andre, 1979). Costa and Lowery (1990) argue that thinking-skills programs were only intended for the gifted and talented and that mainstream students were not given access to these skills. This view is increasingly coming under challenge as certain cognitive concepts are accepted. The increasing acceptance of Feuerstein's (1980) Theory of Cognitive Modifiability; Gardner's (1983) Theory of Multiple Intelligences; and Whimbey and Whimbey's (1975) belief that Intelligence Can Be Taught, assist teachers and researchers to understand individual differences in cognition and that effective instruction in thinking-skills strategies does produce an increase in learning (Costa & Lowery, 1990, p. 2).

These comments on general thinking-skills programs and on heuristic approaches have paved the way for an analysis of evaluations that have been conducted on de Bono's CoRT program, Feuerstein's Instrumental
Enrichment program (Feuerstein et al., 1980) and the Productive Thinking Program of Covington, Crutchfield, Davies and Olton (1974). An analysis of the evaluations of these programs is conducted because of their wide use and, due to the limited number of evaluations available, because a comparison can be made of the conceptual and methodological issues raised.

Each of the authors reviewed in this chapter has assisted a comprehensive appreciation of what thinking skills are and how they might be improved in school, and has helped illuminate problems of evaluating the range of programs currently described in the literature. Themes of reviews discussed in this chapter will be taken up again in Chapter 7. In the next Chapter, arguments are offered for investigating further the potential of the CoRT approach, in order to help resolve the question of whether it is likely to be effective in the first year of high school, a time when children enter Piaget's stage of formal operations, and tend to acquire the potential to think effectively about abstract concepts.
CHAPTER FIVE

AN EVALUATION OF CoRT THINKING SKILLS AND SOME RELATED PROGRAMS.

In this Chapter, a range of thinking-skills programs for secondary-school students is evaluated, concluding with the CoRT program, which has been selected for special attention in the present enquiry, for reasons that will be explained.

5.0 Evaluations of some Thinking-Skills Programs

a) Instrumental Enrichment Evaluations

Feuerstein (1979) designed the Instrumental Enrichment (IE) program for "socio-culturally deprived" Israeli children to "compensate and substitute for a deficit" in their cognitive functioning (p.539). IE has been implemented in a number of countries including New Zealand (intellectually retarded adolescents) (Howie, Thickpenny, Leaf & Absolum,1985) and New York (deaf children) (Keane & Kretschmer, 1987).

The first evaluation of the IE program that will be considered in this study occurred in Israel (Feuerstein, Hoffman, Rand, Jensen, Tzuriel & Hoffman, 1986) and was conducted with disadvantaged junior high-school students. Pre- and post-test instruments were administered covering mathematical ability, scholastic achievement, classroom participation and student self-concept. Data were analysed using an analysis of covariance (ANCOVA) and the results showed that, with respect to the control group, statistically significant improvements were made in the mathematical
instrument, but on only one of the scholastic-achievement measures. Feuerstein et al. (1986) concluded that:

although the Instrumental Enrichment program may generalise to areas of content learning, it cannot replace such learning; however, it should be regarded as an efficient means of enhancing cognitive and intellectual capacity - not merely complementing formal content learning, but providing the necessary operational structure within which such learning may occur (p. 549).

This initial evaluation was followed by research conducted in Venezuela (Savell et al., 1986) using a larger sample of students. Students were drawn from both low- and high-socioeconomic backgrounds, results using analysis of covariance showing that the treatment group performed better than the control group on measures of non-verbal intelligence, academic achievement in language and mathematics, and self-concept.

Two evaluations were conducted in Canada, one in 1982 (Narrol, Silverman & Waksman, 1982) and the other in 1987 (Burden, 1987). The 1982 evaluation, using pre- and post-test instruments in mathematics, self-concept and locus of control, found statistically significant gains in three of the five treatment classes (disadvantaged first-year, vocational high-school students) when compared with the control classes. The 1987 evaluation was conducted with 49 low-achieving students who had received only nine months' instruction in IE (the recommended amount of instruction is three to five hours per week over a two-year period). The treatment group showed significant improvement over the control group in reading comprehension,
but, unlike the other evaluations of IE, did not show improvement on non-verbal intelligence measures.

b) Productive-Thinking Evaluations

The Productive-Thinking Program (Covington, Crutchfield, Davies, & Olten, 1974) is a short-term self-instructional program comprising sixteen lessons. The program is designed for upper-primary school students and is aimed at developing creative problem-solving abilities and encouraging favourable attitudes to problem solving.

Olten and Crutchfield (1969) conducted an evaluation using pre-, post-, and delayed post-test measures on 280 students (although they report on the data of only 50). The results gave evidence that the program (an eight-week intervention involving four one-hour lessons per week) improved the productive thinking and attitudes of the treatment students by comparison with the control students. A major difficulty with this evaluation is that the researchers used specially created productive-thinking instruments, which makes comparisons with other program evaluations very hard.

Mansfield, Busse & Krepelka (1978) and Polson and Jeffries (1985) have conducted reviews of the Productive-Thinking Program evaluations and have come to different conclusions. Mansfield et al. (1978) state that "the evaluations have yielded inconsistent results, with some researchers finding substantial evidence for the program's effectiveness and others finding little evidence" (p. 518). Polson and Jeffries (1985) report that in their opinion "the results have been uniformly positive" (p. 431). Mansfield et al. (1978) conclude
it must be noted that the largest training effects have often been found in small studies with serious methodological limitations. The better studies, using large samples and appropriate methodological controls, have provided more modest evidence of the program's effectiveness (p. 522).

5.1 CoRT Thinking Skills Evaluations

Nickerson et. al. (1985), reviewing the early studies of the CoRT program, stated:

On balance the findings are favourable for the CoRT program, as far as they go... However, the data fall short of making a complete case for the general effectiveness of CoRT. Whether the CoRT training would help students solve problems that are different in character from those on which they were trained is unclear. Whether CoRT has enhanced the thinking of the students in other subject areas or in out-of-school situations also remains to be studied, although anecdotal reports to this effect have been made (p. 220).

Adams (1989) claimed that, although CoRT did not produce much evidence for transfer, "for a relatively quick program that serves to build confidence or to "open the door" to thinking, CoRT is a good choice" (p. 73).

Hunter-Grundin (1985) conducted a two-year evaluation of CoRT in primary schools in Cambridge, England. Two groups of 10- to 11-year-old children, totalling 1,118 from 45 primary schools, were involved in the study between 1980 and 1982. Each group was sub-divided into treatment and control subgroups, with each school allocated one treatment and one control class wherever possible. The treatment classes were taught a total of 22 CoRT lessons by their regular teachers during a 10-month period; a maximum of one CoRT lesson per week was taught. The lessons were
selected by de Bono and spanned the CoRT-1, 2, 4, and 5 sections. These sections involved CoRT-1: 'Plus', 'Minus', 'Interesting' (PMI), which is about the treatment of ideas. CoRT-2: 'Consider All Factors' (CAF), which is taking into consideration all the factors involved in being creative in thinking about different ideas. CoRT-4: 'Consequence and Sequel' (C&S), focuses on the consequences. CoRT-5: 'Aims', Goals', 'Objectives' (AGO), focuses on the purpose. The CoRT-1 lessons preceded the other selections.

A simple pre-test, post-test design was used. Several instruments were administered as well as teacher and student questionnaires. The instruments involved tests of: reading comprehension, arithmetic, and logical reasoning; a creativity instrument; and two 10-minute essays.

Small differences were found; however the quantitative analyses revealed the CoRT lessons had little impact on the thinking of the students. Hunter-Grundin (1985) reported:

... the vast majority of pupils in both the experimental and the control classes made significant progress, both in their ability to answer questions of the type included in the reasoning tests, and in their ability to generate their own ideas on various topics and to state these ideas in writing (p. 58).

The qualitative data revealed that most students enjoyed the CoRT lessons and group work, and they believed that the lessons helped them to think better. The most widely used CoRT tools were PMI and CAF, although less than half of the students reported that they used the CoRT tools outside the classrooms.

The best thing I could find to teach children to think was a program designed by Edward de Bono. The program is called CoRT - which stands for Cognitive Research Trust (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney).

De Bono’s program consists of 60 lessons to teach children how to think directly, rather than to teach them to think as a by-product of school-subject (domain-specific) thinking. The sixty lessons in the program are, divided up into six units each of ten lessons. The first unit of CoRT-1 show how to manage divergent thinking - breadth of thinking. The second unit deals with how to organise thinking; the third unit deals with thinking in interactive situations; the fourth unit deals with lateral thinking or creative thinking; the fifth unit deals with information and feelings; and the sixth unit deals with how to have something happen as a result of your thinking. In the program there are sets of thinking tools or strategies that de Bono teaches to people.

De Bono (1986) recommends that CoRT lessons should be taught with a mixture of the following elements: direct instruction by the teacher (where examples of the thinking tool are provided), student work on practice problems, class discussion of the principles of thinking involved, and homework projects. The thinking-tool approach, with limited time span allocated to practice of the tool (two to four minutes), is used as a deliberate process to concentrate the student’s attention on the tool, rather than to begin concentrating on the associated content. De Bono (1986) believes the tool approach builds a metacognitive pattern which is used to direct attention.
The use of labels, such as, CAF and PMI, is de Bono's way of ensuring attention is directed towards the application of the skill. De Bono (1986) argues that it is possible to conduct a lesson without reference to the label, but "... there is very little permanent effect (and) the use of initials is intended to focus attention on the tools" (pp. 38-39).

De Bono (1983a) listed what he saw as the benefits of the CoRT Program as follows:

the CoRT lessons provide a framework where the emphasis is placed directly on thinking;
pupils are encouraged to think, and are given credit for their thinking;
pupils get opportunities to think in groups, to put their ideas across and interact with the ideas of others;
CoRT offers a selection of specific and deliberate thinking skills;
pupils are encouraged to view thinking as a skill that can be learned and practised, (and) pupils can practise and see their improvement;
the improvement is in confidence, focus, fluency, and application;
pupils feel in control of their thinking, rather than drifting in a sea of emotion and confusion; and

another intention of CoRT is the learning of specific thinking tools which can be transferred to other situations (p. 117).

Edwards (1995a) started teaching CoRT-1 at Canberra Grammar School in 1978. Part of the Science curriculum, Snell's Law, was replaced by the CoRT-1 program. This was quite a risk because the students were sitting for a State-wide external examination and could have been asked a question on that part of the curriculum. Edwards (1995a) commented
When I started to teach it, you know when teaching is going well, when it just hums; this hummed. I'm teaching it, the kids are loving it, I'm loving it ... It was fantastic. A wonderful teaching experience (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney).

Edwards (1995a) reported that another science teacher commented that he could not believe the change, for the better, that had come over the students. The Head of the English Department, who did not favour Edwards' style of teaching, commented that the students were "starting to write structured essays in English". Parents started to contact Edwards at the school claiming that the child's behaviour was changing at home. This CoRT-1 intervention had an important effect on Edwards, and was the beginning of a detailed research program, from 1978 to the present day, investigating, not whether de Bono's CoRT thinking skills program does work, but how it works and why it works. Edwards (1995a) comments

I have done much more research on de Bono's work than anyone in the world. ... Despite all the research that I have done in Australia, all the research Philip Adey has done in England with the CASE project, all the research that has been done in America with Dimensions of Thinking, Odyssey, Philosophy for Children, all the research that has been done by Feuerstein in Israel with Instrumental Enrichment, there has been little impact on the introduction of general thinking skills programs in schools. These are amazing programs that teach children to think and produce fantastic results and yet I would say less than 5% of schools around the world do anything with them. I don't think doing research and publishing it is a strong method for change in schools. (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney).
Edwards (1995b) points out that schools generally teach children logical thinking and critical thinking. Logical thinking is where an individual starts with premises, then goes through a set of logical steps and gets an answer. It is Edwards' (1995b) opinion that logical thinking is advantageous in schools because, generally, the problem is defined; in physics logical thinking is important because, as a subject, it is tightly defined; it is helpful in religion because once an act of faith is made then this is tightly defined. So, argues Edwards (1995b), logic works well in those closed systems, but in real-world systems there are often incorrect premises at the start or there are incomplete data. If there are incorrect premises or missing data, and the individual is perfectly logical in the problem-solving process, then there will be a perfectly logical incorrect answer at the end. If the start is faulty then the finish will be faulty too.

Critical thinking, according to Edwards (1995b), is concerned with analysing ideas once the individual has them, but how does the individual develop the ideas in the first place? Edwards (1995b) states that "what I am interested in is what is called generative thinking. I believe de Bono's work is extremely powerful in generative thinking" (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney).

The Edwards and Baldauf (1983) study was conducted with 72 Year-10 male science students from a private college in Canberra. The researchers used pre- and post-essays on familiar and unfamiliar topics and reported that there was a greater than one-third of a standard deviation improvement in the marks given in both types of essay. Edwards and Baldauf (1983) claimed that the results showed a positive effect on student thinking "and that the unit's effects were probably generalisable" (Edwards & Baldauf, 1983, p. 136).
Edwards and Baldauf (1987) conducted a second study, this time involving 60 Year-seven children being taught CoRT-1 over a four-week period. All the students were pre-tested and delayed post-tested eleven weeks after instruction. The students were from three classes, with each class being given a variation in treatment. Class 1 were given instruction reinforcing the use of the CoRT thinking tools and were given encouragement for their use at home. Class 2 were given the same reinforcement in the instruction but were not given the reinforcement on home use, while Class 3 did not receive the reinforcement in class or for home use.

The instruments used in the analysis were:

Otis-Lennon School Ability Test - Intermediate Form R (OLSAT) (Otis & Lennon, 1982),

Torrance Tests of Creative Thinking (TTCT) - Verbal Test Booklet A (Torrance & Ball, 1984),

Self-Concept as a Learner Scale (SCAL) (Waetjen, 1967).

As well as using these instruments, the class teachers were asked to rate the achievement of each student in Mathematics, Science, Social Science and Language; the students also completed an essay; and qualitative data from a questionnaire and interviews were gathered.

The researchers reported that the results showed statistically significant gains were made in:

Scholastic aptitude (OLSAT),

Self-concept as a learner (SCAL),

Flexibility and originality of thinking (TTCT).

Edwards and Baldauf (1987) commented:
... no pre-test - delayed post-test differences were found in language arts whereas there were significant changes in mathematics (negative), social science (positive), and science (positive) (p. 465).

This study additionally reported improvements in student-teacher interaction across a range of measures and reported on the "impressive" benefits as noticed by the headmaster, who regularly took the class. Edwards (1994) commented:

... The teacher noted that her teaching style had become much more interactive; she now used group work more; she knew her students and their thinking at a much deeper level than ever before in thirteen years of teaching; the students had achieved outstanding and unexpected results on a set of standardised national tests; and the students now contributed many more ideas of a far higher quality than they had before CoRT instruction.

The Headmaster confirmed the teacher's observations. The teacher who had taught the students the year before had reported to him, "There are a couple of good workers, the rest you have to push hard or do extraordinary things to get anything out of it." He agreed they had been like this, but now they were more responsive and more confident in their thinking than any group he had taught. ... Feedback from the children themselves was also positive, with the majority reporting seeing big improvements in their thinking and self-confidence, and many reporting wide use of the CoRT skills across the curriculum and in their everyday life (p. 12).

Edwards goes on to state:

Despite results such as these, and similar promising results with a range of other thinking-skills programs, there are no reported results in the research literature of continuing system-wide, or even significant school-wide, implementations of CoRT or other programs (p. 12).

In a third study, (Edwards, 1991), 202 Year-7 students were used, 115 being allocated randomly to the experimental group and 87 being allocated to...
the control group. Two CoRT-1 lessons were taught each week for ten weeks. A pre-test, post-test and delayed post-test were administered. Using an analysis of variance (ANOVA) procedure, Edwards (1991) reported significant improvements in scholastic aptitude, flexibility and originality, thinking approaches, social science and language arts. For the control group the results showed that CoRT-1 treatment did not significantly affect measures of fluency, mathematics, science or self-concept from the point of view of thinking ability.

Edwards (1991) reviewed several other evaluations of CoRT, namely, an early evaluation by Rosenthal, Morrison and Perry (1977); a 1979 evaluation by Tripp; De Sanchez and Astorga's 1983 evaluation of the impact of the Venezuelan implementation of an adaptation of CoRT; two honours students' evaluation; Matthews (1985) and Hart (1986) and an evaluation by Melchior and Edwards (1989) of the CoRT-1 program in a junior high school in New York.

Edwards (1991) was unconvinced of the findings of the Rosenthal et al. evaluation because the study was limited in approach. This study involved 90 university students, of whom half were randomly allocated to two CoRT-style lessons, and half to a lecture on the same topic. The whole study was of limited duration, taking only one and a half hours for pre-test, treatment, and post test. On three of the four subscales of the Torrance Test of Creative Thinking, the CoRT class performed better but the claims of Rosenthal et al. (1977) remain in doubt, as neither treatment could be regarded as an adequate representation of the two approaches being compared. From the Tripp (1979) study, Edwards (1991) reports on two major hypotheses that emerge:
CoRT seems to help guide the less able students in the production of ideas, and it seems to give them the confidence to think since they can now produce ideas not offered by others (p. 97).

From the De Sanchez and Astorga (1983) evaluation Edwards (1991) reported that they found "increasing gains over three years" (p. 97) on open-ended problems similar to those used in the treatment and from the Matthews (1985) study Edwards (1991) commented on some methodological difficulties, which may have resulted in some of the data being unreliable. However, feedback from parents "suggested positive effects from the CoRT treatment" (p. 98).

The Hart (1986) study was different in that adults were investigated to see if CoRT-1 training would have an effect on thinking skills of people over 50 years of age. Edwards (1991) reported that:

Cross-sectional comparisons indicated that increases in flexibility of thinking and acceptance of a positive 'stereotype of old people' were significant and sustained. Longitudinal comparisons showed that increases in fluency, originality and flexibility, as well as self-concept, were significant. The increases in fluency, flexibility and self-concept were sustained over a six-week period (p. 98).

Eriksson (1990) conducted a comparative study of the effects of two thinking programs: CoRT-1 and the Integrated Education Model (IEM) (Clark, 1986). The IEM combines thinking with intuition, perception, creative problem solving, individual or group problem solving and sensation. The study was conducted at the University of Witwatersrand in South Africa with mixed-race primary school children who attended an after-school centre. The students were allocated randomly to treatment and control groups, one
group being taught CoRT-1 and the other IEM, for a total of ten hours. Qualitative and quantitative data were collected and pre- and post-tests were administered. The test instruments concentrated on locus of control, self concept and creativity, and comparisons of pre- and post-test scores found statistically significant improvements in the locus of control and creativity constructs for the CoRT group. Eriksson's (1990) study reported that "...students had enjoyed the group problem-solving activity, that the course had changed their ideas about thinking and given them useful tools" (p.140). However, the study revealed that the students felt that "the skills had little impact on their solving of daily problems and no effect on their school work" (p.140).

In June 1996, Edwards (1996a) gave an address at the New South Wales Secondary Principal's Conference on the 'Direct Teaching of Thinking Skills'. In this address Edwards made reference to research projects on the direct teaching of thinking skills which show, even with as few as seven or eight direct-thinking-skills lessons in a school, there is an immediate impact on the students:

... I.Q scores go up, creativity scores go up, sometimes self-concept scores go up, and their scores on boring content exams go up. ... There is an enormous amount of evidence to show that the direct teaching of thinking has a powerful impact in a whole range of ways, on students and on classrooms (Audio-tape transcript from an address presented at the New South Wales Secondary Principal's Annual Conference, Tweed Heads).
At the same conference, in a workshop presentation, Edwards (1996b) commented that the CoRT program was "simple, powerful, elegant; quick to learn - elegant to use" (Audio-tape transcript).

The CoRT Thinking-Skills program (de Bono, 1973) is being used in this study because previous research in Australian schools has shown that the program is suitable for use with junior high-school students and test results have revealed that there is a treatment effect in certain areas.

5.2 Discussion of Methodological Issues

The success of any program largely depends on the ease with which it can be implemented (Adams, 1989; Nickerson, Perkins & Smith, 1985; Sternberg, 1984). Nickerson et al. (1985) point out that a program should be designed to assist a teacher with teaching and should not be inconsiderate of a teachers' time. Adams (1989) suggests that budget considerations are important and Sternberg (1984) advises minimal specialist teacher training is required. Adams (1989) is critical of programs like IE because they take "weeks and months of teacher training" (p. 45). IE has the additional problem of not having a large number of specialist trainers and allowing only accredited teachers access to the resources. In comparison, de Bono (1976) claims that CoRT can be taught with little or no training, stating that "training is not required to explain or teach the subject matter itself" (p.181), and as Hunter-Grundin (1985) points out, "(t)he deliberate simplicity and practicality of the materials has meant that the teachers are able to use them without specialist training or background" (p.29).

The analysis of covariance (ANCOVA) was the most frequently used measure in the IE and the Productive Thinking Program evaluations
(Mansfield, Busse & Krepelka, 1978; Savel, Twohig & Rachford, 1986). The pre-test mean for each dependent variable is taken as the covariate and, as in the example provided by Feuerstein (1979), this is a useful technique for compensating the difference between treatment and control groups at pre-test. However, Pedhazur (1982) believes that ANCOVA analysis should be limited to random groups and that when the test is not used in this way the assumptions underlying ANCOVA are violated.

Edwards (1988) used multivariate analysis of variance in the evaluation of CoRT, concluding: "in no case did a MANOVA result vary sufficiently from the result generated using repeated-measures ANOVA to warrant a reinterpretation of the data" (p.163). Huck, Cormier and Bounds (1974) recommend the use of multivariate analysis as it allows for a greater exploration of the interaction effects and is a more robust procedure.

In Olten and Crutchfield's (1969) evaluation of the Productive Thinking Program and in Hunter-Grundin's (1985) evaluation of CoRT, self-developed instruments were administered which prevented worthwhile comparisons between programs being made. It is necessary that standardised and readily available instruments are used so that comparison and replication can be made. Edwards (1988) used, amongst other measures, the Otis-Lennon School Ability Test - Form F Level 1 (OLSAT, Otis & Lennon, 1982) and reported statistically significantly gains. The OLSAT was found to be a reliable measure of scholastic aptitude with primary children in Queensland (Edwards, 1988) and with another primary-school group in Venezuela (Herrnstein, Nickerson, de Sanchez, & Swets, 1986). De Bono (1976) has commented:
Because standard tests give us a numerical result we feel comfortable with them. Unfortunately what we rarely do is to question the applicability of the test. We tend to suppose that if the test is a good test then its application must be valid. There is a huge danger, however, in using inappropriate tests, and in the field of thinking one is very much aware of the danger (p. 125).

In developing a test designed to measure intelligence, Binet (Gould, 1981) feared that the measure could be used as a label, or as a convenient excuse, in which some students' behaviour could be diverted to follow a predicted path. Binet (Gould, 1981) insisted that the measure he devised should be used only for the limited purpose of identifying students whose poor performance indicated a need for special education. Binet (Gould, 1981) believed that the scale would assist in the improvement of those students in need of special help and in no way was to be used to limit any students development. Goddard (Gould, 1981) took Binet's measure to America and changed the original concept to one of it being a measure of innate intelligence. Goddard was director of research at the Vineland Training School for Feeble-Minded Girls and Boys in New Jersey and agreed with Binet that the scale worked best in identifying students just below the normal range, a group he labelled 'morons'. Goddard also believed that the scale was a measure of a single, innate entity called intelligence. Goddard used the scale as a justification in his arguments for restricting immigration and for selective breeding (Gould, 1981).

Terman (Gould, 1981), a professor at Stanford University, popularised Binet's scale and renamed it the Stanford-Binet. Terman standardised the scale so the mean score was 100 at each age, and introduced a standard deviation of 15 or 16 points at each chronological age. Terman hoped
(Gould, 1981) that the Stanford-Binet would "determine the minimum intelligence quotient necessary for success in each leading occupation" (1981, p.181). Certain professions would be closed to those with an IQ below 100 and individuals characterised by crime, vice and feeble-mindedness (placed in permanent custodial care) would be eliminated from public scrutiny through the mass testing of the population using the Stanford-Binet.

The mass use of IQ scales received its greatest boost through the work of Yerkes (Gould, 1981). Yerkes persuaded the United States Army to use IQ style tests for every recruit in the mobilisation period prior the America's entry into World War One. Almost two million recruits were tested using, for the first time, mass-produced written tests of intelligence. Yerkes commented on "the steady stream of requests from commercial concerns, educational institutions, and individuals for the use of army methods of psychological examining" (Gould, 1981, p.195).

Edwards (1995b) has commented that standardised tests are "massively dishonest" (Audio-tape transcript) and that a test, such as the Torrance Test of Creative Thinking, is "hopelessly out of date" (Audio-tape transcript), in that it was normed many years ago and does not reflect changes that have taken place in the world. Edwards (1995b) makes the further comment:

I believe a significant number of the tests we use do not cognitively engage most students and the measures we get are totally inaccurate (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney.).
It was because of this view that Edwards and a research team from James Cook University surveyed "thousands" (Audio-tape transcript) of students to develop a test that was cognitively engaging. Edwards (1995b) developed an instrument over the course of three years research, but came to the conclusion that a static measure was not helping students to advance. In Edwards' (1995b) opinion it was not important to know the level attained by a student, but rather it was of primary importance to help a student to advance. Edwards (1995b) used stimulated-recall on students doing test questions, as part of an attempt to ascertain whether standardised tests did measure student thinking. When students were being videotaped while they took tests and were interviewed afterwards to see what they were thinking at the time of doing the test, Edwards (1995b) found an apparent disparity between what students write and what they were thinking. Edwards (1995b) comments:

All of our testing in schools and universities is based on the assumption that what goes down on paper is an accurate representation of what is in the head. I'm telling you it is not. We are engaged in a massive sham. Paper and pencil testing is a massive sham .... . What goes down on the paper sometimes has very little to do with what goes on inside the child's head. Sometimes it is a reflection but it is a very pale reflection (Audio-tape transcript from a paper presented at the International Confederation of Principals, Sydney).

Edwards (1995b) goes on to point out that, as Dame Marie Clay in New Zealand and Piaget have known for a long time, "if you want to know what is going on inside a student's head then you sit down with the student, one on one, and you talk to the student; you interview the student" (Edwards, 1995b). Edwards (1995b) suggests that a standardised test should be the starting point for an interview with the student; it should not be the end point,
as is most often the case. An interview gives the teacher a good understanding of the richness of a student's thinking. Such an understanding is not available from looking at the result of a standardised test. Edwards (1995b) gives an example from his research into student thinking where a student commented that "I never write down anything that could possibly be wrong" (Edwards, 1995b). This student had been variously described as a wonderful student, a top student, a 90%-in-tests student, a great student. As Edwards (1995b) reports, with regards to one particular student,

... anyone who gives her a creativity test is going to get a totally misleading score for her because she has learned from her cultural background that you never write down anything that could possibly be wrong. Now unless someone works one on one with her that person is not going to pick that up. I believe we should give away most types of testing we do at the moment (Edwards, 1995b, Audio-tape transcript).

In June 1996, Edwards conducted a workshop at the New South Wales Secondary Principal's Annual Conference, entitled "Myths and Realities of Assessment and Evaluation" (Edwards, 1996b), and in a recorded presentation reiterated his beliefs regarding the use of standardised testing procedures. Standardised tests, such as the Otis-Lennon School Ability Test and the Torrance Test of Creative Thinking do not "cognitively engage most children" and these tests "are massively, massively culturally arrogant and massively sub-culturally arrogant" (Edwards, 1996b). Edwards goes on to assert that standardised tests are often developed by people who live in cities and, therefore, are city tests (Edwards, 1996b). The Torrance Test of Creative Thinking, one of the most used tests to test for creativity in thinking, is regarded by Edwards (1996b) as a test of endurance, a test that is out of date. Scoring a standardised test, making assumptions and
judgements about it, is not the way to find out how a child is thinking, according to Edwards (1996b). If a person really wants to know how a student thinks, then the best way is to sit next to them and ask, "Tell me what you are thinking?" (Edwards, 1996b).

Goleman (1995) argues that achievement tests are based on a limited notion of intelligence, one that does not account for the true range of skills and abilities that matter in life.

Gardner (1983) proposes that there is not one measurable kind of intelligence but rather a broad spectrum of intelligences. This model extends the standard concept of intelligence being a single, immutable, measurable factor, which can be used to predict an individual's place in life. Gardner and Krechevsky (1993) and Feldman (1986) developed Project Spectrum, a curriculum that intentionally cultivates a variety of intelligences. Project Spectrum recognises the multi-faceted nature of human abilities and goes beyond the traditional focus of schools on the three Rs. In an interview Gardner (1986) commented:

... The single most important contribution education can make to a child's development is to help him toward a field where his talents best suit him, where he will be satisfied and competent. We've completely lost sight of that. Instead we subject everyone to an education where, if you succeed, you will be best suited to be a college professor. And we evaluate everyone along the way according to whether they meet that narrow standard of success. We should spend less time ranking children and more time helping them to identify their natural competencies and gifts, and cultivate those (New York Times Educational Supplement, Nov. 3, 1986.).
Gardner and Krechevsky (1993) compared Stanford-Binet Intelligence Scale test results with Spectrum abilities and found that there was no significant relationship between children's scores on the two tests. The five 'smartest' children, according to the intelligence test, showed a range of abilities on the Spectrum test. The abilities ranged from music, to visual arts, to social understanding, to logic and to language. None of the five children were strong in movement, numbers, or mechanics; movement and numbers actually showing to be weak spots for two of the children. Gardner and Krechevsky (1993) concluded that the Stanford-Binet Intelligence Scale did not predict successful performance across a range of Spectrum abilities. However, the Spectrum results were able to give teachers and parents an indication of what activities the child would have spontaneous interest in, and where the child may develop enough interest to move from proficiency to mastery.

Gardner et al. (1993) believes that identifying naturalistic sources of information about cognitive abilities is a more preferable identification process than standardised tests or correlations among tests. Gardner states that it is “important to consider individuals as a collection of aptitudes” rather than believing that they have some form of singular problem-solving ability “that can be measured directly through pencil-and-paper tests” (1993, p. 27).

Like Edwards (1995), Gardner et al. (1993) advocates investigating “more closely what actually happens” (p.171) when individuals undertake problem-solving tasks and points out that ‘creativity tests’ are “biased heavily in favour of two varieties of intelligence - linguistic and logical-mathematical” (p. 176) with those individuals having this particular combination more likely to do well on formal tests, “even if they are not particularly adept in the domain actually under investigation” (p. 176).
5.3 Transfer

The issue of 'transfer' is central to the debate on the effectiveness of thinking-skills programs (Nickerson et al., 1985; Adams, 1989; Ennis, 1989; Brell, 1990; Perkins & Salomon, 1991). Adams (1989) and Brell (1990) believe the 'transfer' is the most fundamental issue, while Adey (1994) believes long-term, 'far' transfer is the 'Holy Grail of Cognitive Psychology'. Adey (1994) states, that in the 'desperate' search for transfer,

what one would be looking for would be evidence of enhanced performance of the experimental group in domains far removed from the domain of the intervention program. This is what is meant by far transfer, and it has been the relative failure of very many attempts to provide convincing evidence of far transfer which has strengthened the position of those who claim that domain specific strategies are the only ones worth the attention of educators (p. 196).

Adey (1994) goes on to suggest that, "any person who allows themselves to be deterred from the search for general thinking skills" (p. 196) needs to reminded of the words of Nickerson, Perkins and Smith (1985):

If (teaching thinking) cannot be done, and we try to do it, we may waste some time and effort. If it can be done, and we fail to try, the inestimable cost will be generations of students whose ability to think effectively will be less than it could have been. So we are better advised to adopt the attitude that thinking can be taught, try hard to teach it and let experience prove us wrong if it must (p. 324).

Using the CASE Project (Cognitive Acceleration through Science Education) as a two-year intervention strategy, Adey (1994) reported on three important features:
the effects are long term, showing up two and three years after the end of the intervention; there is far transfer from the science content of the intervention lesson to performance in English; there seems to be some gender-age interaction (p. 198).

The CASE project was implemented in science classes in several London comprehensive schools over a two-year period. The treatment was designed around Piagetian schemata of formal operations, specifically: control and exclusion of variables, ratio and proportionality, equilibrium, compensation, combinatorial thinking, correlation, probability, compound variables, and conservation involving formal modelling (Adey & Shayer, 1990). The skills were not taught directly, as they would be in a CoRT lesson; instead the students were required to construct the schemata themselves. Once a particular schema was identified then it was related to examples from the regular science curriculum. It was in this way that the researchers believed the general skills were infused into the teaching program.

Adey (1994) believes the 'long-term far transfer' effect was due to the general intervention strategy, rather than to any other effect which could be said to have influenced student intrinsic motivation (p. 198).

The concept of transfer stems from learning theory and refers to the process in which knowledge acquired in one context is able to be applied in another, different context (Perkins and Salomon, 1992). Using this definition of transfer, Perkins and Salomon (1991) report that research on transfer "has shown that transfer often does not occur" (p. 218). Neither the study by Adams (1989), nor the study by Burden (1987), both of which reported on evaluations of IE, the Productive Thinking Program, and CoRT showed significant transfer effects. Hunter-Grundin's (1985) study of CoRT did not
report on any evidence of transfer, although Edwards (1991) suggested that transfer had occurred across language-arts and social-studies achievement.

De Bono (1976) states that through the use of CoRT,

(i)t seems that there is good direct or indirect transfer to English essays... But unless a deliberate effort is made the transfer to other subjects is poor... The transfer to situations outside school seems good, however (p. 242).

De Bono (1994) clarified the issue of transfer by saying

Thinking is the operating skill with which intelligence acts upon experience. Intelligence is a potential. Thinking is an operating skill. That skill can be improved by direct attention. Thinking skill can be taught directly as a subject. The method I prefer is the 'tools method'. Thinking tools are designed from considerations of the mind as a self-organising information system. These tools can be learned and practised on a wide variety of different thinking situations. In this way skill builds up in the use of the tool. The tool is then applied to new situations. In this way transfer is achieved (p. 54).

Lawson (1991) presents a transfer model which comprises the following steps:

pre-training assessment of strategy use,
training in use of strategy,
acquisition of strategy assessed,
maintenance of strategy over time assessed,
transfer of strategy use on novel task assessed (p. 209).

Lawson (1991) believes this model depicts the 'typical transfer situation'. The model assumes that training in the use of a thinking strategy has occurred and the researcher is attempting to investigate strategy use over time and in different situations. Lawson (1991) points out that an understanding of transfer is important because a student who is able to show
use of a trained strategy on a novel task, without the need for prompting, is likely "to display other effective learning behaviours" (p. 209). This view is supported by Vygotsky (1978) with the concept of the zone of proximal development, which regards a student's ability to transfer a strategy to a new situation as a sign of cognitive competence. Hiebert and Wearne (1988) have discussed this view in relation to mathematics:

Tasks that measure transfer are those that have not been included in the instructional activities, but that require the target cognitive process(es). Because such tasks are novel it is likely that they will require some processes in addition to the target processes for solution... Spontaneous use of the target processes to solve these novel tasks indicates that the processes are learned at a deep and enduring level (p. 108).

Swanson (1989) identifies lack of transfer as one of the characteristics of students with learning problems and others (Crisafi & Brown, 1986) believe it is often lacking in otherwise competent children. Gage and Berliner (1988) point out that discussion of transfer is often overshadowed by discussion on learning. This situation, Lawson (1991) believes, is due to the influence of behaviourist psychology, where learning is often regarded as a state prior to, and as a prerequisite for, transfer. Researchers (see Borkowski & Varnhagen, 1984) who adopt this view usually explain transfer in terms of generalisation, or, as occurring spontaneously. Generalisation refers to the degree of spread, or the extension of the sphere of influence of the strategy, to encompass situations that are different from those that were present at the time of training. Spontaneity is indicated by the independence of the student from support structures available at the time of training and from any prompting by the teacher.
Perkins and Salomon (1989, 1991) make a distinction between 'low-road' transfer and 'high-road' transfer, pointing out that not all transfer is spontaneous. 'Low road' transfer '... reflects the automatic triggering of well practised routines in circumstances where there is considerable perceptual similarity to the original context' (1991, p. 218). 'High-road' transfer ... depends on deliberate, mindful abstraction of skill or knowledge from one context for application in another' (p. 218). Lawson (1991) argues that,

(m)uch use of learned strategies results from a lengthy and deliberate processing. To describe all transfer as being spontaneous, or as involving only generalisation, is to seriously understate its complexity (p. 222).

Lawson (1991) presents a list of factors (Table 4) which is suggested as having an influence on the production of transfer.
Table 4
Selected factors argued to facilitate strategy use

<table>
<thead>
<tr>
<th>Dispositions</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Retrain attributional style (Short &amp; Ryan, 1984).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metacognition knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Discuss purpose of strategy training (Lawson &amp; Fueloep, 1980).</td>
</tr>
<tr>
<td>* Teach specific strategy knowledge.</td>
</tr>
<tr>
<td>* Teach general strategy knowledge (Pressley, 1986).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Teach attention focusing strategies (de Bono, 1982).</td>
</tr>
<tr>
<td>* Prompt analysis of key features of concepts (Stein et al., 1986).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge base</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Teach mastery of basic knowledge (Pressley, 1986).</td>
</tr>
<tr>
<td>* Encourage induction of explicit schema (Gick &amp; Holyoak, 1983).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Teach executive processes (Belmont et al., 1978)</td>
</tr>
<tr>
<td>(Brown &amp; Campione, 1978).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Promote discrimination and extinction of attention (Zeaman &amp; House, 1984).</td>
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</table>

<table>
<thead>
<tr>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Provide active manipulation of materials (Borkowski, Levers &amp; Gruenenfelder, 1976).</td>
</tr>
<tr>
<td>* Provide multiple examples (Gage &amp; Berliner, 1988).</td>
</tr>
<tr>
<td>* Provide error information and corrective feedback (Gerber, 1986).</td>
</tr>
</tbody>
</table>

(Lawson, 1991, p. 225)

5.4 Conclusion

Baldwin (1896) stated that it would not be surprising "... to find the unthinking masses drifting along in grooves made by their predecessors" and that "a great want of the world is thinking teachers capable of educating a race of thinkers" (p. 185). A century later Nickerson et. al. (1985) noted,
If one accepts the idea that a fundamental challenge for education today is to prepare people to anticipate change - to reshape the future rather than accommodate to it - the need for a better understanding of how to teach thinking skills becomes apparent (emphasis added) (p. 5).

When considering which thinking skills approach to use, it should be kept in mind that while "some thinking skills training programs are probably not a whole lot better than snake oil ... the good ones, although not miracle cures, may improve thinking skills" (Sternberg & Bhana, 1986, p. 67). In reviewing the effects of thinking-skills programs, one of the issues relates to the amount of engaged time it takes for the program to be most effective.

Shayer and Beasley (1987) asserted that: "the intended frequency of IE lessons is five 50 minute to one hour lessons a week, for a period of two years at least, ... and that three lessons a week is the minimum frequency at which the intervention is effective" (p. 104). This statement has some validity for evaluations of IE that were of a reduced duration (e.g. Brainin in Burden, 1987; Narrol, Silverman & Waksman, 1982) were shown to be less effective. However, this problem does not appear to be evident in CoRT evaluations. Only Hunter-Grundin’s (1985) study and Edwards’ (1994) research exceeded the typical 10 lessons from CoRT-1. It is worth noting that the gains reported by Edwards (1988) were achieved with two lessons per week for a total of only eight hours of instruction over five weeks. This appears to be an impressive achievement especially when compared with the more extensive
interventions of IE (up to 500 hours) and the Productive Thinking Program (on average 32 hours). Edwards (1994) argues that the more substantial CoRT interventions involving infusion of the CoRT skills, throughout the curriculum, and once the skills have been mastered, produce more powerful results. This is an initial reason for the use of the CoRT-1 program in this work.

The CoRT program (de Bono, 1976), along with the Productive Thinking Program (Covington, 1985) are intended for an upper school audience while IE is intended for disadvantaged young adolescents from 12 to 14 years (Shayer & Beasley, 1987). The similarity of age, for effective program use, allows reasonably fair comparisons to be made across program evaluations (Edwards, 1988). The similarity in the age of students used in this study is a further reason for the use of CoRT-1.

In a number of IE evaluations, teacher support and program monitoring was evident (Burden, 1987). In Narrol et al's. (1982) study, weekly supervisory and consultative visits were made by the research team and each teacher involved. Additionally, the teachers kept daily logs and video-taped selected lessons, which were used in later monitoring processes. This procedure prevented all the lessons from being monitored, also the case with the Hunter-Grundin (1985) evaluation of CoRT. In the Hunter-Grundin evaluation the teachers were asked to keep daily lesson reports, a process abandoned in favour of weekly reports. A newsletter produced by the researcher was abandoned because of the disclosure of information the teachers regarded as confidential. While Hunter-Grundin did observe some of the implementation lessons, not all the observed lessons were reported
on. Unlike these evaluations Edwards (1988) observed each CoRT lesson directly in an attempt to determine how closely the implemented program matched the intended program. In the work being reported on here, the teacher as researcher was directly involved in every lesson and had first-hand experience of the programs implementation. The two reasons of proximity to implementation and ability to make comparisons with existing evaluations, are additional to those already expressed, for the use of CoRT-1.

The use of the Otis-Lennon School Ability Test (OLSAT, Otis & Lennon, 1982) by Edwards (1988), and repeated measures analysis of variance procedures (Edwards, 1988) in evaluations of CoRT, are further reasons for the use of CoRT-1 in this study. Finally, this study discusses the issue of transfer and uses the de Bono (1976), and Edwards (1988; 1991) research to compare the effectiveness of CoRT-1 in these areas, as well (These issues are discussed further in chapter 7).

The evaluations of CoRT, CASE, and IE discussed in this Chapter suggest that these programs do lead to improved academic performance and that transfer of the general skills across subject disciplines, does occur. This established, we turn in the next Chapter to the relationship between thinking, learning, metacognition and problem solving.
6.0 Problem Solving.

a) Problem Solving as part of the Learning Experience.

Some researchers have argued that problem solving is an essential part of the learning experience, especially in mathematics education (Charles, 1983; Greeno, 1988; Lave, Smith & Butler, 1988; Lester, 1988; Resnick, 1988; Schoenfeld, 1992; Silver, 1988; Stanic & Kilpatrick, 1988; Thompson, 1985). Charles (1983) has put the case, in the claim that problem-solving can "have the potential to elicit a higher level of mathematical thinking than many of the learning tasks that students encounter in the study of mathematics" (p. 50).

Mayer (1991) analyses mathematical problem solving as incorporating a series of steps. The first step is problem representation, in which a conversion of the words and pictures that make up the problem is made into an internal mental representation; the second step comprises problem solution, where a move is made from mental representation to final solution (p. 459). Mayer (1991) points out that these two steps can each be further broken up into two subprocesses: problem translation and problem integration. Problem translation "involves converting each sentence or major clause into an internal mental representation" while problem integration "involves combining the information into a coherent structure" (p. 459). The process of translating the problem involves linguistic and semantic
knowledge while the process of integration involves strategic knowledge.

Mayer (1991) gives a definition of these various types of knowledge:

*Linguistic knowledge* - knowledge of the English language, such as recognising words, recognising that 'floor tiles' and 'tiles' refer to the same objects, and determining that the room is a rectangle with 7.2-meter length and 5.4-meter width.

*Semantic knowledge* - knowledge of facts about the world, such as that 1 meter equals 100 centimetres or that squares have four equal sides.

*Schematic knowledge* - knowledge of problem types, such as knowing that area problems are based on the formula area = length x width.

*Strategic knowledge* - techniques for how to use the various types of available knowledge in planning and monitoring the solution of problems, such as setting subgoals like finding the area of the room and finding the number of tiles needed.

*Procedural knowledge* - knowledge of how to perform a sequence of operations, such as how to divide 0.09 into 38.88 (p. 459).

Problem solution can also be broken up into subprocesses: solution planning and monitoring, involving the development and overseeing of a plan to solve the problem; and solution execution, involving the completion of the plan. Mayer (1991) points out that "planning and monitoring depend on strategic knowledge, whereas execution depends on procedural knowledge" (p. 459).

Stanic and Kilpatrick (1988) have identified problem solving as having three themes. The first is problem solving in context, where the process is used to reconcile other goals. This theme relates to the role that problems play:

as a justification for teaching mathematics,

to provide specific motivation for subject topics,

as recreation,
as a means of developing new skills, as practice.

The second theme identifies problem solving as a skill. The teacher outlines the strategies available to solve problems, and, with practice by the student, successful use of these strategies is attained. The third theme depicts problem solving as an art. Stanic and Kilpatrick (1988) argue that problem solving can be learnt by imitation and practice.

Polya (1957) believed that the purpose of problem solving is to train students to become better thinkers, to assist students to think for themselves. In the process of problem solving, Polya (1965) identified four steps:

- Understanding the problem,
- Devising a plan,
- Carrying out the plan,
- Looking back.

These four steps are similar to the four phases of problem solving identified by Wallas (1926):

*Preparation* - information is gathered and preliminary attempts at solution are made.

*Incubation* - the problem is put aside to work on other activities or sleep.

*Illumination* - the key to the solution appears.

*Verification* - the solution is checked out to make sure it 'works'.


Duncker (1945) conducted research into the stages of problem solving by analysing the spoken-aloud thought processes of a subject, while the
subject was thinking. Duncker (1945) concluded that there were four basic processes that were part of problem solving:

*Functional solution or value* - elements of the problem must be seen in terms of their general or functional usefulness in the problem, and general or functional solutions precede specific solutions,

*Reformulating or recentering* - problem solving involves successive stages of reformulating (or restructuring) the problem with each new partial solution creating a new, more specific problem,

*Suggestion from above* - reformulating the goal to make it closer to the givens,

*Suggestion from below* - reformulating the givens so they more closely relate to the goal, ... (Mayer, 1991, p. 52-53).

### 6.1 Components of Problem Solving.

#### a) Novice and Expert Problem Solvers.

Several researchers have studied differences between novice and expert problem solvers. Chase and Simon (1973) found that experts have a greater store of specific knowledge, but not necessarily more cognitive skill, than novices. Chi, Glaser, and Rees (1982) comment on the problem solving difficulties of novices thus:

the problem-solving difficulties of novices can be attributed to inadequacies of their knowledge bases and not to limitations in the architecture of their cognitive systems or processing capabilities (p. 71).

Sweller (1989) and Sweller and Owen (1989) point out that there is strong evidence that experts have a better memory than novices in relevant problem states. Not only do experts have a better memory of problem states
but they also categorise problems differently from novices. Experts classify problems according to the particular principle that needs to be invoked to solve the problem. Novices classify the problem according to the surface structure of the problem regardless of any underlying principle of solution. Experts and novices also differ in their use of problem-solving strategies. Novices use means-ends analysis to solve problems while experts used schema acquisition and rule automation.

Mayer (1991) summarises four major aspects of expert problem solving:

With respect to factual or syntactic knowledge, experts store knowledge in large units that can be accessed rapidly.  
With respect to semantic knowledge, experts can relate specific features of a problem to meaningful underlying concepts.  
With respect to schematic knowledge, experts can discriminate among problem types in a way that allows them to categorise problems based on solution plans.  
With respect to strategic knowledge, experts work forward guided by a global plan and consider alternatives (p. 413).

Dreyfus and Dreyfus (1986) conducted a study of expert and novice problem solving, looking particularly at the differences between behaviour. They commenced their research by studying novice and expert chess players and by studying novice and expert pilots. From their research they postulated that people go through stages: novice - advance beginner - competent - proficient - expert. Dreyfus and Dreyfus (1986) suggest that novice behaviour is characterised by being rule-governed.

They point out that there is little else a novice can do but rely on rules; if there is no experience then there is a problem deciding how to act, and
therefore an individual will follow established rules. When an individual is a
novice the individual needs rules, but the individual needs particular types of
rules: these are widely generalisable rules. When the individual is a novice,
the individual needs things that work in a wide range of settings; this is why
Dreyfus and Dreyfus (1986) argue that novices require widely generalisable
rules. The theory further states that, as the individual progresses from
novice to expert, rule-governed behaviour drops away to zero. The
behaviour of experts is not governed by rules. No-one can teach a person to
be an expert; an individual learns to be an expert by doing things, by
thoughtful, lived experience.

Edwards (1995) provides an example of this through the use of the
anecdote about a teacher who has been teaching for thirty years and is still a
first-year-out teacher, because the teacher has not been teaching for thirty
years at all: the teacher has been teaching for one year thirty times.

Experts know the rules; they know them so well that they ignore them.
The kind of rules experts know so well, according to the theory of Dreyfus
and Dreyfus (1986), is different from the rules novices use. Experts’ rules
are highly contexturalised rules; experts have the ability to pick the context
and use the appropriate rule. Novices, on the other hand, have limited
experience and need rules to help them. Advance beginners are people who
are starting to develop their own experience. They still rely very much on
rules but are characterised by thinking that there is an answer available
somewhere.

Competent people are highly analytical; they take problems, analyse
them, break them down, make good plans, and are thorough in what they do.
Proficient people start to be intuitive in the way they do their work, but they also start to synthesise. Proficient people are also easily recognised by their maxims; they will give an exception to the rule every time. What separates the proficient people from the expert is that proficient people know intuitively that something needs to be done and before they act they go back into analysis. The expert knows what needs to be done and does it.

Ross and Maynes (1982, pp. 11-12) state that experts have a better understanding of how to solve problems than do novices. They point out that novice problem-solvers use oversimplified strategies that contain only a few inadequate steps. Expert problem-solvers, in contrast, use complex procedures that comprise many more steps which are organised into meaningful structures.

While the strategies of expert problem-solvers are much longer than those of novices, the expert requires less time to solve a problem. This is because the strategies employed by the expert have become automatic, placing less demand on the expert's cognition. One of the reasons why experts' tend to need less time to solve a problem is because the experts' problem-solving strategies have been organised into more efficient processes. Sweller (1993) suggests that the cognitive load required to carry out a task is determined by the way the task is presented. Unnecessary structural features of tasks, presented to a learner in learning and problem solving, impose a heavy cognitive load and work to prevent effective learning and problem solving from taking place. Schema acquisition and rule automation allow the expert to skip steps and to use short cuts. The expert combines operations into more compact systems after component operations have been fully mastered. The expert is not able to show a novice how to solve a problem using an expert strategy because the novice would find the
strategy unworkable, because the novice had not mastered the component operations.

A further distinguishing feature between expert and novice problem solving relates to the extent that the problem solver is conscious of his or her own cognitive processes. Usually, the novice is a follower of the rule and is unreflective about the problem-solving process. The expert, however, is very conscious of the cognitive procedure involved and undertakes to monitor the process involved.

Ross and Maynes (1982) point out that experts differ from novices in the degree to which they are able to diagnose a problem as belonging to a particular type. The expert is able to relate aspects of a problem to the general-solution case and apply generalisable-solution strategies. Ross and Maynes (1982) comment that the ability to relate problems to general-solution categories can be assisted through learning (p. 12). They point out that

(o)ne would anticipate that instruction in solving one problem type would have beneficial effects in learning to solve problems within a second type: at a minimum one would expect that learning time would be modestly reduced (p. 32).

b) Means-ends analysis.

Means-ends analysis is a strategy used in an attempt to reduce differences between each problem state encountered and the goal state. This technique normally involves working backward from the goal to the givens. Means-ends analysis places a heavy load on cognitive-processing
capacity and interferes with learning. There are two related reasons put forward by Sweller (1989) and Sweller and Owen (1989) as to why this is the case. Using means-ends strategies to solve a problem only engages the problem solver in attaining the goal; the learning processes encountered along the problem-solving path are largely ignored. The other reason involves the problem-solving process used in means-ends strategy. The solver must simultaneously cognitively handle the current problem state, the goal, any relationship between the current and goal states and the relationship between these states and problem-solving operations. This leaves the solver with little working memory for schema acquisition. Schema acquisition enhances expert problem solving through the recognition that particular problems require particular patterns for solution. Once the schema has been acquired, the expert is able to generate the appropriate moves for problem solution, a forward-working procedure. The expert uses the schema to encode and reproduce problem states and solutions, a process that reduces the cognitive load on working memory. Novices do not have the appropriate schema and are therefore forced to engage in lengthy and slow search processes.

**c) Rule automation and schema acquisition.**

Rule automation assists problem solving and learning by allowing problem-solving operators to be engaged automatically without conscious processing. Rule automation leaves enough cognitive processing for means-ends analysis to be used. If one attempts to use a nonautomated rule, it is possible that there will be insufficient cognitive space both to access the rule and conduct an efficient search for a solution.
Sweller (1989) believes that "schema acquisition and rule automation may be the basic components of skilled problem solving" (p. 458). Schema originated strategies can "provide relatively effortless solutions" (p. 459) and, if the problem has been correctly classified, "will be rapid and probably error-free" (p. 459). Rule automation allows cognitive space to be fully utilised for the problem-solving search rather than being wasted in attempts to recall the rule. If schema acquisition and rule automation are not utilised then the problem-solving strategy of means-ends analysis will frequently be used and this strategy can interfere with learning. Sweller (1989) outlines the negative effect means-ends analysis can have on learning. In summary, Sweller (1989) argues that means-ends analysis directs attention to "inappropriate aspects of the problem" (p. 460) and imposes heavy cognitive load that prevents cognitive resources being applied to the solution.

d) The use of worked examples.

In order to enhance learning, Sweller (1989) proposes working forward using a goal-free strategy, which reduces cognitive load, and directing attention through the use of worked examples. A goal-free strategy is one that does not include a specific goal, so the solver is required to work forward from the givens. Sweller comments, drawing on his findings, that

(from an educational point of view, the results suggested unambiguously that practice on goal-free problems enhanced learning more than did practice on conventional problems (p. 462).

The use of worked examples also reduces cognitive load by focusing attention on the problem state and associated moves. The research of Cooper & Sweller (1987) suggested that the use of worked examples reduced cognitive load, facilitated schema acquisition, and increased
problem-solving flexibility. The conclusion reached by Sweller (1989) was that "a far heavier than usual use of worked examples should be beneficial to students" (p. 463).

6.2 Teaching Problem-solving Skills.

a) Introduction.

Ross and Maynes (1982), believe that there is a general procedure for teaching problem-solving skills. This procedure involves seven steps, namely, the teacher is advised to:

1. select an instructional context;
2. construct growth schemes;
3. set problem-solving goals for the context;
4. develop practice materials;
5. develop teaching strategies to promote growth;
6. develop test instruments;
7. sequence instructional events in lesson plans (pp. 13-32).

However, Thompson (1988) takes the view that teaching problem solving is an art, and therefore, a prescriptive method or methods of how best to teach problem solving will never exist.

Before Thompson had developed this view, Polya (1957) devised a heuristic framework to assist students with problem solving. The framework consisted of four steps:

1. Understanding the problem.
2. Devising a plan.
3. Carrying out the plan.
4. Looking back (pp. xvi-xvii).

Polya's (1957) framework does not include metacognitive components, and in his opinion, only through the practice of problems do students develop their problem-solving skills. Lester (1988) disagrees, offering the example that "I became convinced that training in the use of a collection of skills and heuristics without attention to affective and metacognitive aspects of problem solving is inadequate" (p. 117). Silver (1985) added weight to the argument by stating, "careful observation of many persons solving complex math problems suggest that many of the important influences on the success or failure of a problem-solving episode may be metacognitive in nature" (p. 260).

Schoenfeld (1982) undertook a study with a group of college students, which attempted to investigate their 'managerial strategies' of problem solving. Schoenfeld (1982) based the study on the following hypothesis

... that in addition to an adequate knowledge base of facts and principles, the following are necessary (and on the cognitive side, perhaps sufficient) conditions for success in problem solving:
1. a mastery of basic problem solving techniques, and
2. a 'managerial strategy'. This helps to select appropriate approaches to problems and to terminate fruitless ones-in general, to help one budget problem-solving resources (p. 32).

This study concluded that students, who were able to use heuristic interventions and who had the 'managerial strategy' to be able to monitor their problem-solving processes, showed improvement in their learning. While these findings were tentative in their conclusions they did lay the foundation for other research studies.
Artzt and Armour-Thomas (1990) set up a study to investigate the heuristic and cognitive processes in mathematical problem solving. One outcome of the research was the development of a framework for protocol analysis. Hayes (1989) defines a protocol as "a description of the activities, ordered in time, in which a person engages while performing a task" (p. 69).

Hayes (1989) points out that researchers are not interested just in the answers protocol analysis gives, "but, more importantly in the sequence of things they do to get those answers" (p. 70). According to Hayes (1989) there are three kinds of protocols: motor protocols, eye-movement protocols, and verbal protocols. Motor protocols are the physical activities of the subject; eye-movement protocols are the places where the subject fixes sight; and verbal protocols are 'thinking-aloud' protocols, where the subject is asked to say everything that occurs, no matter how trivial it may seem. The protocol analysis is an attempt to describe the psychological processes that a subject uses to perform a task. As Hayes (1989) points out,

(t)he psychologist's task in analysing a protocol is to take the incomplete record provided by the protocol, together with his knowledge of human capabilities, and to infer from these a model of the underlying psychological processes by which the subject performs the task (p. 81).

The Artzt and Armour-Thomas (1990) study involved video-taping seventh-grade students solving problems in small groups. The protocols of the students were analysed while they were solving problems. A conclusion reached by the researchers was that students were more successful at solving problems when they engaged in metacognitive processes. The study also concluded that cognition and metacognition were interdependent. Greater metacognition, to the detriment of time for cognitive operating, did
not necessarily lead to success in problems solving. The converse was also shown to be true; that is, more cognitive operating and less planning or monitoring did not lead to success in solving problems. The study reported that students did not progress sequentially in their problem solving. The students appeared to move between behaviours in a random, or at least non-linear, way. The use of small groups was believed to have pedagogical implications, in that small groups allowed the teacher to detect better their strengths and weaknesses in problem-solving skills, and then the teacher could use this information to improve instruction. Additionally, the small-group method was thought to allow teachers better access to student metacognitive processes and to identify individual learning styles and differences.

6.3 The use of Metacognitive processes to teach problem-solving.

a) Introduction. An understanding of Metacognition.

Researchers have begun to look closely at metacognition as a way of developing students' problem-solving skills, although this is not a new phenomenon. The Ancient Greeks believed it to be educationally important to 'know thyself' (Biggs & Moore, 1993, p. 307). Dewey (1910) referred to 'reflective self-awareness', and, more recently, Flavell (1976) discussed metacognition as being "one's knowledge concerning one's cognitive processes and products ... (It) refers to the active monitoring and consequential regulation of those processes" (p. 232). Biggs and Moore (1993) believe metacognitive processes "are those that imply self-determination, or autonomy, in learning and problem solving" and they go on to say that metacognition "refers to controlling the 'how' and the 'when, where and why', or in other words, the procedural and conditional knowledge of
learning (p. 307). Mayer (1991) states that metacognition "refers to an awareness of one's own cognitive processing (p. 256), while Schoenfeld (1992) refers to metacognition as the executive function of thinking.

b) Approaches to learning using Metacognitive Instruction.

Biggs and Moore (1993) point out that a great deal of research consistently finds that there are three approaches to learning, which have been labelled, surface, deep and achieving (p. 310). Surface learning is basically extrinsic; that is the task is carried out because of the influence of either positive or negative consequences. Surface learning can reveal metacognitive skill, but more frequently this approach is used without evidence of metacognition. Brophy (1986) suggests that the main influence operating on the student is to get the task out of the way.

The deep approach is mainly based on intrinsic motivation and as Biggs and Moore (1993) point out students using this approach will:

- possess a great deal of relevant knowledge;
- operate at a high, or abstract, level of conceptualisation;
- reflect metacognitively on what is to be done, using optimal strategies for handling the task;
- enjoy the process;
- be prepared to invest time and effort (p. 312).

The achieving approach implies competition for grades and cost-effective use of time and effort. Biggs and Moore (1993) point out "deep and achieving scores were highest when students said that they enjoyed school, saw school as useful and their teachers as fair" (p. 318).
Wang, Haertel & Walberg (1994) revealed that student aptitude was the most influential of six broad types of influences on student learning, comprising 54.7% (p. 78). Among the categories of student aptitude, metacognitive processes was shown to have the most powerful influence on a students' learning (p. 74), while of the 28 categories that influenced student learning, metacognitive processes rated second, just behind classroom management (64.8%), at 63% (p. 78).

Biggs and Moore (1993) believe that there are three ways that students acquire appropriate learning strategies:

- Spontaneously, through wit and experience;
- Implicitly through teaching; and
- Explicitly through teaching (p. 324).

They go on to make the comment that: "(f)or teachers, the first position is irresponsible, the second admirable and the last controversial" (p. 324), and as the controversial one, that it is the last that draws their attention. In making a summary Biggs and Moore (1993) state:

Learners need to acquire strategies for self-direction and autonomy in learning. Two main approaches to teaching strategies are in use: teaching strategies within the context in which they are to be applied and teaching strategies so that they transfer across contexts. ... Heuristics, or self-questioning, can also be taught, either as general problem-solving strategies or again as keyed into content teaching. There's also evidence that teaching students about the psychology of learning can help them learn better (p. 333).

Garofalo and Lester (1985) have developed a cognitive-metacognitive framework which was the result of an effort to develop a metacognitive tool for analysing metacognitive aspects of mathematics performance. The framework consists of four categories of activities involved in performing
mathematical tasks, namely: orientation, organisation, execution and verification. These four categories bear a close resemblance to Polyà's (1957) four-phase model of problem solving, with the addition of explicit metacognitive aspects. Garofalo and Lester (1985) believe the framework could be used as an introductory approach to the investigation of metacognitive aspects of mathematics problem solving.

Fortunato, Kehr Hecht, Tittle and Alvarez (1991) offer an alternative approach to metacognitive instruction. In this study the emphasis was directed toward the processes employed in solving a problem rather than the solution to the problem. To assist in focusing on this emphasis, students were required to respond to statements about their thinking before, during, and after working on a problem. The statements all related to aspects of metacognition and were grouped in four sections. The sections related to:

- interpretation of the problem and planning;
- monitoring the solution processes;
- evaluation of the procedure chosen; and
- strategies selected and alternatives.

The results of the responses can be used to form the basis of discussions on problem-solving strategies. It is thought that these discussions then serve to assist the development of the metacognitive skills of awareness and control of cognitive operations.

Gray (1991) suggests classroom activities which are designed to cater for the development of metacognition, again, specifically in the mathematics classroom. Gray argues that an awareness of one's thinking and the ability to describe one's thought processes are important in the development of metacognitive skills. Gray recognises that the task of describing the thought
processes that occur during problem-solving is very difficult. In recognition of this difficulty, Gray suggests the use of student pairs in problem solving and incorporating verbal and written descriptions of the thinking processes. Using simple problems, Gray points out that students appear to be more able in describing their thinking if they are given a specific problem to answer. Questioning by the teacher helps to direct the student's thinking and to assist the student to give feedback. By giving verbal and written responses to the thinking process, the present author believes this will assist reflection and monitoring, which, in turn, will assist the students to self-evaluate their thinking. Gray (1991) used a number of other strategies which were believed to assist students to focus on an awareness of their thinking. These strategies include:

- An emphasis on planning, where students would generate a list of questions or information they needed to assist in problem solution.
- Clarification of parts of the problem, where students would rewrite problems in their own words.
- Encouragement given to students to collaboratively devise many different ways to solve a problem, and then to reflect on the methods utilised.
- Encouragement given to students to examine the solutions they have found to be problems and to be self-monitoring.

Perry (1994) states that teachers can encourage students to be better thinkers. One aspect of being a better thinker is to increase our knowledge of how we go about thinking. Perry (1994) argues that 'thinking aloud' helps students to become more aware of their own learning processes. The teacher can assist the student by not only encouraging 'thinking aloud' in the learning environment but also through the use of 'strategy awareness'
questions, 'strategy-control' questions and 'strategy-use' questions (p. 1). This questioning technique allows students to focus their thinking, in the same way that de Bono's thinking 'tools' allows the student to focus and then consider a wide range of alternatives. While Perry (1994) presents 'thinking aloud' as a metacognitive skill, the main point is the teacher's role in the successful teaching of the strategy. Costa and Lowery (1990) hold the same opinion on the vital role of the teacher in enhancing student thinking and learning. They outline several instructional techniques that can be used to assist in problem-solving and in improving students' knowledge of how they think and learn.

Having considered aspects of the relationship between thinking, learning, metacognition and problem solving, the next section explores basic brain functions, as part of a metacognitive process, which can be taught to students, and is designed to enhance student understanding of thinking and learning processes.

6.4 Understanding basic brain function.

   a) An Historical Perspective.

An understanding of an individual's cognitive resources should also involve a basic understanding of brain function. Plato was convinced that the mind must be located in the head because the head is shaped like a sphere, Plato's idea of the highest geometric form. Aristotle, on the other hand, believed the mind to be located in the heart, as it was at the centre of the vitality and warmth of the human body. Hippocrates noted in a study of an epileptic patient that there appeared to be a mental duality in the patient's behaviour: it was as though there were two minds in the one brain.
Archilochus, an Ancient Greek poet, believed that individuals were divided into two groups: those who believed in one big thing (these individuals Archilochus labelled hedgehogs); and the foxes, who believed in many little things (Berlin, 1953). Bacon believed that humans displayed two ways of knowing: one through argument and one through experience. In 1844 Wigan reinforced the idea of two minds and in 1874 Hughlings-Jackson put forward the concept that one hemisphere of the brain was the more dominant (Herrmann, 1994, p. 27). The French philosopher Descartes believed the mind, while it lived in the brain, was a non-material entity, entirely separate from physical tissue. Descartes pronounced "I think therefore I am", giving his clear indication that consciousness is the only sure evidence that we really exist. Sperry (1977) and Ornstein (1976), after separately conducting experiments, came to the similar conclusion that there were specialist regions within the brain. Today powerful technologies, such as magnetic resonance imaging and positron-emission tomography have provided a window on the human brain. The recognition of the importance of understanding brain function comes with the then United States President Bush declaring the 1990s the Decade of the Brain.

b) Contemporary views on brain function.

i) Damasio.

Damasio (1995) argues that Descartes was wrong in his concept that the mind and brain are independent. Damasio (1995) believes that the mind is created by the brain and consciousness is the result of the interplay of the senses, with body chemicals, memory, emotion, language and the symbolic representations that humans use. Damasio (1995) presents the case that learning and memory are both processes by which data is stored to be retrieved at a later date. The storage takes place as a pattern of connections
between neurons, which are the brain's building blocks. The neurons transmit information in the form of electrical impulses. The neurons are separated by tiny gaps called synapses. When an impulse moves through a neuron, the cell releases chemicals called neuro-transmitters into the synapses. The neuro-transmitters work to induce or inhibit impulses in connecting neurons. When information enters the brain, the pathway that is taken is reinforced, as are the connecting neurons, allowing the information to be more readily recalled. The more the pattern is reinforced, the more likely the pattern will not go into short-term memory, but into long-term memory. From long-term memory the pattern can be recreated by inducing the neurons to be activated along the established pathway.

Damasio (1995) presents the case that memories of concrete facts and events are coordinated through the hippocampus, a crescent shaped collection of neurons deep in the brain. The amygdala, an almond-size knot of nerve cells located close to the brain stem, specialises in memories of fear and regulates the heartbeat and other visceral functions; the basal ganglia, clumps of grey matter within both cerebral hemispheres, handle cognitive functions and physical skills; the cerebellum, at the base of the brain, governs conditioned learning and some reflexes. The prefrontal cortex appears to be at work when someone is fearful, but works to control the feeling in order to work more effectively with the situation at hand. The motor cortex, located toward the front of the brain, is involved in conscious thought and controls the voluntary movement of body parts. The somatosensory cortex, located in the middle of the brain behind the motor cortex, receives and processes sensory signals from the body. The visual cortex, located at the back of the brain within the occipital lobe, receives and processes signals from the retinas of the eyes. The corpus callosum is a large band of nerve fibres through which information flows back and forth between the left and
right hemispheres of the brain. Damasio (1995) believes the thalamus is the relay station for most information going to the brain. The largest part of the brain is the cerebrum. It is divided into two hemispheres with four lobes each containing an outer layer of grey matter cells, called the cerebral cortex, and underlying white matter that relays information to the cortex. The cortex handles the most sophisticated functions of the brain, from processing visual images to thinking and planning. As a result of many years of research of both himself and others, Damasio (1995) concludes that the left hemisphere of the cerebrum controls the movement of the right-side as well as spoken language, number skills, written language, scientific skills and reasoning. The right hemisphere of the cerebrum controls the movement of the left-side as well as musical awareness, three-dimensional forms, art awareness, insight and imagination.

Damasio (1995) argues that the prefrontal-amygdala doorway is crucial as the repository of the likes and dislikes an individual collects over a lifetime. This doorway is the opening for emotional learning. If emotional memory in the amygdala is not connected then the emotional reactions which have been part of the memory are no longer triggered, and feelings become neutral. To Damasio (1995) and Goleman (1995) feelings are indispensable for rational decision making: the emotional brain is as involved in reasoning as the thinking brain. Goleman (1995) puts forward the concept that in a sense individuals have "two brains, two minds - and two different kinds of intelligence: rational and emotional" (p. 28).

ii) Herrmann.

Herrmann (1994) discusses brain dominance, called "preferred modes of knowing" (p. 17), in that each individual has a preferred way to learn,
understand, and express something. An individual's preferred mode of knowing is the one that would be used in problem solving. Herrmann (1994) argues that a left-brain approach to solving a problem would involve step-by-step procedures in a logical, sequential manner. Right-brain problem solving would be conceptual, involving movement, sound, patterns and insight all combined in a holistic approach. The preferred way of knowing is to do with what an individual prefers to learn and how the individual prefers to go about learning it. The implication for learning is that, if an individual’s cognitive style is not reasonably well matched to the delivery of information, then the learner may well have to apply greater cognitive resources to learning and may become emotionally upset, also hindering the learning process. Herrmann (1994) argues that left-brain models have become entrenched in many educational systems, which emphasises the three Rs to the neglect of intuition, art, music, and dance. Left-handedness used to be regarded as educationally noncomformist, to the detriment of the right-brain, and had to be corrected. The concentration of many learning strategies on single-side brain processes failed to recognise the duality of brain learning and the different preferred learning styles of many students.

Herrmann (1994) gives an insight into two current theories of brain organisation: the triune brain theory and the left brain-right brain theory. The triune brain theory proposes that the human brain is made up of three brains, each superimposed over the other. The first is an ancient, reptilian brain driven by instinct and working on precedent. The second is the limbic, or mammalian brain, which controls the nervous system, emotions and is the central register of rewards and punishments. The third is the neocortex, which enables humans to think, perceive, and speak. These three brains overlap in the functions that they perform yet they differ in style. The reptilian...
and limbic brains are thought to control instinctual behaviours, while the neocortex appears to be more adept at new ways of learning.

The left brain-right brain theory is composed of several parts: the left and right halves of the neocortex; the left and right halves of the limbic system; and the connectors, which are the pathways by which different parts of the brain connect to each other. In addition to these specialised structures are two ways of brain functioning: situational functioning and iterative functioning, which, added together, indicate left brain - right brain theory. The neocortex is divided up into the left and right hemispheres and this is where all the processes concerning vision, hearing, motor control, sensation, thinking and decision making, language and the formation of ideas, take place. Inside the two cerebral hemispheres are the left and right halves of the limbic system. The limbic system commands the greatest blood supply to the brain because of the large amount of work it does. This system controls body temperature, chemical balance, heart rate, blood pressure and regulates eating, drinking, sleeping, waking, emotions, and hormone release. The limbic system also contributes to cognitive processing in that it plays an important role in transferring incoming messages to memory and can overwhelm logical modes of processing by an emotional surge.

Connectors in the brain carry messages within each brain hemisphere and between the hemispheres and the two halves of the limbic system. According to Herrmann (1994) connectors within each half of the brain are made up of two types, projection fibres and association fibres. Projection fibres radiate out to each lobe of each hemisphere, linking in relay the brain stem and the cortex. Association fibres connect specialised regions in each brain half, thus allowing each hemisphere to integrate its functioning. Connectors between each brain half are called commissures, of which there
are three: the corpus callosum; the hippocampal commissure; and the anterior commissure. The commissures allow the brain to coordinate the activities located in parallel regions of each cerebral hemisphere and also in each limbic half.

Not only is the brain interconnected in its structure, but it is also situational in its functioning. Situational functioning means that when the brain is presented with a particular situation, the region of the brain that specialises in the performance of that task will be activated, while those regions not required rest. Iterative functioning is a back-and-forth movement of messages among the brain's specialised centres. This can be a single movement or a very complex process depending on the task. Herrmann (1994) linked the concepts of brain duality, left brain - right brain theories, triune brain theory, specialisation, interconnectedness, iteration, and situationality to arrive with the concept of brain-dominance profiles. These profiles stem from an individual's preferred mode of operating in each of four quadrants as identified by the Herrmann Brain Dominance Instrument (HBDI) (Herrmann, 1994).

The major patterns for individual preferences for different thinking modes, as outlined by Herrmann (1994), are:

1. Although 81 possible combinations of preferences exist, about 12 main brain-dominance profiles are present in over 80% of the population...
2. Everyone has at least one primary preference.
3. Over 90% of our data base is multi-dominant.
4. Preferences and avoidances are of equal importance.
5. Individuals with different profiles tend to behave in specific, predictable ways with regard to such things as time, creativity, dress, money, problem-solving, and intuition.

6. Individuals with similar profiles tend to communicate more easily with each other even across cultural boundaries.

7. People of similar profiles tend to gather into tribes and may exhibit classic tribal behaviour, including shutting others out and making war.

8. Problems in groups can often be resolved when people understand their profiles, as well as the tribal tendencies and the opportunities that working with a variety of different profiles can open up.

9. Many occupational norms cross cultural boundaries e.g., chemists, bookkeepers, nurses, commercial pilots, etc., because the work is the same (p. 75).

There are three important concepts that need to be kept in mind when examining brain-dominance profiles. An individual profile should be regarded as being neither right nor wrong, good nor bad. The HBDI (1994, pp. 43-73) measures preference for a mental activity, not necessarily competence in performing it, and profiles tend to remain constant, but can change. Herrmann believes that preferences across each of the four quadrants, looking at the population overall, is reasonably equal. This is considering primary quadrant dominance alone, and does not take into account multiple dominants across the quadrants. Looking at each quadrant individually gives a picture of the primary preference as if it were the only mode of operating, something that rarely occurs in nature, but can help to add understanding to the compatibilities and incompatibilities among preferences (see Herrmann, 1994, pp. 381-405 for a more detailed explanation).
The brain dominance concept has been developed by Herrmann (1994) into the whole-brain teaching and learning model (p. 220). This model divides the learning process into the four brain quadrants, the puts them into two categories: structured (left) and unstructured (right). In the structured modes (quadrants A and B), there is some "hard" processing (p. 220) which deals with logical and quantitative issues, and there are some procedural activities involving planning and sequential learning processes. The unstructured modes are non-linear, non-verbal, and "soft" processing (p. 221) which involves emotional and interpersonal activities. Herrmann (1994) believes that taken together these strategies comprise the whole range of preferences for teaching and learning.

Herrmann (1994) has labelled the quadrants as A, B, C, and D. An individual's A-quadrant preference points towards analysing, logical problem-solving, a favouring of factual information. An individual in this mode of operating only, would prefer logic and reasoning, with a noticeable absence of emotion and imagination. B-quadrant preference has a number of similarities to A-quadrant, in that they are both verbal and linear, and both reject emotion and intuition. B-quadrant-only favours experience, long-established precedence, dislikes short cuts and tends to focus on one thing at a time. Procedure and precedence, safe and predictable with a tendency towards authority, are features of B-quadrant-only preferred mode of processing. C-quadrant-only is looked upon as the most sensitive and receptive. Emotions play a large part in understanding and communicating, although the empathy between the individuals or groups is more important than the message. The most imaginative is the D-quadrant-only individual. This individual prefers the excitement of new ideas, variety, incongruities and surprises. Meeting deadlines, working with a team and communicating verbally are the processes that D-quadrant-only individuals find most difficult.
In the preceding Chapters, the present study has explored learning, thinking, metacognition and basic brain function and attempted to come to an understanding of how each is interlinked with the other. As with an understanding of the learning and thinking process, along with strategies to enhance learning and thinking, many of the aspects of metacognition discussed here will be used in the teaching of general thinking skills and problem-solving, as will be explained in subsequent discussions. This study goes on to investigate the impact, through quantitative and qualitative measures, that together they have on enhancing student thinking and learning.
CHAPTER SEVEN

THE GENERAL QUESTION FOR INVESTIGATION.

Throughout the literature review a question continued to emerge: Can student thinking and learning be enhanced through the application of a general, non-domain-specific, thinking-skills program?

One of the purposes of the literature review was to provide a background from which this question could be articulated and refined to assist in the clarification of the focus for this research. The literature review has shown that the teaching of de Bono's CoRT program, in certain instances, enhances student thinking, as does the teaching of metacognitive skills. It should be noted, however, that there is not as extensive evaluative evidence for the latter process as there is for evaluations of the CoRT program. The literature review has assisted in further refinement of the general question for investigation, which now becomes:

*Does the teaching of general thinking skills using the CoRT program, and teaching students about metacognition, improve student thinking and learning?*

This general question has been divided into more specific research questions, namely:

1. What effect does the ten-lesson CoRT -1 program have on the in-class thinking and learning of Year-Seven students from a South Coast Comprehensive High School?
2. What effect does the explanation of thinking and learning processes have on the in-class thinking and learning of Year-Seven students from a South Coast Comprehensive High School?

3. Do Year-Seven students from a South Coast Comprehensive High School, who have been taught CoRT-1, and, who have been taught about metacognition, transfer these skills to out-of-class learning and out-of-class thinking?

The first research question is concerned with the effect of the ten-lesson general thinking-skills program, CoRT-1. This research study will be useful in comparing the results of other evaluations of CoRT-1. The problem-solving and thinking-skills booklet, developed for student use as part of the research, is included in Appendix C. Students have been asked to use the general thinking-skills tools in CoRT-1 to help them solve these problems.

The second research question is concerned with the role of metacognition. The issue here is whether increasing student understanding about how each individual thinks and learns, assists students in thinking and learning processes.

The third research question addresses the issue of transfer of general thinking skills to subject-specific classroom learning and to out-of-classroom learning situations.

This section of the study identifies the research hypotheses and the general propositions for the research questions. The first research question is tested by the use of two standardised measures, while the second and third research questions are addressed by an analysis of questionnaire and
Question 1. What effect does the ten-lesson CoRT-1 program have on the in-class thinking and learning of Year-Seven students from a South Coast Comprehensive High School?

Proposition 1. The Scholastic aptitude of Year-Seven students, from a South Coast Comprehensive High School, will be enhanced as a result of their being taught the ten-lesson CoRT-1 program.

Research Hypothesis 1. There will be a significant improvement in scholastic aptitude, as measured by the Otis-Lennon School Ability Test - Level 1 Form F, for Year-Seven students (N=92) at a South Coast Comprehensive High School, who were trained in CoRT-1, when compared with a control group (N=92) of Year-Seven students from the same high school, who were not trained in CoRT-1.

Research Hypothesis 2. There will be a significant improvement in scholastic aptitude, as measured by the Otis-Lennon School Ability Test - Level 1 Form F, for Year-Seven students (N=92) who complete the ten-lesson CoRT-1 program.

Proposition 2. The approach to learning of Year-Seven students, from a South Coast Comprehensive High School, will change as a result of their being taught the ten-lesson CoRT-1 program.
Research Hypothesis 3. There will be a significant improvement in student approach to learning, as measured by the Learning Process Questionnaire, for Year-Seven students (N=92) at a South Coast Comprehensive High School, who were trained in CoRT-1, when compared with a control group (N=92) of Year-Seven students from the same high school, who were not trained in CoRT-1.

Research Hypothesis 4. There will be a significant improvement in student approach to learning, as measured by the Learning Process Questionnaire, for Year-Seven students (N=92) who complete the ten-lesson CoRT-1 program.

Proposition 3. Year-Seven students, from a South Coast Comprehensive High School, will judge that CoRT-1 has assisted them in their in-class thinking and learning.

Research Hypothesis 5. Year-Seven students, from a South Coast Comprehensive High School, will be judged, through their responses in questionnaire (N=74) and interview (N=30) to have been assisted in their in-class thinking by training in CoRT-1.

Research Hypothesis 6. Year-Seven students, from a South Coast Comprehensive High School, will be judged, through their responses in questionnaire (N=74) and interview (N=30), to have been assisted in their in-class learning by training in CoRT-1.
Question 2. What effect does the explanation of thinking and learning processes have on the in-class thinking of Year-Seven students from a South Coast Comprehensive High School?

Proposition 4. Year-Seven students, from a South Coast Comprehensive High School, will judge that the explanation of the thinking and learning process assists them with their own in-class thinking.

Research Hypothesis 7. Year-Seven students, from a South Coast Comprehensive High School, will judge, through their responses in questionnaire (N=161) and interview (N=38), that their in-class thinking has improved.

Proposition 5. Year-Seven students, from a South Coast Comprehensive High School, will judge that the explanation of the thinking and learning process assists them with their own in-class learning.

Research Hypothesis 8. Year-Seven students, from a South Coast Comprehensive High School, will judge, through their responses in questionnaire (N=161) and interview (N=38), that their in-class learning has improved.

Question 3. Do Year-Seven students, from a South Coast Comprehensive High School, who have been taught the ten lessons of the CoRT-1 program, transfer these skills to out-of-class learning and thinking?
Proposition 6. Year-Seven students, from a South Coast Comprehensive High School, use the CoRT-1 thinking tools to assist them in their thinking in out-of-class thinking situations.

Research Hypothesis 9. Year-Seven students, from a South Coast Comprehensive High School, recognise, through their responses in questionnaire (N=74) and interview (N=30), that they use the CoRT-1 thinking tools to assist their thinking in out-of-class thinking situations.

Proposition 7. Year-Seven students, from a South Coast Comprehensive High School, use the CoRT-1 thinking tools to assist their learning in out-of-class learning situations.

Research Hypothesis 10. Year-Seven students, from a South Coast Comprehensive High School, are assessed, through their responses in questionnaire (N=74) and interview (N=30), to use the CoRT-1 thinking tools to assist their learning in out-of-class learning situations.

Proposition 8. Year-Seven students, from a South Coast Comprehensive High School, use knowledge about their thinking and learning processes, to assist them in their thinking in out-of-class thinking situations.

Research Hypothesis 11. Year-Seven students, from a South Coast Comprehensive High School, are assessed, through their responses in questionnaire (N=161) and interview (N=38), to use knowledge about their thinking and learning
processes, to assist them in their thinking in out-of-class thinking situations.

**Proposition 9.** Year-Seven students, from a South Coast Comprehensive High School, use knowledge about their thinking and learning processes, to assist them in their out-of-class learning situations.

**Research Hypothesis 12.** Year-Seven students, from a South Coast Comprehensive High School, are assessed, through their responses in questionnaire (N=161) and interview (N=38), to use knowledge about their thinking and learning processes in out-of-class learning situations.
CHAPTER EIGHT

RESEARCH DESIGN AND METHOD

8.0 The Research Setting.

Seven Year-Seven classes from one New South Wales Department of School Education South Coast High school were involved in the study. The school is situated in the Shellharbour educational and local-government district. The school was chosen because of the comprehensive nature of the school (in that there are no distinguishing educational features such as disadvantage, selectivity, special focus) and that the Year-Seven student population is judged to be reflective of the socio-economic and educational standard of the community which it serves. The school organises the Year-Seven classes according to a streamed, academic structure in which most classes are of an approximately even size, except the remediation class and a 'special' class. The remediation class has some students diagnosed as slightly to moderately intellectually impaired. One class (the 'special' class) was deliberately organised to contain a larger-than-normal number of discipline problems. The Year-Seven classes were organised according to information supplied to the school counsellor from the local primary schools. Using this information a 'best-fit' situation applied, so that between each class there is a reasonable amount of overlap. A small number of academically gifted students choose to attend Year Seven at a selective high school in a
nearby city, rather than attend this local comprehensive high school. The Year-Seven students had no known exposure to the CoRT-1 program prior to this study.

Table 5 lists the classes and the size of classes that were involved in the study.

Table 5

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<th>Girls</th>
<th>Total</th>
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</tr>
<tr>
<td>7 Gold</td>
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</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>99</td>
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</tr>
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</table>
8.1 The Sample.

One hundred and eighty four Year-Seven students from a New South Wales Department Of School Education South Coast High School were the subjects of the study as either treatment or control subjects in relation to the CoRT-1 program and one hundred and sixty-one as treatment subjects in relation to metacognition. The 'treatment' teacher was an experienced teacher, who held an executive position in the school. The 'treatment' teacher had taught the CoRT program at a previous school but had not previously taught students about metacognition. This teacher had participated in two in-service courses on the use of the CoRT program. None of the Year-Seven students had been taught the CoRT program nor had any been taught about metacognition.

8.2 The Intervention.

The program consisted of the ten lessons of CoRT-1 and 6 lessons on metacognition. The 10 CoRT-1 lessons were presented to the students on a weekly basis with a gap of one week before the commencement of the six lessons on metacognition. Each lesson was scheduled for 40 minutes, although several lessons went up to five minutes over. Randomly selected students were withdrawn from main-stream English classes to attend the treatment class. English classes were specifically chosen because they are timetabled at the same time and are mixed ability in composition. These
factors assist in obtaining a random sample and are judged to be least likely to affect the overall treatment result. Class teachers continued with normal lessons for those students not randomly withdrawn. The students were provided with a work book entitled "Thinking Skills and Problem Solving" (Appendix C). The work book was an amalgam of problems that students would work on both in class and for homework. The students were expected to use CoRT-1 thinking tools and to reflect on their thinking while solving these problems. The work book was also designed to be interesting and enjoyable. The sequence of the lessons as well as a brief description of each lesson follows.

Lesson 1. PMI (Plus, Minus, Interesting). This lesson is the first lesson from CoRT-1. The PMI is used by students to assist in finding a variety of solutions to a problem or explorations of an idea.

Lesson 2. CAF (Consider All Factors). CAF involves the students in undertaking a wider exploration of the problem or idea before entering a solution. The emphasis is on what factors have been left out in the decision making process.

Lesson 3. RULES. This is a practice lesson which gives students an opportunity to practise the thinking tools PMI and CAF.

Lesson 4. C&S (Consequences and Sequel). This thinking tool is used by students when they are considering the consequences, over time, of a decision or action. The time period involved can be immediate, short-term (1-5 years), medium-term (5-25 years) and long-term (over 25 years).
Lesson 5. AGO (Aims, Goals, Objectives). This thinking tool assists the students to focus their thinking directly on what they are doing. The main point of the lesson is to have the students focus on the intention of actions.

Lesson 6. PLANNING. This is a practice lesson where students can apply the thinking tools C&S, AGO, CAF and PMI.

Lesson 7. FIP (First Important Priorities). This is a focus lesson, where the application of the thinking tool assists students to pick out the most important ideas, factors, objectives or consequences. This thinking tool can be applied when students want to compress a list of ideas which have been generated through the application of a previous thinking tool.

Lesson 8. APC (Alternatives, Possibilities, Choices). The APC thinking tool assists students to explore all the alternatives to a problem or idea besides the obvious ones. It can assist students to explore solutions, other than solutions based on emotions.

Lesson 9. DECISIONS. This lesson gives students the opportunity to practise the tools of FIP and APC as well as other tools that have been taught.

Lesson 10. OPV (Other People's Views). This lesson assists students to see the other person's point of view, and it is also the final lesson of CoRT-1.

There was a one week gap here.
Lesson 11. How the Brain functions. This lesson takes the student for a simple tour through the brain and studies how the brain functions. A plastic model of the brain gives students a 'hands-on' opportunity while parts of the brain are discussed. Concepts such as left or right hemisphere, short-term and long-term memory, synapses, brain waves, specialised functions and their location are discussed in this lesson.

Lesson 12. Continues the exploration of the brain. In this lesson the following theories are discussed:

1. Triune brain theory
2. Four-quadrant theory
3. Brain dominance.

Lesson 13. Expands on the concept of brain dominance and preferred thinking styles. The Herrmann Brain-Dominance Profile is discussed (Herrmann, 1995).

Lesson 14. This lesson explores Learning. Topics that are explored consist of:

1. What is learning?
2. Individual learning styles
3. What is thinking?
4. Motivation to learn.

Lesson 15. This lesson explores metacognition and different approaches to learning.
Lesson 16. This lesson discusses strategies that could be used to assist learning. Included in this lesson are such concepts as:

- mnemonics
- heuristics
- mind maps
- concept maps
- self-reflection.

The students were taught one lesson per week which was scheduled to last for about 40 minutes but several lessons went up to five minutes over time. The first CoRT lesson was taught in early April with the CoRT treatment finishing in late July and the study concluding in early October. The implementation schedule was interrupted during school vacations (approximately four weeks as there were two vacation periods during this time). Over the entire period, four scheduled lessons were missed due to the unavailability of the 'treatment' teacher, so there were some occasions where a class may have had two lessons in the one week, or where the treatment took a longer time for some classes. The treatment, therefore, was not exactly the same for each class each week; some classes were further ahead in the lesson schedule than others. There were not, however, any significant departures, in any class, from the recommended implementation (CoRT-1, Teacher's Notes, de Bono, 1986).
The training of the 'treatment' teacher consisted of attendance at a one-day inservice course conducted by Science Associates, the Sydney distributors of the CoRT program, held at the University of Sydney, in the second semester 1993 and again in second semester 1994. The remainder of any training was done by the 'treatment' teacher privately. This brief training program is in keeping with de Bono's recommendations (de Bono, 1994). The structure of a typical CoRT-1 lesson (Appendix A) was followed and the relevant Teacher's Notes (Appendix B) were read prior to the commencement of each lesson. An understanding of metacognition and related information was conducted as personal research and through attendance at relevant inservice courses.

8.3 Instrumentation

Two quantitative instruments were administered in this study in relation to the CoRT-1 program and a questionnaire (Appendix E), individual student questionnaire comments were recorded (Appendix F), and individual interviews (Appendix G) were conducted in relation to metacognition.

The Otis-Lennon School Ability Test Level F Form 1 (OLSAT) (Australian edition) (Otis & Lennon, 1989) was used to measure scholastic aptitude. This is a 72-item test which yields Verbal and Nonverbal sub-scores as well as the Total score. The classification of an item as verbal or nonverbal depends on whether a knowledge of the English language is
necessary in giving a response. Cluster content includes verbal comprehension, verbal reasoning, arithmetic reasoning, figural reasoning and quantitative reasoning.

The OLSAT was standardised for Australian children (aged 10-15 years) with approximately 5000 students from 190 schools and took into account the indigenous and ethnic composition of the Australian student population.

The OLSAT provides test results on raw scores, scaled scores, school ability indexes, stanine and percentile rank. The raw scores provide little information about the quality of the student performance other than the number of questions answered correctly. The scaled score links together all of the levels and different forms of the test. This is especially suitable for studying change in performance over time. The school ability index (SAI) is a normalised standard score with a mean of 100 and a standard deviation of 16 (National Norms Booklet, 1993, p. 23). The SAI places scores in bands across national averages, so that:

2% of students will obtain SAIs above 132;
14% of students will obtain SAIs between 116 and 132;
68% of students will obtain SAIs between 84 and 116;
14% of students will obtain SAIs between 68 and 84; and
2% of students will obtain SAIs below 68 (1989, p. 26).
The National Norms Booklet (sixth Ed., 1993) has SAI tables which correspond to Scaled Scores for Five-Year-Old Students up to and including 18-Year-Old Students.

Percentile rank corresponds to SAI scores by showing the relative standard of a student in comparison with students of the same age. Stanines are strongly recommended for making age-based comparisons and grade-based comparisons.

The OLSAT was selected for use in this study because it has been used as a measurement instrument of the effectiveness of the CoRT program in several Australian studies (Edwards & Baldauf, 1987; Edwards, 1991; Ritchie & Edwards, 1994) and has proved to be a reliable measure.

The Learning Process Questionnaire (LPQ) (Biggs, 1987) is designed to measure the extent to which a secondary-school student uses different approaches to learning. The LPQ is a 36-item, self-reporting questionnaire (see Appendix H) that yields scores on three basic motives for learning and three basic learning strategies. The three basic motives for learning are: surface motive, deep motive, and achieving motive. The three basic learning strategies are: surface strategy, deep strategy, and achieving strategy. Table 6 outlines the three basic motives for learning and the three basic learning strategies.
Table 6

Motive and Strategy in approaches to learning and studying

Please see print copy for image

(Biggs, 1987, p. 3)

In the LPQ manual Biggs (1987b, pp. 3-4) (Appendix H) notes that the following three points should be considered. It is possible for students to combine approaches; a combination of some approaches can predict a student's boredom with school and a possible intention to leave or a combination can predict a future tertiary education orientation; the learning styles are fairly consistent and may persist over time; and deep and achieving learning approaches are most effective when students become aware of their own learning processes. Biggs (1987a) comments:

Research performed in Australia and elsewhere makes it clear that approaches to learning have important effects on student progress. Work with the LPQ has specifically demonstrated that approaches to
learning may be crucial in determining quality of learning, formal examination results, student satisfaction and morale, and what plans the student has for further schooling (p. 7).

Teachers may use the LPQ scores to assist in instruction or to make referrals. The LPQ profiles of subscale scores should be considered in reference to either of these decisions. Table 7 shows deciles as profiles using these arbitrary ranges: 'above average' (deciles of 8,9,10) shown as '+', 'average' (deciles of 4 to 7) shown as '0', and 'below average' (deciles of 1 to 3) shown as '-'.

Table 7

Deriving profiles from subscale scores

Please see print copy for image

For further explanation six of the more common profiles are discussed. Deep (oo ++ oo or -- ++ --) (Biggs, 1987a, pp. 14-17). Students in this category tend to do well academically, relate to previous experience, and show a certain independence of spirit.

Achieving (oo oo ++ or -- ++ ++). These students tend to be careful in planning, are generally ambitious, perform well in formal examinations and have a high academic self concept.

Deep-Achieving (oo ++ ++ or -- ++ ++). This is a combination of deep and achieving with the student being oriented towards high performance.

Surface-Achieving (++ oo +). This orientation belongs to students who have a desire to achieve but adopt the easiest path to succeed.

Surface (++ oo oo or ++ -- --). Students with this profile tend to have a poor academic self-concept. They underestimate and are unhappy with their performance. Generally, these students do not have an understanding of the 'how' and 'why' of their learning. Biggs (1987a) states that these students do not have an understanding of 'metalearning' (p. 15), which is described as a student's "awareness of and control over their own learning processes" (p. 5).

The LPQ was selected for this study for several reasons. First, Biggs' approach to the measurement of learning styles on a global index represents a consolidation of much of the research that has been done on learning styles. Biggs has incorporated the major findings of leading researchers into a survey which would appear to most accurately assess students' own perceptions of their approaches to learning.
Second, the LPQ has been designed for use in secondary schools, and has been tested by Biggs (1987b) with 14 year old and year 11 students. Third, the LPQ was specifically designed for use in Australia, with Australian students.

Finally, Biggs places considerable importance on the fact that the process of learning consists of motives as well as strategies. This is developed into a theory of learning based on metacognition (1985; 1987a), which is very important to this study.

Biggs believes that there is a relationship between students and the learning process associated with any task. There is "psycho-logic" (1987a, p. 10) in how students see their personal role in a learning situation, and in making decisions about it. For each student there are two elements involved: motive and strategy. The student's "encoding strategy" (p. 10) is represented by the motive the student perceives to be dominant, and the "self-regulatory" (p. 10) system is represented by the strategy the student selects in order to deal with it.

Biggs (1987a) has developed a congruence hypothesis, which proposes that students motivated in certain ways select learning strategies that are congruent with these motives. The hypothesis also states that congruent motive-strategy combinations will be more effective than non-congruent ones.
This type of reflective self-awareness is part of what is called metacognition (Weinstein & Mayer, 1986; Derry & Murphy, 1986; Biggs, 1985; 1987). Metalearning (Biggs, 1987a) is directly relevant to the development of the LPQ and is the label given to the specialised application of metacognition to student learning. The LPQ, therefore, relies heavily on the concept of metacognition in that it seeks to measure students' awareness of their approaches to study based on the two factors of motive and strategy selection.

The LPQ has undergone several applications and experiments which have tested its reliability (Biggs, 1987a; 1987b). The stability of test scores over time has been demonstrated as being reasonable using test-retest methods. There has been some change in motivation noticed over time, but this can be explained in terms of normal development. Internal consistency has been found to be satisfactory (National Norms Booklet, 1993, p. 23). The least consistent factor is the surface motive, because this can involve two aspects of extrinsic motivation: fear of failing and doing just enough to get by.

The validity of the LPQ has also been examined (Biggs, 1987a; 1987b). This has been done primarily through experiments measuring construct validity. The construct validity of the LPQ is favourable, and in line from the theory from which it was developed. High levels of deep and achieving approaches are associated with the desire to stay in school for longer periods than are high surface approaches.
There is consistency with students' subjective estimates of performance and satisfaction with results. Results correlate negatively for surface approaches, positively for achieving and positively for deep approaches only with preferred subjects, where intrinsic motivation is significant.

Construct validity has also been measured using performance results, ability and locus of control (National Norms Booklet, 1993, pp. 24-25). Students who tend towards an internal locus of control generally do better than those more external. It was found that a deep approach improves results of students of high ability, no matter what the locus of control. For low-ability students, the deep approach only helps if they are internals, while the approach works negatively on them if they are externals. High-ability students with internal locus of control appear to be unaffected by the achieving approach, and do consistently well. However, high-ability students with external locus of control benefit greatly from an achieving approach. This approach also helps low-ability students of internal locus of control, but not those who are external.

8.4 Research Design

The Solomon (1949) (Campbell & Stanley, 1966) Four-Group Design was used in relation to the CoRT-1 part of the study. This design was used because it is regarded as having "higher prestige" (Campbell & Stanley,
1966, p. 24) and with two of the experimental and control groups' not having the pre-treatment test, then the main effects of testing and the interaction of testing and the treatment can be determined. Campbell and Stanley (1966) point out that this design increases generalisability and that the effect of the treatment is replicated in four different fashions, increasing the strength of the inference greatly. A comparison between O6 (O = test) with O1 and O3 can show the combined effect of maturation and history. The design is as follows:

```
R O1 X O2
R O3 O4
R X O5
R O6
```

The symbols for the design stand for:

- **R** = random selection
- **O** = test
- **O1-O3** = pre-treatment test groups (n=120)
- **X** = treatment (n=92)
- **O2-O6** = post-treatment test groups (n=184)

The OLSAT and LPQ instruments were administered to each of the groups by the researcher in half-group O1, O3 and combined-group O2 - O6 sittings. The tests were administered in accordance with the instructions in the various manuals, with the OLSAT administered first in each case. The pre-treatment test was conducted one week prior to the commencement of the treatment, and the post-treatment test was conducted one week after the
completion of the treatment. Figure 1 gives the test-administration schedule which must be considered with the Solomon Four-Group Design.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Pre-Test</th>
<th>n</th>
<th>Post-Test</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLSAT</td>
<td>X</td>
<td>120</td>
<td>X</td>
<td>184</td>
</tr>
<tr>
<td>LPQ</td>
<td>X</td>
<td>120</td>
<td>X</td>
<td>184</td>
</tr>
<tr>
<td>Questionnaire - Treatment</td>
<td>X</td>
<td></td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>Interview CoRT-1</td>
<td>X</td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Interview Metacognition</td>
<td>X</td>
<td></td>
<td></td>
<td>38</td>
</tr>
</tbody>
</table>

*Figure 1: Test Administration Schedule*

The OLSAT and LPQ tests were used only to measure any effect of the 10 lessons of the CoRT-1 program. All the students were taught lessons 11-16 on aspects of metacognition by the 'treatment' teacher. These lessons were conducted in the students' normal English class.

Data collected from the OLSAT were analysed by paired-sample *t* test, independent-sample *t* test, analysis of variance and an analysis of covariance using the SPSS for Windows V6.135 (1995) base pack, with professional and advanced statistics added. The hardware used comprised a Contura 410c laptop with 8mg ram.
8.5 Quantitative Analysis of Data

The SPSS for Windows 6.0 (1995) was used to determine treatment effects, on the OLSAT instrument, for the subjects involved in the CoRT-1 part of the study. The paired-samples $t$ test (O1-O2; O3-O4) was used to analyse the OLSAT data because there exists a nominal independent variable and an interval-level dependent variable and there are only two conditions in each instance. The paired-samples $t$ test allows the researcher to compare the means to determine the probability that the difference between the means is a real difference rather than a chance difference.

The independent-samples $t$ test (O5-O6) procedure tests the significance of a difference in means for independent samples.

A 2x2 analysis of variance (ANOVA) procedure is used (O2, O4, O5 and O6) to test the null hypothesis that several group means are equal in the population, by comparing the sample variance estimated from the group means to that estimated within the groups. The general factorial model is the most general procedure in SPSS for univariate analysis of variance.

The analysis of covariance (ANCOVA) is used because it tests for differences between treatment groups, adjusting for pre-existing differences.
The LPQ instrument data was interpreted according to an analysis of the decile scores and mean scores for the six subscales, the three scales and the composite approach (Biggs, 1987a, p. 12).

8.6 Analysis of Questionnaire and Interview Data

a) The Use of Students' Perspectives

The student perspective is an invaluable source of information to the educational researcher because of the roles that students continually play, either collectively or individually, in short circuiting or supporting the plans of the educational administrator. In not using the student perspective, the educational researcher is leaving out the perspective of one of the most important participants in the teaching and learning process. Edwards (1995), in particular, holds very strong views on the necessity of the researcher to research the student perspective. This view implies that students should be at the centre of educational research, rather than, as it sometimes would appear, at the periphery. This is a further reason why the student perspective has been used in this study.

There are some plausible reasons for the small number of educational research studies which have added the student perspective to the statistical data gathered. One reason could relate to the limited time available for researchers to have access to a representative sample of students in a school. Few school administrators would be pleased to have large numbers
of students withdrawn from class, nor are they willing to have school and/or classroom procedures disrupted. Class teachers also often express concerns over certain research procedures, such as video-taping or cassette recording, and can be concerned over the possibility of judgements being made on classroom management, teaching strategies and learning outcomes.

Another reason relates to the researchers' concerns about the reliability and validity of the information gained from students. However, the research of Marsh (1988) has shown that a number of research studies have sought to include data from students because the data have been found to be a reliable source. Marsh (1988) also found that students make consistent judgements, are able to provide reliable accounts of classroom behaviours and are able to make accurate judgements about the teacher behaviours they see each day. The work of Marsh (1988) is supported by Kojimoto (1987) who found students' comments as being "highly descriptive and sometimes insightful" (p. 69).

b) Questionnaire

One hundred and sixty one students completed the Problem-Solving and Thinking-Skills questionnaire, of these 74 were from the CoRT-1 treatment group. All one hundred and sixty one students participated in the problem-solving and metacognition part of the program. The questionnaire used a five-point Likert scale with students being asked to circle the response
which is most correct for themselves. The five-point scale rating categories were:

5 means all the time  
4 means most of the time  
3 means half of the time  
2 means some of the time  
1 means not at all.

Of the ninety-two students who had been randomly selected from the Year-7 cohort to be CoRT-1 treatment students, seventy-four were randomly selected to complete the questionnaire. Questionnaire items 1, 2, 5, 7, and 8 specifically relate to these students. Item 5 is included as part of the identification of whether students transfer CoRT-1 strategies to situations outside the classroom. The questionnaire items are:

1. Thinking tools, such as CAF and PMI, make it easier for me to think about the work that I am doing.

2. Thinking tools, like CAF and PMI, have made it easier for me to learn.

5. I use thinking tools, such as CAF and PMI...

7. I believe that using thinking tools, such as CAF and PMI, will help me to learn.

8. I believe that using thinking tools, such as CAF and PMI will help me to think.
Questionnaire items 3, 4, 6, 9, and 10 relate to metacognition; all students completing the questionnaire were able to respond to these items. Item 6 is part of the process of identifying whether students transfer this knowledge to situations outside the classroom. These questionnaire items are:

3. Learning about how the brain functions has made it easier for me to understand how I think.

4. Learning about how the brain functions has made it easier for me to understand how I learn.

6. I use knowledge about how the brain functions ....

9. I believe that understanding how the brain functions will help me to learn.

10. I believe that understanding how the brain functions will help me to think.

Students were asked to respond to these items on the same five-point scale already outlined. The data from the questionnaire were analysed using Chi-Square likelihood ratio available in the SPSS program.

c) Interviews

Of the 92 CoRT-1 treatment students 30 were randomly selected for an individual interview. Of the 184 students in the Year-7 cohort, who were taught aspects of metacognition, 38 were randomly selected for an individual interview. In both cases the interview was held during school time with the students being withdrawn from class.
The CoRT-1 treatment students were asked the following questions:

1. Has being taught thinking strategies, from the CoRT-1 program, helped you to think?

2. Which of the CoRT-1 strategies can you recall? Why does this strategy stand out?

3. Has using Cort-1 strategies, like CAF or PMI, helped you to learn?

4. Do you use any CoRT-1 strategies in the classroom? Which strategy? Which lesson(s)? Is there any particular reason for this?

5. Have you used any CoRT-1 strategy, in any situation, outside the classroom?

6. Have the CoRT-1 strategies helped you? If so, why? If not, why not?

The 38 students who were individually interviewed about aspects of metacognition were asked the following questions:

1. Has learning about how the brain functions helped you to learn?

2. Has learning about how the brain functions helped you to think?

3. Do you think about your own preferred way of learning?

4. Do you think that an understanding of how you learn will help you - in school? - out of school?

5. What do you think your preferred way of learning is?

6. What is the difference between thinking and learning?
Each student interview was conducted in a separate room and field notes, as well as student responses, were recorded in writing. Some interviews were audio-taped, though this procedure was used only randomly as many students felt intimidated by the process. The audio-taping of students ceased when it was felt that students were being restrictive in the responses they were giving. As a trial strategy six students were videotaped, but this was also felt to be intimidating. This procedure was also discontinued very early in the interview schedule. The taking of field notes and allowing students to write out their responses during the interview was felt to be the most satisfactory process.

The field notes and written student responses became the data source. The data were searched for evidence of the effects of using CoRT-1 thinking skills and using aspects of metacognition and for the possible reasons for the effects of using or not using either. The evidence is discussed in Chapter 6. A copy of the Questionnaire is included as Appendix D and samples of the students' written interview responses are included in Appendix E.

There are advantages to qualitative research, particularly the interview. According to Pope and Denicolo (1986), the interview is suitable for identifying and investigating intuitive theories. In this study, students' intuitive theories about their learning styles are required to be assessed.
While the questionnaire initiates this process, the interview allows the process to mature.

Interviews can allow for flexibility. The interviewee has the opportunity to respond in a thoughtful way, qualifying remarks made and thinking through a response made in a deliberate manner. The interviewer can structure questions according to the students' understanding of their meaning.

Interviews provide content depth. They allow the interviewer to be reasonably sure of the interviewee's personal meaning. They ensure that the student knows exactly what is to be answered, eliminating the element of guessing at the intent of a question. Properly conducted, interviews provide for active and perceptive listening by both parties. Much can be determined from body language, inflection, language tone and the rapport developed between the two.

Quantitative and qualitative research are often seen as two polar opposites. Pope and Denicolo (1986) see quantitative research as being the dominant methodology; though, increasingly elements of both are being used. The variables and hypothetical relations used in quantitative research rely on qualitative, conceptual considerations. Chaudron (1986) believes that the pattern of research today is towards:
... (q)ualitative refinement of the relevant categories and quantitative
analysis of the extent of the relevance (p. 714).

8.7 Summary

Quantitative and qualitative techniques were used in this study of the
effects of teaching 10 CoRT-1 lessons and 6 lessons on aspects of
metacognition to Year-Seven students at a South Coast Comprehensive high
school. Two research questions investigated by test instruments were:
1. What effect does the ten-lesson CoRT-1 program have on the in-class
   thinking and learning of Year 7 students from a South Coast Comprehensive
   High School?
2. What effect does the explanation of the thinking and learning process have
   on the in-class thinking of Year-Seven students from a South Coast
   Comprehensive High School?

The primary data source for the third question, namely: Do Year-Seven
students, from a South Coast Comprehensive High School, who have been
taught the ten lessons of the CoRT-1 program, transfer these skills to out-of-
class learning and thinking?, was determined from questionnaire and
interview responses.

The quantitative results are presented in Chapter 9 and the analysis of
questionnaire and interview data is discussed in Chapter 10.
QUANTITATIVE RESULTS

As described in Chapter 8, a paired-sample t test, independent-samples t test, ANOVA and ANCOVA procedures (OLSAT) and an analysis of Decile scores and Mean scores (LPQ) were used to test hypotheses related to the first question for investigation. In this chapter, the results from these analyses are reported as they relate to the first question, and the appropriate propositions and hypotheses.

9.0 OLSAT Data Analysis

9.1.1 Results for the Effect of the Ten-Lesson CoRT-1 Program on the Scholastic Aptitude of Year-Seven students.

The first question for investigation was: What effect does the ten-lesson CoRT-1 program have on the in-class thinking and learning of Year-Seven students from a South Coast Comprehensive High School? Two hypotheses, each relating to Scholastic Aptitude, were tested using the SPSS (1995) paired-samples t test (Tables 8 and 9), independent-samples t test (Table 10), ANOVA (Table 11), and ANCOVA (Table 12) procedures. The paired-samples t test looks at changes within a group, while the independent-samples t test is used to compare changes in different subjects.
A 2x2 ANOVA design is used, with the first independent variable being the pre-test, the second independent variable being the treatment and the dependent variable is the post-treatment OLSAT score. The 2x2 ANOVA will yield 3 F ratios with the interaction effect being the major interest.

The ANCOVA procedure was used to attempt to adjust for the initial differences between the groups, as revealed in the paired-samples and independent-samples t tests.

The first research hypothesis was:

There will be a significant improvement in scholastic aptitude, as measured by the Otis-Lennon School Ability Test - Level 1 Form F, for Year-Seven students at a South Coast Comprehensive High School, when compared with a control group of Year-Seven students from the same high school, who were not trained in CoRT-1.

Research Hypothesis 2 stated:

There will be a significant improvement in scholastic aptitude, as measured by the Otis-Lennon School Ability Test - Level 1 Form F, for Year-Seven students who complete the ten lesson CoRT-1 program.

Table 8 shows the paired-samples t test results at pre-treatment and post-treatment test data (01 and 02) (N=60), i.e. groups with treatment. The variable is the School Ability Index (SAI) which is a normalised standard score with a mean of 100 and a standard deviation of 16.
Table 8

$t$-test for Paired Samples. O1 and O2 Treatment students

(N=60) for pre- and post-test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of pairs</th>
<th>Corr</th>
<th>2-tail Sig</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAI01</td>
<td>60</td>
<td>.703</td>
<td>.000</td>
<td>60</td>
<td>15.363</td>
<td>1.983</td>
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<tr>
<td>SAI02</td>
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<td></td>
<td>104.966</td>
<td>15.363</td>
<td>1.983</td>
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Paired Differences

<table>
<thead>
<tr>
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<th>SE of Mean</th>
<th>t-value</th>
<th>df</th>
<th>2-tail Sig</th>
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</thead>
<tbody>
<tr>
<td>15.363</td>
<td>1.983</td>
<td>-1.0167</td>
<td>13.078</td>
<td>1.688</td>
</tr>
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</table>

The two-tailed probability is used to decide whether the null hypothesis should be rejected. A two-tailed test is used because the researcher is concerned with the absolute magnitude of the difference regardless of the direction. If the probability is small (.05 or less is often used, and has been used in this study), the null hypothesis is rejected. In this case $p = 0.549$ and hence not significant, and therefore, the null hypothesis is not rejected. However, the Mean scores show a slight difference in the direction suggested by the research hypothesis.

Table 9 shows the paired-sample $t$-test for pre- and post-treatment SAI test data for the control variables O3 and O4 (N=60), i.e. the group with no treatment.
### Table 9

**t-test for Paired Samples. O3 and O4 Control students for post-treatment test (N=60)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of pairs</th>
<th>2-tail Corr Sig</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
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<tr>
<td>SAI03</td>
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<td>.591 .000</td>
<td>102.7667</td>
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**Paired Differences**

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<th>df</th>
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<td>.4000</td>
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<td>1.945</td>
<td>.21</td>
<td>59</td>
<td>.838</td>
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</table>

95% CI (-3.491, 4.291)

Table 9 does not show a statistically significant difference (p=0.838) between the groups O3, O4 on the SAI scores.

Table 10 shows the independent-sample t-test results for the treatment students at post-treatment (O5) (N=32) and the control students post-treatment (O6) (N=32), i.e. the difference between test results where there were no pre-test measurement taken.
Table 10

t-test for Independent Samples. O5 Treatment (N=32) and O6 Control (N=32) at post-treatment test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of cases</th>
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<th>SE of Mean</th>
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<tr>
<td>Group O5</td>
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<td>110.4688</td>
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<td>Group O6</td>
<td>32</td>
<td>105.5938</td>
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</table>

Mean Difference = 4.8750


$t$-test for Equality of Means

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<th>df</th>
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<td>Equal</td>
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<td>62</td>
<td>.207</td>
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<tr>
<td>Unequal</td>
<td>1.27</td>
<td>59.91</td>
<td>.208</td>
<td>3.827</td>
<td>(-2.780, 12.530)</td>
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</table>

Table 10 does not show a statistically significant difference, on post-treatment SAI scores, between the treatment group O5 and the control group O6 (p=0.207). However, the Mean score for the Treatment group (O5) is higher than the Control group (O6) which is in the direction expected under the research hypothesis.

Table 11 gives the ANOVA data with the dependent variable being the post-treatment OLSAT score for all students (N=184) and the first independent variable being pre-test O2-O4 (N=120), no pre-test O5-O6 (N=64), and the second independent variable being treatment O2-O5 (N=92), no treatment O4-O6 (N=92).
Table 11

Analysis of Variance for O2, O4, O5, O6 for pre-test (Ind var 1), treatment (Ind var 2) based on post-treatment OLSAT score.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean square</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td>584.438</td>
<td>2</td>
<td>292.219</td>
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<td>.468</td>
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<td>Ind 1</td>
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<td>.718</td>
<td>.398</td>
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<td>Ind 2</td>
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<td>.269</td>
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<tr>
<td>2-Way Interactions</td>
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<td>17.932</td>
<td>.047</td>
<td>.829</td>
</tr>
<tr>
<td>IND1 IND2</td>
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<td>17.932</td>
<td>.047</td>
<td>.829</td>
</tr>
<tr>
<td>Explained</td>
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<td>3</td>
<td>198.280</td>
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<td>.671</td>
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<tr>
<td>Residual</td>
<td>69053.894</td>
<td>180</td>
<td>383.633</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>69648.734</td>
<td>183</td>
<td>380.594</td>
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</tr>
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</table>

184 cases were processed.

Table 11 does not reveal a significant difference for either the 2-way interactions, nor for the main effects. This means that there is no significant difference between the treatment and non-treatment groups.

Table 12 gives the interaction term (group by tests), which shows that there might be a treatment effect ($p = 0.059$), although the difference was found to be significant at the 10% level of significance, though not at the 5% level. The Mean scores also point towards a treatment effect, O2 being 106 and O4 being 102.
Table 12

ANCOVA results with Interaction effect

Regression analysis for Within + Residual error term
Individual Univariate .9500 confidence intervals
Dependent Variable . . POSTTEST

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<tr>
<th>COVARIATE</th>
<th>B</th>
<th>Beta</th>
<th>Std. Err.</th>
<th>t-Value</th>
<th>Sig. of t</th>
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<td>.096</td>
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<td>.000</td>
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</tbody>
</table>

COVARIATE Lower -95% CI - Upper

| PRETESTS       |  .506 | .888  |

Source of Variation

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
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<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
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<td>216.09</td>
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<td>Group* Pretests</td>
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<td>.059</td>
</tr>
<tr>
<td>Group</td>
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<td>2.58</td>
<td>.111</td>
</tr>
<tr>
<td>Pretests</td>
<td>10181.35</td>
<td>1</td>
<td>10181.35</td>
<td>47.12</td>
<td>.000</td>
</tr>
<tr>
<td>(Model)</td>
<td>15268.62</td>
<td>3</td>
<td>5089.54</td>
<td>23.55</td>
<td>.000</td>
</tr>
<tr>
<td>(Total)</td>
<td>40335.33</td>
<td>119</td>
<td>338.95</td>
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</table>

R-Squared = .379
Adjusted R-Squared = .362

Adjusted and Estimated Means

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<td>106.533</td>
<td>104.355</td>
<td>106.533</td>
<td>.000</td>
<td>.000</td>
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</table>

Despite an apparent improvement in test results for treatment students, as compared with those for control students, the difference was not found to be significant. However, inspection of the Mean scores, as shown in Figure 2, reveals that the treatment and control groups behaved differently, in the predicted direction, giving tentative support for research Hypothesis 2.
Figure 2: Display of Mean Scores for the School-Ability Index for both Treatment and Control Groups over each Testing Occasion.

For the treatment group O1 - O2 (N=60) the pre-treatment test mean was 104.9667 (SD = 15.363) and the post-treatment test mean 105.9833 (SD = 17.998), which suggests a slight possibility of there being some effect of the treatment.

For control group O3 - O4 (N=60) the difference in the mean was .4000, which shows little change over time (SD for O3 = 14.808 and SD for O4 = 17.937).

For the treatment group O5 (SD = 13.803) and the control group O6 (SD = 16.677) (N=32) there is a 4.8750 higher mean on post-treatment test
results for the treatment group. This would also support the contention that there might have been some positive effect of the treatment.

For the treatment group O2 (SD = 17.998) and the control group O4 (SD = 17.937) (N=60) a post-treatment test analysis of the mean shows a 3.6166 higher mean for the treatment group, though again not statistically significant.

While there is no statistical significance at the specified (alpha) level (.05) as a result of t-test analysis, however, ANOVA procedures do show statistical significance and the repeated findings of higher means for the treatment group point towards the possibility of an effect of the treatment. This effect does not appear to be very large, but is encouraging and does suggest a future research direction.

The paired-samples t-test, independent-samples t-test, ANOVA and ANCOVA show that neither Research Hypotheses has been formally supported. However, there is tentative support, through an analysis of the group mean scores, that the treatment did have an effect, although not at an acceptable level of significance. These results point towards Research Hypotheses 1 and 2 not being supported, although a small difference in scholastic aptitude is noticeable giving tentative support to the rejection of both null hypotheses. The issues raised as a result of this analysis will be discussed further in Chapter 10.
This chapter will now investigate the results of the student response to the Learning Process Questionnaire.

9.2 LPQ Data Analysis

9.2.1 Results for the Effect of the Ten Lesson CoRT-1 Program on the Student Approach to Learning of Year-Seven students.

The Learning Process Questionnaire (LPQ) tables of norms give the results in deciles. Decile scores are used to assist the user to "judge how typical a student's score is in broad terms" (Biggs, 1987, p. 11). Due to the large number of student responses in this study, the decile scores will be used to ascertain if there are any changes over time of treatment and control students. The mean scores for each group, treatment and control, will also be calculated. Biggs (1987) suggests a five-way grouping to interpret the deciles.

1 would be 'well below average', in that the score is included in the bottom 10 per cent of the population.
2 or 3 would be 'below average', as the score falls within the 11th and 30th per cent of the population.
4, 5, 6 or 7, would be within the 'average' range, that is, within the middle 31 to 70 per cent of the population.
8 or 9 would be 'above average', in that 71 to 90 per cent of the population would score lower than this.
10 would be 'well above average', with over 90 per cent of all other scores lower than this (Biggs, 1987, pp. 11-12).

Biggs recommends that, once the student results have been calculated, instructional or referral decisions should be made, in conjunction with the student's profile, which represents the student's general orientation to learning. Any recommendations, regarding particular students and/or groups of students, which arise from an analysis of the LPQ results, will not be part of this study, but will be used as part of the overall planning of the school's future directions.

The first question for investigation was: What effect does the ten-lesson CoRT-1 program have on the in-class thinking and learning of Year-Seven students from a South Coast Comprehensive High School? Two hypotheses, each relating to student approach to learning, were tested by an analysis of the Decile scores and Mean scores for each of the six subscales, the three scales and the composite approach of the LPQ.

Research hypothesis 3 was:

There will be a significant improvement in student approach to learning, as measured by the Learning Process Questionnaire, for Year-Seven students at a South Coast Comprehensive High School, who complete the ten-lesson CoRT-1 program, when compared with a control group of Year-Seven students from the same high school, who were not trained in CoRT-1.

Research Hypothesis 4 stated:

There will be a significant improvement in student approach to learning, as measured by the Learning Process Questionnaire, for Year-Seven students who complete the ten-lesson CoRT-1 program.
Table 13 shows the Decile scores for each subscale, scale and composite approach of the LPQ:

Subscale items are: Surface Motive (SM), Surface Strategy (SS), Deep Motive (DM), Deep Strategy (DS), Achieving Motive (AM), Achieving Strategy (AS);

Scale items are: Surface Approach (SAP), Deep Approach (DAP), Achieving Approach (AAP).

The composite approach is: Deep Achieving Approach (DAA).

a) The LPQ: A summary of the Theory, Interpreting the Scores and Use in the classroom.

Before looking at the data for Table 13, it is worth reiterating the theory behind the LPQ, and to give an understanding of how the LPQ is interpreted, and the recommendations for use in the classroom.

i) A summary of the LPQ Theory.

The LPQ is "designed to assess the extent to which a secondary school student endorses different approaches to learning and the more important motives and strategies comprising those approaches" (Biggs, 1987, p.1).
The LPQ is a 36 item, self-reporting questionnaire that gives data on three basic motives for learning and three learning strategies, and the approaches to learning that are formed by these motives and strategies. The manual (Appendix H) outlines the theory behind the LPQ and what the subscale and scale scores mean.

Biggs (1987) believes that three sets of factors may be distinguished in school learning. The first set of factors are those that are independent of the learning situation, and include personal and situational factors. These factors are referred to by Biggs (1987, p. 2) as presage factors, and they may affect the student's performance directly, or indirectly, through their influence on process factors.

Process factors (Biggs, 1987, p. 2) are believed to determine the way the student goes about learning; the students' motives for learning and the strategy that accompanies that motive. As examples, Biggs (1987, p. 2-3) cites levels of student motivation as recognisable approaches to learning, namely, deep, achieving, and surface. Biggs states:

The LPQ operationalizes these approaches, and their constituent motives and strategies, in terms of scale and subscale profiles. These profiles represent an individual's *general orientation* to learning: that is, a composite of motivational states and strategy deployment that is relatively consistent over situations. (1987, p. 3)
Surface and deep strategies refer to ways in which the student engages in the actual task, while the achieving strategy refers to the way the task is carried out. Students can combine an achieving approach with either a surface, or a deep, approach.

Biggs comments:

The three approaches lead to different kinds of learning outcome. The surface approach leads to retention of factual detail at the expense of the structural relationships inherent in the data to be learned, while emotional or affective outcomes are feelings of dissatisfaction, boredom, or outright dislike. The deep approach leads to an understanding of the structural complexity of the task and to positive feelings about it. The achieving approach, particularly in combination with deep, leads to good performance in examinations, a good academic self-concept, and to feelings of satisfaction. (1987, p. 4)

Biggs (1987) believes that learning approaches, especially deep and achieving, are most effective when students are aware of their own learning processes and try to deliberately control them. This process is called 'metalearning' by Biggs (1987, p. 5) and refers to students' awareness of and control over their own learning process.

Students can be trained (Biggs, 1987, p. 9) to develop different approaches to learning. Biggs (1987, p. 9) cites two independent studies at university (Biggs and Rihn, 1984) and in secondary school (Edwards, 1986),
which are reported to have shown that students can be trained to improve deep and achieving approaches, and that such improvement boosted examination performance.

**ii) Interpreting the Scores.**

LPQ results are given in deciles because scores in this form are believed to assist the user to judge how typical a student’s score is in broad terms: average, below average, above average.

Biggs (1987, p. 11-12) suggests a five-way grouping to interpret the deciles. The first group would be ‘well below average’, the score falls in the bottom 10 percent of the population. The second and third groups would be ‘below average’, with the score falling in the 11th and 30th percent of the population. Groups four, five, six and seven fall in the ‘average’ range, that is, within the middle 31 to 70 percent of the population. Groups eight and nine are ‘above average’ and fall in the 71 to 90 percent of the population. Group 10 is ‘well above average’, with over 90 percent of all other scores lower than this.

**iii) Using the LPQ in the classroom.**

There are two main classroom uses which may be distinguished: the making of instructional decisions and the making of referral decisions. In both cases the the teacher should consider LPQ profiles of subscale scores. Each individual students’ profile represents their general orientation towards
learning, or learning style, which is regarded as being typical for that individual. Biggs (1987, pp. 14-16) believes six common profiles can be identified. These are: deep (oo ++ oo or -- ++ --), Achieving (oo oo ++ or -- -- ++), deep-achieving (oo ++ ++ or -- ++ ++), surface-achieving (++, oo --), surface (++ oo oo or ++ -- --), and low-achieving (oo oo --o or +o oo --o).

Students who are predominantly deep generally do well academically. Biggs (1987) states:

Deep students want to follow their own academic interests, relate to their own previous experience, generate their own examples, and to follow their own leads. As far as possible they are best left alone. If teachers become too directive, these students may drop out, either in fact, or if the 'official' goals are not rejected outright, they may be sought with a surface approach, effectively dropping out in practice. (p. 14)

A program such as CoRT-1 would be of benefit to these students in helping them to organise their learning, and possibly, to explore subjects at a higher level.

The achieving student is mainly interested in good marks. The achieving student tends to be deliberate, a careful planner, and has a high academic self concept. The traditional secondary school, with an emphasis on norm-referenced evaluation, note-taking exercises, syllabus-oriented teaching, to give some examples, is made for these students.
The deep-achieving is a combination of the first two mentioned. The deep-achieving student does not usually present many problems, however, if a deep-achieving student is not doing well, there are likely to be quite specific reasons, a language problem being common. A second possibility is that the student thinks a major tool for learning has not been mastered. The problem may be a lack of confidence, and such a possibility may well be relieved by a program such as CoRT-1, where a student is assisted to explore thinking and learning in a wider context. An understanding of metacognitive processes may also be of assistance.

Surface-achieving students' want to achieve, but are frequently unsuccessful because they adopt a surface approach to do so. The teacher would work towards encouraging an achieving approach, by assisting them to manage their time more effectively and to be more organised. These students would be assisted by a cognitive intervention strategy, such as CoRT-1, or SHEIK.

Surface approach students tend to have a poor academic self-concept. High surface students are usually not confident 'metalearners'. They have little insight into the 'how' and 'why' of their learning. A program to assist students with an understanding of their learning, such as that outlined in the preceeding Chapters of this present study, would be of great importance.
Low-Achieving students are skilled task avoiders, and usually have a great fear of failure. There are some strategies the teacher can employ to assist these students, including criterion-referenced assessment, giving an understanding of individual learning styles, introducing cognitive intervention strategies, and assisting the student to understand how learning and thinking occur for each individual.

Biggs (1987) believes,

As knowledge grows, and as teachers themselves conduct research and development, one might move more towards formal structuring of the classroom according to predominant learning profiles. (p. 17)

After having been reintroduced to the theory behind the LPQ, and having been given information on the interpretation and classroom use of the LPQ scores, this present study will analyse the students' Decile scores and endeavour to make conclusions regarding whether the CoRT-1 program and an understanding of metacognitive processes have changed individual students approaches to learning.

Table 13 shows the Decile scores for each subscale, scale and composite approach of the LPQ.
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<thead>
<tr>
<th>DECILE</th>
<th>SMO1</th>
<th>SMO2</th>
<th>SMO3</th>
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These Decile scores are used to determine the Mean score and profile in each of the subscales, the scales and the composite approach. Biggs (1987, p.13) suggests that the Decile scores be reported in bands within each subscale, namely:

'above average' - deciles 8,9,10 - '+' and designated band 1,
'average' - deciles 4,5,6,7 - 'o' and designated band 2,
'below average' - deciles 1,2,3 - '-' and designated band 3.

Table 14 presents the Mean scores for each LPQ subscale for each group 01 through to 04 and 05 - 06 on pre- and post-treatment tests for treatment and control. All Mean scores have been rounded to the nearest whole number.
Table 14
Mean scores for each LPQ subscale.

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Figure 3 gives a graphical presentation of the subscale scores which shows little difference between the treatment groups and the control groups. This analysis tends to support the acceptance of the null hypotheses.

Figure 3: Mean scores for each LPQ subscale for Treatment and Control groups
The important trend that appears to be emerging is the profile of low-achievement, especially that of low-achievement motivation. Although there are many variations in the pattern of low-achieving, when low-achieving motivation is combined with high surface motive, which tends to be the case here, the “students’ motive to avoid failure (SM) is stronger than their need to achieve success (AM)” (Biggs, 1987, p. 16). This will be further explored in the following Tables and in Chapter 10.

Table 15 presents the Mean scores for each LPQ scale for each group O1 through to O4 and O5 - O6 on pre- and post-treatment test for treatment and control. All Mean scores have been rounded to the nearest whole number.
<table>
<thead>
<tr>
<th>Decile band</th>
<th>Group</th>
<th>Surface Approach</th>
<th>Deep Approach</th>
<th>Achieving Approach</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
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<td>O1</td>
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<td>4</td>
<td>5</td>
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<tr>
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<td>O2</td>
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<td>O1</td>
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<td>3</td>
<td>5</td>
<td>0 0 0 0</td>
</tr>
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<td>0 0 0</td>
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<td>O5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>- 0 0 0</td>
</tr>
</tbody>
</table>
A cross-check of the Table 15 data does not reveal support for the Research Hypotheses. The trend is again towards a low-achieving profile, especially towards low achievement motivation. The Means scores for the LPQ composite item will be explored next, to see if this item reveals support for the Research Hypotheses.

Table 16 gives the Mean scores for the LPQ Composite item for each group O1 to O4 and O5 - O6 on pre- and post-treatment test for treatment and control.
Table 16
Mean scores for LPQ Composite item.

<table>
<thead>
<tr>
<th>Decile</th>
<th>Group</th>
<th>Deep Achieving Approach</th>
<th>Achieving Approach</th>
<th>Symbol</th>
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</thead>
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<td>5</td>
<td>0 0 0</td>
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<tr>
<td></td>
<td>O2</td>
<td>4</td>
<td>4</td>
<td>0 0</td>
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<tr>
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<td>O3</td>
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<tr>
<td>3</td>
<td>O5</td>
<td>5</td>
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<td>0 0</td>
</tr>
</tbody>
</table>
The analysis of the LPQ subscale, scale and composite data does support the acceptance of the null hypotheses. The data suggest that there is a noticeable trend within this year-seven cohort towards low-achieving, especially towards low achievement motivation and high surface motive. There is also some evidence to suggest support for the deep and deep-achieving profiles. This information gives an overall picture of a cohort that is not necessarily of low intelligence (primary-school data, Year-seven placement tests and counsellors' comments), but does not like attention being drawn to achievement, especially competitive achievement and public attention. Again, many of these students may have a fear of failure and probably have developed competence in being task avoiders. Many of these students may have a poor academic self-concept and, generally, they may appear to the class teacher and/or their parents or caregivers to be doing badly; but this does not necessarily reflect their ability. There is a need for long-term planning to assist these students reach achievable goals. There is little, if any, evidence to support the Research Hypotheses, but a study of a graphical presentation of subscale, scale and composite Mean scores does reveal some treatment effect.
Figure 4 shows the Mean scores for the subscales, scales and composite items of the LPQ for each group O1 - O2 pre- and post-test treatment, O3 - O4 pre- and post-test control, O5 post-test treatment and O6 post-test control.
Figure 4: Mean scores for the subscale, scale and composite items of the LPQ for all groups, Treatment and Control, pre- and post-test.
The graph of the Mean scores of treatment groups 01 and 02 from pre- to post-treatment test does not readily show an effect of the treatment, although when compared with the control groups 03 and 04, the mean scores of 02 are much closer to 01 and in some points 02 equals 01, and in one point the mean score is higher. The treatment appears to have kept the pre- and post-treatment test results closer together in 01 - 02. In comparison there appears to be a consistently lower Mean score for 04 to 03. The mean scores of treatment group 02 is higher than that of control group 04, in all subscales, scales and in the composite approach, thus giving a further indication that there might have been some treatment effect.

The treatment group 05 generally has a higher Mean score than the control group 06, and the post-treatment group 05 has a higher or a similar Mean score in four of the subscales, one of the scales and in the composite approach, than the pre-treatment test control group 03.

The analysis of the LPQ data does not support Research Hypothesis 3, nor is there support for Research Hypothesis 4. There is tentative support for a treatment effect which tends towards a rejection of the null hypotheses. The issues raised from this analysis will be further explored in Chapters 10 and 11.