CHAPTER 5

THE DEVELOPMENT OF CONSERVATION ABILITIES AND LOGO

What is Conservation?

During the past forty years examination of the intellectual and cognitive development of children has led to considerable interest in the process of transition through the developmental phases. One of the identifiable components of transition is the acquisition of "conservation" abilities. Conservation is defined by Flavell (1963) as

> the cognition that certain properties (quantity, number, length, etc.) remain invariant (are conserved) in the face of certain transformations (displacing objects or object parts in space, sectioning an object into pieces, changing shape, etc.).
> (Flavell, 1963, p.245).

Piaget (1965) considers conservation a necessary prerequisite for general rational activity which also forms the basis for a framework of numerical reasoning. Murray (1982) states that it is necessary for the conserver to employ both logical and physical principles because the physical contents of the task - the materials and manipulations - are not sufficient to impose the conservation deduction.

Piaget (1965) identified three stages for the development of conservation abilities: in the initial stage perceptual factors only govern the judgment of quantity; in the intermediate stage perceptual factors and conservation considerations are at work; and finally in the last stage there is complete conservation. Piaget (1965) views the movement through these stages as movement from the perceptual-intuitive which lacks reversibility, to the operational.

Factors Affecting Conservation

There are a wealth of studies examining the nature of children's developing conservation abilities and most agree that task structure, assessment context and the children's levels of conceptual development all play some role in their display of conservation ability (Sigel and Hooper, 1968; Murray, 1972, 1982; Gelman, 1982; Miller, 1982; Gold, 1986; Tulloch, 1981; 1986). Murray's (1982) work found that in the particular experimental situation which he devised, the children's ability to add and subtract was the most influential predictor of their ability to conserve number. Wohlwill and Lowe (1962) and Smedslund (1962) also suggest that this is true, whilst at the same time the work of Wallach et al. (1965) suggests that training in reversibility may do away with the need for facility in addition and subtraction.

Rose and Blank (1974) found that repetition of the same question before and after the transformation gave different results to those gained when the question was asked only after the transformation. McGarrigle and Donaldson (1975) found that presenting the conservation transformation as an "accident" performed by a naughty teddy bear provided a context where it was reasonable to ask the subjects whether there was a difference, and higher conservation performance levels were recorded on this occasion than on occasions when there was no story context. Tulloch (1986) sums up these approaches when she says that

> the child's response must therefore be understood, not just in terms of a level of conceptual development nor as a situation specific process, but as an interaction between a knowledge base and problem-solving strategies, generated by the task situation.
> (Tulloch, 1986, p.250).

Another dimension not dealt with above is the possibility of children acquiring conservation skills through situations involving social conflict. This proposition was put forward by Murray (1972). Over a hundred children with a mean age of 6.7 years were given no instruction that would develop conservation abilities, but were tested individually for these skills, and then placed in groups where agreement about conservation tasks had to be reached. They were then tested individually again. There was a considerable improvement in ability for those children who, in the first instance, were not conserving. Murray (1972) states that social conflict can be seen as an important mediator of cognitive growth, a statement which he sees as confirming Piaget's position that social interaction has a role to play in the transition from egocentrism to operational thought.

Conservation of Number

Piaget (1965) saw the ability to use one-to-one correspondence as the basis for judgment of numerical equivalence. However, not every child who can demonstrate one-to-one correspondence can in fact conserve. Wadsworth (1984) presents the situation of a four-to five-year old who is shown a row of objects and asked to construct a row that is the same. Invariably the child constructs a row of the same length, but not necessarily one that contains the same number of items. He says that most children of this age will place an object at the beginning and the end of the row and then fill in the middle with any number of objects, not corresponding to the original row. He goes on to point out that the five-to six-year old will be more systematic and perform this task correctly using one-to-one correspondence. However, the same child seeing one row lengthened without any change in the number of elements will declare they are no longer equivalent. When questioned about this, the child will reply that one row has more because it is longer! This can be true even when the children count the objects because they hold that there is equivalence only when there is visual correspondence in the length of arrays. Miller (1982) conducted research using this example. He put forward another example where, instead of using inanimate objects, he got real children to spread themselves out in a row. In these instances, the children being tested actually seemed to believe that the number of real children had changed during the rearrangement - a fact that Miller (1982) find even more amazing than the well validated fact that children believe that inanimate objects increase in number as they are spread on a table.

Wadsworth (1984) maintains that the Piagetian explanation of such behaviour is simply that the child is making a perceptual rather than a cognitive response and is also lacking in reversible thought.

This discrepancy between children's ability to count and engage in one-to-one correspondence and their ability to conserve is also well documented in the work of Gelman (1982) and her associates. Gelman (1982) further investigated the types of training strategies that could lead young children from the counting phase to the conserving phase. Her findings confirmed her views that one can expect from children, displays of competence which only become obvious under "appropriate" circumstances. This she based on the work of Rozin (1976):

> I interpret the above transfer findings in terms of an accessing account of cognitive development. Rozin (1976) proposed that part of cognitive development involves an increasing ability to access the structures underlying early cognitive and perceptual abilities. What are early and possibly innate abilities, are used in restricted (or even just one) situation(s). But with development these are used in wider and wider settings because of a growing general ability to gain access to underlying competences. For Rozin, development also involves an increasing ability to access structures to serve a new ability.
> (Gelman, 1982, p.217).

Another element that must be considered in assessing children's ability to conserve is the manner in which these abilities are themselves assessed. Gold (1986) says that a number of authors suggest that children in fact have the conserving abilities but fail to understand the communication that is requiring them to demonstrate these abilities. He sums this up by suggesting that it is not that children *cannot* understand the question, but that they *misunderstand* it. They then proceed to answer the question they think is being asked. Miller (1982) also argues that differing methods of assessing conservation leads to different performance levels.

Whilst most researchers have sought the answer to the conservation ability question within the developmental framework, as far back as 1958, Churchill suggested that some children develop these abilities through counting, whilst for others the development is related to perceptual strategies.

Conservation of Length

The most commonly used experience to ascertain whether children can conserve length is the change of position experiment as it was put forward by Piaget et al. (1960) and also reported by Lovell et al. (1968). The children were given two rods about 5 centimetres in length and were asked to confirm that they were actually equal in length by holding them, measuring them etc. They were then moved to the following three positions - a) one rod about half a centimetre ahead of the other, b) the rods forming the letter T and c) the rods at an acute angle to one another, but still touching. On each occasion the children were asked if the two rods were still the same length. Lovell et al. (1968) report that children in the pre-conservation stage stated that the rod that was moved was longer, as they were thinking in terms of the further extremities. The children who were in the transition stage sometimes replied correctly with the rods in one position, but not in another. Children who were clearly conservers recognized that the rods were, and had to be the same length. Reiber (1983) reports very similar findings. He says that children who could not conserve responded that one rod was longer than the other, whilst the child who was in transition usually but not not always, said that the rods would be equal but was unable to say why this was so.

Logo and Conservation

Papert (1980) said that children must engage in "Piagetian learning" which can be described as learning from the materials around without being taught. He proposed that the use of Logo was one such way in which engagement in "Piagetian" learning could happen. The use of Logo with young children raises the issue of what prerequisite skills are required for them to gain some command over the language. Two studies of young children using Logo try to relate its use to their conservation abilities.

Rieber (1983) examined the proposition that as the use of Turtle Graphics in Logo deals with rigid lines and shapes, one can presume it is a pre-requisite to be able to conserve length. He gives the example of the child trying to draw a square who would appear to need to see and understand the restrictions of length. Furthermore it would appear that children would also need to be able to conserve number because of the emphasis on numerical input in the use of Logo.

Rieber's (1983) study of seven year olds using Logo showed that they *could* use Logo efficiently despite the fact that they could not completely conserve length and despite the fact that the concepts used required a level of abstraction that their developmental level dictated they should *not* be able to deal with.

Munro-Mavrias (1983) using Logo with five year olds, did on the other hand find significant correlation between children's success with Logo and their ability to conserve and their ability to reverse their thought processes. Her follow-up study also showed the same correlation between ability to use Logo and ability to conserve. However in this study, children who were in the process of leaving the pre-operational stage, performed better than those who were clearly pre-operational.

When the results of Munro-Mavrias (1983) and Rieber (1983) are both considered, it appears that ability to conserve may well be an issue in the use of Logo, in those instances when the children are completely unable to conserve. However, it seemed that in these two studies at least, any movement out of the pre-operational stage somehow gives the child an ability to engage in the use of Logo. It could be speculated, given the results of these two studies, that the use of Logo actually enhances the period of transition from the pre-operational stage.

Conclusions

There is, from the above discussion, a clear need to investigate the relationships between conservation abilities and the use of Logo by children in the present study. Apart from the obvious role played by developmental factors in the acquisition of conservation abilities, it would be interesting to investigate the role of social interaction and particularly social conflict in the development of these abilities. Furthermore, the role of conservation abilites in the use of Logo raises the potential influence that the use of Logo could have on spatial abilities, and the development of young children's spatial abilities is the subject of the following chapter.

CHAPTER 6

YOUNG CHILDREN AND SPATIAL DEVELOPMENT

Piaget's Theory of Spatial Development

In looking at the theories of children's spatial development, by far the single most influential source has been that proposed by Piaget and Inhelder (1956). Although as Sigel and Hooper (1968) point out there are three major stages - topological concepts, projective concepts and Euclidean concepts - identified within this theory, Leeds et al. (1983) have reduced these to two developmental phases: spatial perception and spatial representation. This confirms that the concept of space must be developed before concepts of measurement of that space can be acquired. Dodwell (1968) rightly states that the stages of development of spatial concepts proposed by Piaget (1956) are far more complex than those proposed for the development of number concepts (1965), although the same sorts of stages are envisaged in both.

Acquisition of spatial concepts is seen to be coordinated with the child's growth of logical reason, so that the development of spatial concepts is aligned with the development of logical thought. Thus this development is directly related to the child's egocentric view of the physical world. Piaget's (1956) theory of the development of spatial operations and concepts is

> that the first spatial operations the child comes to understand involve primitive notions of proximity, enclosure, and boundary which are entirely non-metric in character. Piaget makes a perfectly reasonable distinction between *perceived* space and *conceived* space: whereas a quite young child may be able to distinguish perceptually between, say, a square and a circle, this does not mean that the child can conceptualize this difference, or marshal the operations which are necessary for making anything more than a perceptual distinction.
> (Dodwell, 1968, p. 119).

The studies relating to spatial development carried out by Piaget (1956) parallel the three types of geometrical concepts noted above. He does not suggest criteria for the examination of the generality of his findings either between children of similar ages or between the different tests used. What Piaget's work does confirm is that while children may acquire a verbal facility with spatial concepts or be able to reproduce some visual representation of an object before them, they may well not have the operational capacity to actually understand what it is they are doing. For example, work done by Lovell et al. (1968) shows clearly that many primary school children carry out measurement tasks successfully, but when questioned about it, show no comprehension of what it is they were doing.

Although Piaget (1956) gives consideration to the genesis of space perception, Flavell (1963) states that the main focus of his developmental theory is clearly that of space representation, and this enables him to create the desired links with intellectual development. Laurendeau and Pinard (1970) state that

> spatial representation derives from sensorimotor activity, to which it is added when the appearance of the symbolic function enables the child to act not only on objects which are real and physically present in his perceptual field but also on objects which are symbolized or mentally represented.
> (Laurendeau and Pinard, 1970, p.13).

Piaget (1956) has outlined the steps in the internalization of representational space in the child as those of the intuitive or preoperational level (2 to 7 years) through to the mobile and reversible structures of operational thought (7 to 12 years). Leeds et al. (1983) describe the characteristics of the drawings that might be expected from children aged 5 to 8 years:

> Straight lines, angles, circles and other geometric shapes are used to represent all people, houses and other basic objects. The drawings have no stable point of reference. Instead, a number of irreconcilable points of view are present. A house might be depicted showing all sides, and two boys playing catch might be shown with a front and side view, respectively.
> (Leeds et al., 1983, p.142-143).

Despite the centrality of Piaget's (1956) theories, Braine (1968) points out that in trying to state a particular age at which a certain response could be anticipated, "the only age which is not completely arbitrary is the earliest age at which this type of response can be elicited using the simplest experimental procedures" (p.187). Dodwell (1968) also points out that there are several factors which can cloud the patterns of stage development, namely special interests and training, availability of formal instruction, and the difficulties of transfer of rules from one context to another. The work of Braine (1968) seemed to confirm that in many instances where Piaget (1956) claimed to be assessing the development of children's performance of logical operations implicit in measurement, they should actually have been seen to be studies of the development of skill and interest in the techniques of measurement itself. Finally, there is the difficulty posed by the findings of Fishbein et al. (1972) whose work showed that even the complexity of the task had no significant effect on the number of egocentric errors that children made under test conditions.

Factors Affecting Spatial Development

The work of Fishbein et al.(1972) confirms the view that there are two developmental factors - social and cognitive development - that are at work in the development of the child's concept of space. They describe three stages of social development, that of "egocentrism" where children believe that others feel, think or perceive what they do; "nonegocentrism" where children are aware that other people may feel differently about an external event than they do, but do not know that they can find out how others feel; and finally "empathy" where children are aware there are other points of view, can find out about them and respond in a similar manner when in the same position. All of these stages are seen as impacting spatial development and the work of Fishbein, Lewis & Keiffer (1972) confirms the theoretical view of Laurendeau and Pinard (1970) that the stages of social development are coexistent with spatial development. The work of Fishbein and his associates (1972) aligned the three stages with three rules of perception. These were as follows: "you see what I see", "if you aren't in my place, you don't see what I see", and "if I were in your place I would see what you see". On the basis of their work, they concluded that white middle-class children acquire all three rules by age three to five and probably even earlier.

Shlechter and Salkind (1983) in reviewing other research (Borke, 1975; Fishbein, Lewis & Keiffer, 1972; Shantz & Watson, 1970, 1971) conclude that

> human spatial cognition is determined more by conditions within the environment than by conditions within the organism. Consequently, children under seven, in favourable environmental conditions, are capable of coordinating different spatial perspectives and effectively demonstrating mature spatial processing.
> (Shlechter and Salkind, 1983, p. 1092)

Their own research consequently confirmed this position that differences in environmental differentiation does affect children's spatial coordination and that the environments for which cues are clearly defined, provide the optimal environment for the fostering of young children's spatial understandings. Presson (1987) also found that differential experiences with some specific elements can affect the way that spatial information is stored and remembered. He also found that the specific effects established by a particular differential experience was the same for children aged six and ten years.

Shlechter and Salkind (1983) further note the paradox of the findings of Fishbein et al (1972) which indicate the organismic conditions which also affect the spatial coordination of young children. They concluded that children had shorter response latencies when their responses were egocentric and associated with less mature thought processes, than when their responses were correct or non-egocentric. Further data analyses showed that latencies were in fact longest when children were answering from a non-egocentric framework. They associated these facts with White's (1965, 1967) model of information processing, and saw correct and non-egocentric responses as reflecting cognitive-level decision-making.

Wright and Vliestra (1975) further argue that differences in children's ability to coordinate spatial perspectives are associated with conceptual tempo and levels of reflectivity and impulsivity. They posited that reflective children would make slower and more correct responses to spatial coordination problems, whilst impulsive children would respond quickly with egocentric responses. The research of Shlechter and Salkind (1983) further refined this position suggesting that:

> egocentic responding occurs when the child does not have enough information to understand the spatial situation. This hypothesis makes sense in light of the fact that only when response uncertainty is present do differences in the conceptual tempo become apparent.
> (Shlechter and Salkind, 1983, p.1096).

Finally, it will be shown in Chapter 7 that spatial ability is predominantly related to simultaneous processing ability although not exclusively so (Kirby and Das, 1978). Luria (1973) relates simultaneous synthesis to such things as ability to find one's bearing within a system of spatial coordinates, ability to distinguish correctly between right and left, ability to find one's bearing on a map and ability to tell the time by the position of the hands of a clock.

Conclusions

The research available confirms the opinion that the development of young children's spatial abilities is related to many other aspects of their development. These aspects include social and cognitive development, information processing style and conceptual tempo. It also seems reasonable to suggest that for young children at least, spatial ability is related to a variety of environmental factors and that differential experiences do influence the storing and recall of spatial information.

Finally, the theoretical issues surrounding the development of spatial abilities in children provide a framework that can be related to the claims that the use of Turtle Graphics in Logo can enhance spatial development (see Chapter 2). The use of Logo could be perceived as a particular factor in the children's environment which overtly confronts them with spatial concepts of location and orientation and its use could be seen as an experience capable of influencing storage and recall of spatial information.

CHAPTER 7

A MODEL OF INDIVIDUAL DIFFERENCES

The idea that children use the Logo language in very different ways is not surprising. Papert (1987) reports that during the period of time that he has been observing children working with Logo, he has been struck by just how divergent their uses can be. He says there are children who exhibit "precise, abstract, analytic" skills, in striking contrast to children who show a "kind of broad-brush intuitive style that comes naturally to them."

As the study reported here sought to clarify cognitive and metacognitive activities that might be enhanced by the use of Logo, and whether some types of learners would find Logo to be of more benefit to them than to others, it was necessary to have a model by which the children's different ways of processing information could be described. This model clearly needed to relate to cognitive processing rather than to measures of intelligence.

For the last thirty years educational psychologists and researchers have sought to produce theories of learning that incorporated models of individual differences. Bovy (1981), Salomon (1981), Thorndike and Stasz (1980), Cronbach and Snow (1977), Tobias (1976) and Estes (1974) are some whose theories and models have contributed to this research.

However, it is the model of individual differences based on the work of the Russian neuro-psychologist A.R.Luria, that has been used in the study. Luria's clinical observations of brain-damaged patients have led to investigations of cognitive tasks which distinguish between the simultaneous and successive processing of information, and also to the investigation of the role of cognitive control in information processing. This chapter therefore seeks to define these dimensions and to relate them to other characteristics which are used to describe the children in this study.

Simultaneous Processing

Luria (1973) stated that the zones of the cortex which lie between the occipital, temporal and central regions play a basic role in the organization of simultaneous sytheses. However, it has been mainly the work of Das et al. (1979) that has elaborated Luria's theories into working models. They define simultaneous processing as:

> the synthesis of separate elements into groups, these groups often taking on spatial overtones. The essential nature of this sort of processing is that any portion of the result is at once surveyable without dependence upon its position in the whole. It is hypothesized by Luria that simultaneous syntheses are of the following three varieties: a) Direct perception.... according to Luria, this type of formation is primarily spatial; b) Mnestic processes: This refers to the organization of stimulus traces from earlier experience.....; c) The last variety of synthesis is found in complex intellectual processes. In order for the human organism to grasp systems of relationships, it is necessary that the components of the systems be represented simultaneously....
> (Das et a., 1979, p.49)

Definitions similar to this are also found in the work of Jarman & Das (1977), Kirby & Das (1978, 1977), Das & Molloy (1975), Das (1984, 1973), Molloy & Das (1980), Kirby (1980), Merritt & McCallum (1984), and Das & Jarman (1981).

The presence of the simultaneous processing capacity has been shown through factor analyses of a battery of tests, including tests such as Raven's matrices, a figure-copying task and the Memory-for-Designs test. Kirby and Das (1978) point out that the simultaneous processing ability was confirmed in their research as being "primarily related to spatial ability" (p.65), although as Das et al. (1979) indicate, the simultaneous dimension is not solely spatial.

Das (1984) indicates that certain verbal tasks have been shown to require a dominance of simultaneous processing, a fact that had already been emphasised by Das and Jarman (1981). They point to the work of Kirby and Biggs (1979) who gave Grade 9 children tests of three kinds of ambiguities involving lexical, surface and deep structure, so as to explore any relationship with simultaneous processing. There were significant correlations for all three with the simultaneous factor scores.

Meanwhile, Das (1984) further pointed out that some Piagetian tasks - conservation of liquid, transitive inference, and class inclusion - required simultaneous processing.

Failure to engage in simultaneous structuring can be manifested through difficulty with many commonplace activites. Finding directions, telling the time and making a bed all depend on adequate systems of coordinates resulting from the ability to structure spatial information about one's surroundings. Classroom tasks such as map reading, letter reading and the reproduction of geometric shapes are all dependent on the organization of spatial relationships, whilst grammatical syntax and basic mathematical operations are also reliant on the integrity of spatial schemas. The place-value number system further relies heavily on recognition of the positional value of one digit in the whole, and children who experience difficulty with positioning in our notational system are often exhibiting lack of development in ability to process information simultaneously.

Successive Processing

Although Das (1973) is adamant that the two categories of information integration - simultaneous and successive - are parallel and not hierarchical, the two processes are distinctly and identifiably different. Das et al. (1979) define successive information processing as the:

> processing of information in a serial order. The important distinction between this type of information processing and simultaneous processing is that in successive processing the system is not totally surveyable at any point in time......Successive synthesis has three varieties: perceptual, mnestic and complex intellectual. According to Luria, the most obvious example of the last variety of successive processing is human speech.
> (Das et al., 1979, p.50).

Again, definitions of successive sythesis have been given in the work of Jarman & Das (1977), Kirby & Das (1978, 1977), Das & Molloy (1975), Das (1984, 1973), Molloy & Das (1980), Kirby (1980), Merritt & McCallum (1984), and Das & Jarman (1981).

Kirby and Das (1978) state that the presence of the successive information processing factor is usually measured by tests involving serial recall. However Das et al. (1979) emphasize the fact that while all of the tests for this factor involve memory, the factor itself is not in essence a memory factor. The most important aspect is the "requirement of maintaining a temporal sequence". (p.53). Das (1984) further points out that another manifestation of successive processing is the individual differences exhibited in the appreciation of syntax.

Finally, the various works of Das and his associates as cited above, all show that there is no hierarchical relationship existing between the simultaneous and the successive information processing abilities. Das (1973) said at an early point in the research development that:

> the two parallel modes are available to an individual and are used according to the nature of the task as well as the bias of the individual toward one or other method of information integration. Cultural or individual preference for the use of a specific mode may thus exist. But intelligence is not marked by a preference for one or the other mode.
> (Das, 1973, p.108).

Cognitive Control

As people in society are more and more bombarded by the information explosion, the need to be able to focus on and "attend" to those aspects of information that might be considered important, becomes more critical. Such a focussing demands some control over one's cognitive abilities. In schools particularly then, teachers are trying to develop in children, the skill of cognitive control or "attending". Luria (1973) describes it thus:

> The directivity and selectivity of mental processes, the basis on which they are organized, is usually termed attention in psychology. By this term we imply the factor responsible for picking out the essential elements for mental activity, or the process which keeps a close watch on the precise and organized course of mental activity.
> (Luria, 1973, p.256).

This use of the word "attention" relates to one's *capacity* to sustain attention and to the ability to exercise control over one's cognitive processing, rather than to a measure of attention span - a concept of attention referred to in Chapter 4. Luria (1973), in his investigation into this capacity, worked with mental retardates and confirmed that these people suffered from an attentional deficit (they did not have the capacity to attend) and that this contributed to most of their learning disabilities. He concluded that most of the learning deficits were attributable to the retardate's proneness to distraction by irrelevant stimuli when in the learning situation.

Learning at school in the early years is dominated by the two basic processes of registration of information and the processing of information. It is the registration of information which makes the initial demands on one's capacity to attend, thus heightening the need to monitor children's individual differences in this capacity as they manifest it in the classroom. Such monitoring is all the more necessary because of its impact on learning. Kagan and Kogan (1970) in substantial research done with six and seven year olds repeatedly showed that performance on the Embedded Figures Test, Matching Familiar Figures Test, Haptic Visual Matching Test, Memory for Digits Test, Memory for Sentences, Incidental Learning Test all showed high correlations with this capacity to attend, although a Vocabulary Test given in the same battery did not - a fact that is not surprising as it clearly does not make the same demands on cognitive control. They also make the point that encoding involves cognitive control in that one attends to one event rather than to another, and that because of this, differences in ability to encode amongst young children are often quite dramatic.

Another relevant aspect of cognitive control is its relationship to problem solving. Zelniker and Jeffrey (1979) state that "attending" is a critical first step in the process of problem solving. This use of the word "attention" implies cognitive control and accounts for the focus given to "attention" in works relating to individual differences in information processing.

A second relationship of interest, is that of "attention" and cognitive tempo as defined by the presence of reflectivity/ impulsivity. Piontkowski and Calfee (1979) state that reflectivity/impulsivity as measured by Kagan's Matching

Familiar Figures Test is related directly to selective attention, again implying the dimension of cognitive control. However, Zelniker and Jeffrey (1979) also account for this relationship in terms of "narrow" and "broad attention". They describe the reflective person as having a greater tendency towards the use of analytic processing (narrow attention), whilst the impulsive person will tend towards the use of global processing (broad attention). They do however, specifically state that such definition relates only to individual preferences for breadth of attention, and does not necessarily reflect other problem-solving competencies that the individual may or may not possess.

A fuller consideration of the relationship between the model of individual differences and reflectivity/impulsivity was given in Chapter 4.

Conclusions and Implications for Research on Logo

The model of individual differences presented in this chapter is a tripartite one attributing ways of organising information to simultaneous and successive processing, whilst the overall controlling process is attributed to the dimension of cognitive control. Whilst the model has its origins in the work of Luria (1973), it is Das and his associates (1979) who have proposed the applicability of a simultaneous and successive processing model to a variety of elements of school achievement. However, they make it clear that this relationship is a complex one and not one that can be explored simply by combining measures of processing and achievement in the one test battery.

In the study of young children using Logo, it is not the relationship of information processing to achievement that is primarily being examined. The Luria (1973) model of individual differences is being used to try to further interpret any changes that may occur in young children's learning as they engage in the use of the Logo language.

CHAPTER 8

SUMMARY OF RESEARCH AND HYPOTHESES

Introduction

Seymour Papert (1980), when sharing in the invention of the Logo language, was motivated principally by his belief that children's best learning will occur when they are encouraged to rely on their intuitions and use the knowledge they have already acquired to develop new ideas. When Logo is used in such a "discovery- oriented" environment, discoveries are not limited to only a few participants - everyone can make original contributions and original discoveries.

The "debates" relating to the measurement of what happens in a Logo environment have been referred to specifically in Chapter 2, but regardless of the methodologies followed, what are the claims about Logo to date?

Logo and Metacognitive Development

A number of works - Streibel (1983), Clements and Gullo (1984), Clements (1985), Church and Wright (1986) - suggest that the use of Logo has brought about enhanced metacognitive development in young children. They give both statistical and anecdotal evidence of children exhibiting improved divergent thinking abilities and enhanced capacities for monitoring their own behaviours. In particular Young (1982) and Clements and Gullo (1984) gave evidence of movement towards a more reflective style of thinking as measured by the Matching Familiar Figures Test. This suggests the first hypothesis.

> Hypothesis 1 Children in the Logo group will develop a more reflective style of thinking than their peers in the non-Logo groups.

The relationship between reflectivity/impulsivity and attention has been discussed in Chapter 4. However, attention can be thought of in two distinct ways. There is the capacity to exercise cognitive control over one's information processing - a concept that is used in the model of individual differences in the study and is measured by the test based on the work of Luria (1973). There is also the concept of attention as it relates to the measure of attention span, and it is this concept that is referred to in the literature relating to reflectivity/ impulsivity. Zelniker et al. (1972) have pointed out that if Kagan, Moss and Siegel (1963) are correct in suggesting that low performance on the Matching Familiar Figures Test could be attributed to short attention span, then the interest level of the task must be increased if there is to be an increase in the length of time that the child will attend, which in turn, will result in a move away from impulsivity towards reflectivity. Another possibility could be that the increasing of one's capacity to sustain attention, that is, the enhancement of one's cognitive control over the processing of information could also result in a movement away from impulsivity towards reflectivity. It is proposed that engagement in Logo activities could provide a vehicle for raising interest in tasks and enhancing one's cognitive control and subsequently moving the user away from impulsivity towards reflectivity.

> Hypothesis 2 Children in the Logo group who are low on the cognitive control factor will improve their capacity to sustain attention and demonstrate more improved performance on the Matching Familiar Figures Test than their non-Logo peers.

Logo and Conservation Abilities

The fact that so much of the "philosophy" of Logo is expressed in Piagetian terms is not surprizing, when one considers that Seymour Papert spent six years working with Piaget in Switzerland. Piaget (1965) has spoken at length about children's conservation abilities, and whether children can conserve or not has subsequently been posted as a pre-requisite benchmark for so many other activities in which children engage.

Rieber (1983) established a convincing argument as to why children would need to be able to conserve length before they could use Logo Turtle Graphics (see Chapter 5). Munro- Mavrias (1983) found significant correlation between the success of five year olds with Logo and their ability to conserve. Rieber (1983) however, found that children *could* use Logo efficiently despite their inability to conserve completely. The resolution of these two opposing findings appeared to lie in the suggestion that perhaps young children's very engagement in Logo activities promoted enhanced conservation abilities. Papert (1980) referred to children needing an environment where they could "mess about" and have "objects to think with."

Munro-Mavrias (1983) found that ability to use Logo efficiently was also related to ability to reverse thought processes and children having some idea of whether their strategies and solutions were likely to be correct. The use of Logo Turtle Graphics where children can "see" the results of their strategizing and then engage in "debugging" techniques to improve these, seemed likely to increase children's capacity to ascertain whether or not their solutions might be correct.

> Hypothesis 3 At the completion of the study, children in the Logo group will demonstrate better performance on Piagetian conservation tasks, than their non-Logo peers. Furthermore, they will have a better understanding of their own conservation abilities than their non-Logo peers.

Logo and Problem Solving

Papert (1980) described a learner as a problem-solver and the early documented research on using Logo with children was in the area of general problem-solving. From the work of Papert and Solomon in 1970 through to that of Clements and Nastasi in 1988, there is impressive evidence that Logo promoted and increased performance on systematic problem-solving skills. However, Clements (1985) also points out that due to the circumstances in which some of the research was carried out, some of the results were inconclusive, and issues of domain specificity and transfer of skills appear throughout the literature as ones that have not been fully resolved. However, the work of Schwatz et al. (1984), Brown and Rood (1984), White and Collins (1983), Gorman and Bourne (1983) and Hines (1983) all suggest that the use of Logo had enhanced the ability of its users to engage in a variety of problem-solving tasks. This created some expectation that the use of Logo by children in the study would produce some enhanced problem-solving skills.

> Hypothesis 4 At the completion of the study, children in the Logo group would perform better than their non-Logo peers on tasks that involved problem-solving skills.

Logo and Spatial Development

The use of Logo Turtle graphics is clearly related to plane geometry and a number of studies have investigated the relationship between Logo and spatial ability. However only two of these, that of Munro-Mavrias (1983) and Rieber (1983) have examined this relationship while working with young children. Munro-Mavrias (1983) found no significant correlations between spatial abilities and ability to use Logo, although she acknowledges that the lack of a control group and the smallness of her sample (26) may have coloured the results. Rieber (1983) on the other hand, found significant differences between the spatial abilities of the children using Logo and the control group and was even more staggered by the level of the concepts that his seven-year old Logo-using subjects had grasped. Clements and Gullo (1984) report that a group of six year olds using Logo were better at describing directions than non-Logo using peers, although they do not attempt to relate this to a broader reference of spatial skills. The point is made in these studies regarding the degree of difficulty involved in trying to measure the spatial skills of children in this younger age group.

> Hypothesis 5 That the Logo environment will develop in its users a capacity for more effective spatial processing than the capacity of their peers in the non-Logo group.

Logo and Information Processing

Reference has been made above to the obvious connections between Logo Turtle Graphics, plane geometry and the spatial skills of those who use this form of Logo. The model of individual differences described in Chapter 7 clearly shows that simultaneous information processing ability has among other things, a relation to spatial ability. Therefore it seems likely that children who have a natural capacity for processing information simultaneously will also have enhanced ability to use Logo Turtle graphics.

> Hypothesis 6 Children classified as high on simultaneous information processing ability will perform better on Logo tasks than their peers with low simultaneous information processing ability.

Conclusions

The six hypotheses presented above were generated as a result of surveying the literature relating to areas of children's development that might relate to or be an outcome of their use of Logo. In addition, some areas of development which appeared to have less direct relation to the use of Logo - namely those of Literacy and Numeracy - seemed to also be worthy of monitoring. The social development of children engaged in the use of computers in general, and Logo in particular has continued to be an area of interest to researchers, so it was also decided to monitor the social development of the children in the study who were using Logo. This assumed importance also because of the inter -relationship between social development and spatial development, social development and the development of conservation abilities and the role of the social dimension in children's problem-solving abilities.

Summary of Research Hypotheses

The following is a summary of the research hypotheses which the study investigated:

Hypothesis 1 Children in the Logo group will develop a more reflective style of thinking than their peers in the non-Logo groups.

Hypothesis 2 Children in the Logo group who are low on the cognitive control factor will improve their capacity to sustain attention and demonstrate more improved performance on the Matching Familiar Figures Test than their non-Logo peers.

Hypothesis 3 At the completion of the study, children in the Logo group will demonstrate better performance on Piagetian conservation tasks, than their non-Logo peers. Furthermore,they will have a better understanding of their own conservation abilities than their non-Logo peers.

Hypothesis 4 At the completion of the study, children in the Logo group would perform better than their non-Logo peers on tasks that involved problem-solving skills.

Hypothesis 5 That the Logo environment will develop in its users a capacity for more effective spatial processing than the capacity of their peers in the non-Logo group.

Hypothesis 6 Children classified as high on simultaneous information processing ability will perform better on Logo tasks than their peers with low simultaneous information processing ability.

CHAPTER 9

RESEARCH DESIGN AND INITIAL ANALYSIS

The Environment and Subjects

Villa Maria Primary School is situated in one of Sydney's higher socio-economic bracketted suburbs - Hunters Hill. Children are nearly all of Australian background and most parents are from professional occupations. Children are therefore quite articulate and are comfortable in the technological environment, as many of them have access to computers at home. The setting up of the experimental group for this study required the involvement of the Kindergarten of 1986, with the understanding that these children would also remain involved in the study whilst they were in First Grade in 1987. This provided a sample of thirty two children who participated in the study, when account was taken of those children who for a variety of reasons - re-location, illness - were prevented from on-going participation in the study.

Villa Maria School is equipped with sixteen microcomputers and this technology receives a high profile in the school. All children use computers as part of their ordinary school programme and teachers are constantly integrating their use of technology into the curriculum.

The children of the Kindergartens of Prouille Primary School situated in Wahroonga, were chosen as the non-Logo control groups because their cultural and socio-economic backgrounds were very similar to those of the children from Hunters Hill. There were two groups of thirty students in the Kindergartens in 1986 and subsequently in the First Grades in 1987, who participated in the study.

Prouille School has no computers for student usage, although many children indicated that they had access to computers in their homes. This was of course significant, although in all other respects, resources and opportunities seemed to be comparable in the two schools.

Prior to commencing working with Logo with the subjects from Hunters Hill (subsequently referred to as the Logo group) it was necessary to spend time with the staff members who would be responsible for these children during the period of the research. Teachers were given an opportunity to learn about Logo themselves and were also given information about the role they could play in the study. Seven ninety minute sessions spread across approximately ten weeks were conducted to accomplish this, thus ensuring that these teachers both understood the philosophical bases of the research and would be able to contribute to and monitor the study, at times when the researcher was not present.

The names of the children used in the study are fictitious, so as to preserve anonymity.

The Model as Applied to The Study

The model of individual differences described above was used in the study, as one of the main descriptors of the children engaged in the experimental work. The model was further used with the children who became the control groups for the main study, all of whom were in the Kindergarten classes at the commencement of the study. The combined groups consisted of 46 boys and 44 girls. At the beginning of November, the Logo group had a mean age of 6.01 years, whilst the non-Logo group had a mean age of 6.14 years. The testing of every child in relation to the model, was carried out in August and September, that is after six months of their first year of school. The testing sessions were broken into four components of twenty minutes each, as it was judged that it was realistic to expect that the children could concentrate on two or three different tasks for this period of time. All tasks were presented to the children using a computer.

Task Procedures: Simultaneous Processing

Simultaneous information processing requires the ability to integrate appropriate information into a spatially organised structure which is simultaneously accessible. Children of five and six years of age have very limited skills in being able to reproduce spatial patterns on paper, and therefore only line drawings with two dimensions were used as tests of simultaneous information processing ability in this study. Tasks of this kind have been previously used by the University of New England in research on individual differences and Tulloch (1986) says that

> the University of New England research has made extensive use of line designs based on 3 x3 dot matrices. The nine dot matrix was found to enable the provision of displays of appropriate complexity for kindergarten children (Ransley, 1981; Tulloch, 1981). (Tulloch, 1986, p.144).

Matrix Copy The task used a set of screen displays each of which contained a nine dot matrix, with one or more straight lines linked. (See Appendix B). The matrix was programmed so as to be present on the screen for a maximum of 60 seconds. The children were given instructions to reproduce the lines on the dot matrix sheets which they were given. Luria (1973) states that direct reproduction of two or three-dimensional structures is one of the simplest indicators of simultaneous synthesis (p.150).

A trial example was given and any errors in carrying out the task were corrected, so as to ensure that children fully comprehended the exercise. There were eleven examples given to the children without any further intervention, except to remind them to move to the next matrix before drawing.

Matrix Memory This task (see Appendix B) was similar to the one described above except that the line patterns were simpler, because each pattern only remained on the screen for three seconds, and the children were therefore required to draw the figures from memory onto the matrix. A trial example was given as above.

The children were given these two tasks in different testing sessions, the copying task being given first with the memory task in a later session.

Task Procedures: Successive Processing

Successive processing requires that the information processor retain the temporal order of given items. Both of the tasks therefore consisted of the presentation of successive items and the child was required to record the sequence of the items.

Colour Tap Tulloch (1986) indicated that this task was a modified version of Ransley's (1981) colour tap procedure. The computer program randomly generated a coloured square sequence on the centre of the screen at one second intervals. Only four colours - red, green, blue and yellow - were used, and no colour was repeated in any given sequence. The four coloured squares were then presented in the corners of the screen in a randomly varied order, and the children were asked to point to the colours they had seen in the sequence, in the same order as they had been presented. (See Appendix B). Tulloch (1986) had correctly ascertained that five-year old children could find this task difficult when more than two colours were presented in the sequence, and so had introduced a system of tailored testing. Children were given practice examples so as their comprehension of the task could be checked, and then all testing began with a sequence of two colours. If the child answered correctly the sequence was increased by one up to a maximum of four, and similarly if the answer was incorrect the sequence was reduced by one to a minimum of two colours. Such tailoring maximises the information gain in situations with young children where tasks must be kept to a short time span, and any sense of anxiety and/or failure is reduced. It should also be noted that the testing time had to be kept within limits acceptable to the children's classroom demands.

Tone Sequences This task was based on the work of Luria (1966) and Neisser (1967), relating kinetic melody and rhythm to the retention of temporal information. The aural presentation therefore used the computer to generate two tones - a distinctly long tone and a distinctly short tone. These tones were then combined to form sequences such as long, short, short, long. Children were given ample opportunity to discriminate between the sounds and identify them before being placed in the testing situation. The test itself (see Appendix B) consisted of twelve sequences, the first of which contained two sounds, with the number gradually increasing up to five sounds. A form of tailoring was again introduced, in that the child was only tested on an increased number of sounds if at least one sequence in the previous block was correct.

Task Procedures: Cognitive Control

The tasks which were used to test cognitive control focussed on the children's abilities for maintenance of selective responses when faced with competing stimuli in the environment. These tasks were structurally similar to those used by Ransley (1981), but had been adapted for use with graphic displays by Tulloch (1986).

<u>The Face</u> The children were placed in front of a computer terminal and shown a stylized face on the screen which contained two blank rectangles for eyes (Figure 9.1).

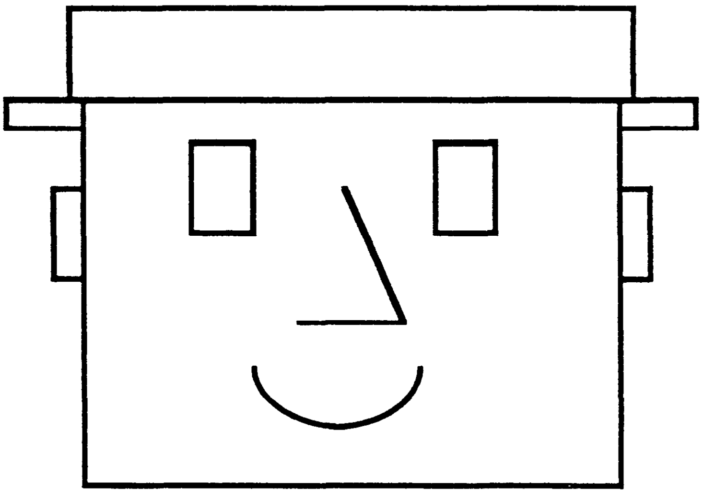


Figure 9.1

They were then shown how the eyes could blink at them with the left eye always blinking in orange and the right eye always blinking in white. The children had to press the space bar on the keyboard whenever the orange eye winked at them but <u>not</u> when the white eye winked. After practice for task comprehension, a sequence of one hundred and eleven randomly ordered eye blinks were presented (See Appendix B). The computer collected data for each child relating to failure to press the space bar in response to the orange wink and incorrect pressing of the space bar for a white blink.

The House A graphic display of a house was presented to the children on a computer screen (Figure 9.2).

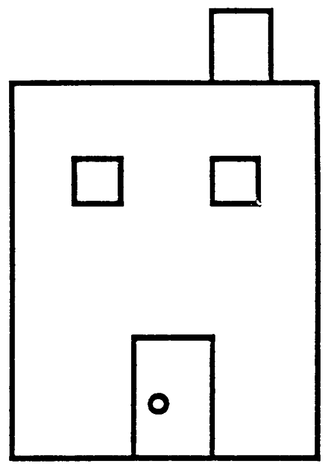


Figure 9.2

The house featured a blue door which opened automatically from time to time. The task for the children was to close the door each time it opened, by pressing the space bar on the computer keyboard. They were subsequently instructed that there was no time pattern associated with the opening of the door and that if they failed to close the door, a burglar could get in and this was signalled by a beeping sound - the burglar alarm going off! If the child pressed the space bar when the door was not opened, the door would turn red alerting them to this incorrect action. Five different periods of time were set for the closing and opening of the door (1, 4, 7, 11, 17 seconds) and there were thirty trials as each time period was used on six occasions (See Appendix B). The mean response time was calculated by finding the average from the length of time between the opening of the door and the child's response on each trial.

Scoring Procedures

Simultaneous Tasks The two matrix tasks, Matrix Copy and Matrix Memory were scored with one point for the single line displays which were simply assessed as either correct or incorrect. Either two or three points were given for the remaining multiple line displays, three points being given when the number of lines involved was greater than two. When two or more points were allocated, one point was deducted if the response contained a single error - for example, a mirror image of the correct figure, the correct shape wrongly placed on the matrix, the omission or incorrect placement of one line with all other lines correctly placed.

Scores on these tasks ranged from 7 - 26, (Matrix Copy, Mean = 21.29, SD = 4.04; Matrix Memory, Mean = 18.03, SD = 4.30), which indicated quite comparable spatial abilities amongst most children with the exception of a few notably weak achievers.

Successive Tasks In the Colour Tap a point was given for each colour that was given its correct position within the sequence (i.e. a Red Green Blue [RGB] response gained two points from the possible three for RYB). The maximum possible score was 21 with the highest score achieved by these groups being 21 and the lowest 0 (Mean = 9.56, SD = 4.90).

In the Tone Sequences a sequence was scored as being either correct or not, with the number of points being awarded to correspond with the number of items in the sequence. The maximum possible score was 40 and the scores of this group ranged from 2 - 40 (Mean = 25.16, SD = 9.15).

Cognitive Control Tasks In the Face task a total error score was obtained for each child by combining the number of false positives and incorrect omissions. There was an extremely wide ranging distribution (Range = 0 - 72) with a small number of very low performers (Mean = 6.43, SD = 8.57).

In the House task a mean response time for each child was taken as the measure of performance, with a trial in which no response was recorded within the allowed ten seconds being treated as a response time of ten seconds. Mean response times ranged from 5.53 to 41.7 seconds (Mean = 13.8, SD = 6.19).

Factor Analysis: Procedure

A Principal Components Analysis (SPSSX, PA1 analysis) was used in the study as the prime purpose of the analysis was the derivation of factor scores (Wilkinson, 1986). Wilkinson (1986) has argued that this is the only appropriate procedure, when the primary purpose of the analysis is the construction of subject scores. The structure was rotated using Varimax and scores on three factors were produced.

The use of this three-factor structure applied to the model was given empirical support originally from the study of Ransley (1981) in which the three factors - cognitive control, simultaneous and successive information processing - were identified from a set of measures gained from tasks similar to the ones used in this study. This support was further substantiated by Tulloch (1986) with tests similar to those used in this study. Tulloch (1986) verified that two tests for each factor provided adequate indicators of each process. An investigatory pilot analysis carried out with 32 subjects confirmed that the three factor model was appropriate in this instance.

Although factor analysis was used to identify this three-factor structure, the identification and naming of these factors related primarily to the theoretical issues discussed in Chapter 7.

Factor Analysis - Solution

Varimax rotation yielded the Factor Pattern shown in Table 9.1. Correlations between the six variables are shown in Appendix F.

The three factors can be identified as simultaneous processing (Factor 1), which is defined almost equally by Matrix Memory and Matrix Copy; successive processing (Factor 2), defined primarily by Tone Sequences but with a substantial weighting from Colour Tap; and cognitive control (Factor 3), defined firstly by House with a strong contribution from Face. These results yield a good simple structure with each task having loadings of over .56 on the expected factor and under .26 on other factors.

Factor scores for each subject were derived from the factor structure in Table 9.1, for use in other analyses including correlational analyses. The subsequent use of MANOVA procedures to examine interaction effects involved the partitioning of subjects into two levels on each factor - high and low - giving 45 subjects at each level.

VARIMAX FACTOR LOADINGS OF THE SIX VARIBALES, MATRIX MEMORY, MATRIX COPY, COLOUR TAP, TONE SEQUENCES, FACE AND HOUSE ON THE THREE FACTORS OBTAINED FROM THE FACTOR ANALYSIS OF RAW SCORE DATA OF THE KINDERGARTEN CLASSES (N = 90).

	VARIMAX FACTOR		
TEST	Simultaneous 1	Successive 2	Cognitive Control 3
Matrix Memory	.892	.093	-.089
Matrix Copy	.875	.176	.024
Colour Tap	.256	.575	-.069
Tone Sequences	.042	.844	.030
Face	.027	-.403	.636
House	-.081	.174	.859

Table 9.1

Conservation Abilities

At the outset of the study and again at its completion, all children were given a ten item test (see Appendix E) to assess their ability to conserve number and length. This test was drawn from the work of Wadsworth (1984) and Piaget (1965). The first seven items related to conservation of number and tested the child's ability to use one-to-one correspondence as the basis for judgment of numerical equivalence (Piaget, 1965). Children were shown three different pictures of two arrays of objects and were asked on each occasion if the number of objects in the arrays was the same. They were then asked to give a reason as to why they answered either "yes" or "no". On the seventh question a row of seven counters was constructed from a pile of counters and placed in a straight line on the table before the child who was then asked to choose some more counters form the pile to construct another row the same as the one laid out for him/her.

The final three items were concerned with the child's ability to conserve length, and the change of position experiment put forward by Piaget et al. (1960) and described in Chapter 5 was replicated. Two rods exactly ten centimetres in length were shown to the children. They were then asked to verify by their own means, that they were exactly the same length, before proceeding to the next step, where the positions of the rods were changed. On the first occasion, one rod was placed about a centimetre ahead of the other. Then the two rods were placed in a "T" intersection, and finally they were placed at an acute angle to one another. On each occasion the child was asked if the rods were the same length. If they responded negatively, they were then asked which one was longer.

All children were interviewed individually and answers to questions recorded. A total score was finally computed.

Metacognitive Development: The Matching Familiar Figures Test

The test (see Appendix D) was administered to all children individually at the beginning and at the conclusion of the study. There are 12 items each of which gives a master picture, five variations of it and one picture which is the exact copy of the master. Children had to choose the matching picture from the alternatives by pointing to their choice. This first response was timed and they were advised whether their choice was correct. If they were incorrect, timing ceased and they then indicated further choices until the correct one was chosen. These choices were recorded and on each occasion, children were informed of the correctness of their choice.

Spatial Development

At the conclusion of the study all children were given three tests to assess their spatial abilities. Two of these tests were taken from the "Discovering Shapes" Workbook and were directly related to abilities to match congruent figures and identify triangles contained within other figures (See Appendix E). The final test was taken from Ekstrom et al's. (1976) Kit of Factor-Referenced Cognitive Tests (See Appendix E). The Manual for this Test classifies it as a spatial scanning task and acknowledges that there are some connections between this test and "planning skills." The authors go on to say however, that "the level of planning required by these maze-type tests seems to be a simple willingness to find a correct path visually before wasting time in marking the paper." They then state that "subjects may discover the simplifying strategy of searching from the goal rather than from the start."

It should be noted that children from the non-Logo groups spent some considerable amount of class time engaging in pencil and paper maze activities as part of their normal classroom activities. This seemed to ensure that the Logo group of children who had worked with Logo mazes during the course of the study were not advantaged in any way in this particular test.

Children were given all three tests at the one time in the following order: 1) test to identify triangles within the figure; 2) test of congruent figures; 3) maze test. They were given examples of the tasks they were required to do on the blackboard, so as to ensure that every child knew what was expected of him/her.

Spatial Test 1. Children were presented with 5 figures, each of which contained a number of triangles. They were asked to write the number of triangles contained in each figure, and one point was awarded for each figure that was totally correct (i.e. highest possible score was 5).

Spatial Test 2. This test required the children to identify the congruent figures in two given sets of figures. A point was awarded for every correct congruence identified (i.e. highest possible score was 12).

Maze Test. In this test children had to find a path through the given sets of mazes. One point was awarded for every square through which the path was correctly traced, and no points were deducted for errors where the correct path had eventually been found (i.e. highest possible score was 12).

Literacy

Pre-Test At the outset of the study, a test of letter recognition (see Appendix C) was given to all subjects. A point was awarded for each of the twelve letters identified correctly by each subject and a total score calculated.

Post-Test At the conclusion of the study, all subjects were given the ACER Primary Reading Survey Test of Word Recognition (see Appendix C). This test contains 16 multiple-choice picture-stimulus recognition items, and children were asked to look at a picture and choose from three possibilities the word closest in meaning to the picture. The instruction to the children was "Which word tells us best about the picture?" The Manual for the Administration and

Scoring of this Test states that the sets of three words for each question or item have been selected so as to represent common sources of reading problems experienced by beginners (p.4-5). Each child was awarded one point for a correct response and a total score was calculated.

Numeracy

Pre-Test At the outset of the study a test of one-to-one correspondence was given to all subjects to assess their counting abilities (See Appendix C). A point was awarded for each numeral which correctly represented the nine given pictures. If children wrote a numeral in either inverted form or mirror image, but had counted correctly, the point was still awarded. A total score was then calculated.

Problem Solving

In order to avoid any bias towards the children who had been using Logo, no problem-solving tests involving any use of shapes or spatial skills were used. All teachers involved with both the Logo and non-Logo groups agreed that a test of arithmetic word problems would be a "fair" instrument for use with both groups.

The test used (see Appendix C) was a version of the test used by Carpenter and Moser (1982) in their research into the development of addition and subtraction problem-solving skills and involved four different types of verbal addition and subtraction problems, namely, joining/separating, part-part-whole, comparison and equalizing. The test was administered to the children in groups of five, with each problem being read twice, aloud and slowly.

Children were awarded a point for each correct answer on the seventeen item test, although separate scores were also given where it was obvious that the child had comprehended the task and performed the correct operation, but had miscalculated and given an answer that was +1 or -1 from the correct answer.

Boehm Test of Basic Concepts

The Manual for the Boehm Test of Basic Concepts (see Appendix C for test) states that the test

> is designed to measure children's mastery of concepts considered necessary for achievement in the first years of school.
> (Boehm, 1980, p.3).

The test contains fifty items with each item consisting of a set of pictures about which statements describing the pictures are read aloud to the children with the children being instructed to mark the picture that illustrates the concept that is being tested.

At the completion of the study, the Boehm test of Basic Concepts was administered to all children. There are two forms of the test, A and B, and both are reported to be comparable. Form A was used on this occasion. It provides children with three examples of the conduct of the test so as to ensure that the subjects understand the nature of the task. At each group administration of the test, these examples were given to the children to ensure understanding of what was required.

The test was scored with one point being given for each of the fifty items that was correct, and a total score was then calculated for each child.

CHAPTER 10

THE USE OF LOGO IN THE STUDY

Background

After the work with the teachers at Villa Maria Primary School had been completed (see Chapter 9), work with the children in the Kindergarten class was commenced. They had already been introduced to computers and the keyboard through the use of computer-assisted instruction programs which were being used by the teacher as part of the language programme.

The Turtle Graphics aspect of Logo was introduced into the environment during May which was the beginning of the children's second term in Kindergarten. Extracts from the programme of formal Logo-based activities are contained in Appendix A. An attempt was made, however, to create *a Logo environment*, rather than having the children just participate in formal lessons on how to use Logo. This was achieved through the classroom teacher trying to incorporate continual reference to Logo-based concepts in the Number, Language, Music and Social Studies programmes.

After two months' intensive work with Body Geometry and other associated "Turtle" activities, the children were introduced to the graphic screen Turtle in the Logo language. The version of Logo used for this was Apple Logo I, which had been re-programmed into One-Key Logo. Children worked in directed small groups until there was enough evidence both during formal and informal Logo activities, that they were ready to work, both alone and in pairs, without being led by an adult. From this point on, LTT Logo, for the BBC computers was used, although again the language was re-programmed to function as a One-Key Logo.

A programme of formal and informal Logo activities was maintained, for fifteen months , after which post-testing was carried out, and the research project brought to a conclusion. However, the teacher maintained the environment after this time, because she believed that the children had been set on a path which could not be abandoned. Indeed, an undertaking was given by all existing school staff, to foster and continue the work of the research project, for the period of time that the children remained in the school.

It should be stressed that although no Logo work was done with the children from Prouille School (subsequently referred to as the non-Logo group), a considerable amount of time was spent with these children engaging in computer games and other informal play activities, to avoid a situation arising where testing situations could be biased because of the Logo group having had more contact with the researcher and therefore being more relaxed in her presence.

Reflectivity/Impulsivity and Logo

Clements and Gullo (1984) have argued that children engaged in the use of the Logo language, are forced to think about their errors and how to correct them and that this can lead to the development of a reflective style of thinking. Their research, together with that of Mohamed (1985) and Young (1982) suggests that movement towards more reflective thinking is promoted by the use of Logo. Given the fact that the children in the study would at times be working in groups, it was anticipated that participation in discussion leading to negotiated problem-solving would further enhance the likelihood of this occurring.

Following the research of Clements and Gullo (1984), Mohamed (1985) and Young (1982), the sequence of Logo activities used in the study placed an emphasis on tasks that would force the children to be attentive to the tasks, to plan in advance, reflect on the plans, sometimes discuss them with others, and then as a result of their reflections "debug" their errors. This was effected by giving the children a particular drawing that they had to reproduce. They developed a "methodology" for approaching such a task by first planning their commands, either via the screen or just mentally, and then writing these on the paper beside the drawing. When they had all the commands they felt were necessary to produce the drawing, they would program these into the computer, and see if they achieved the desired result. If a procedure was not doing what the children had anticipated, they usually discussed it among themselves, and when intervention was appropriate, they were helped to think through what was happening, and after this reflection, to adjust the "bug".

Children grew in confidence and also in exhibiting individuality in their approach to and execution of tasks. How the children would respond was not always predictable, but the fact that they were acquiring new and different skills seemed to be noticably obvious to all who observed them at "work."

Problem Solving and Logo

It is possible to equate the use of Logo with aspects of problem-solving. For example the following characteristics for classification of a problem apply directly to any given Logo-based task. They are:

i) the number of possible solutions
ii) complexity, which is defined as the number of logical steps necessary to reach a solution

iii) experience, which is the dependence of success upon the recall of information not provided in the problem and
iv) ambiguity. Ambiguity signifies the extent to which the problem statement explicates, or fails to explicate, the criteria for a successful solution.
(Turner and Bentley, 1982, p.41).

Furthermore while using Logo, young children need to use different combinations of the six processes - estimation, classification, pattern generation, translation, trial-and-error, and verification - which Castaneda et al. (1982) state are available to them. They also believe that developing problem-solving ability is a cumulative process, dependent on the experiences of the child.

Nearly all of the Logo tasks and experiences in which the children in the Logo group were engaged demanded some estimation of the number of turtle steps needed, some classification of shapes, some generation of patterns, some translation of directions into turtle commands and vice versa, a deal of trial-and-error usually referred to as "debugging" and the verification of whether execution of the Logo commands would produce the desired result.

Spatial Skills and Logo

The use of Turtle Graphics because of its very nature, confronts children with the acquisition and use of spatial knowledge. At the beginning of the study much time was spent with the children engaging in activities such as body geometry and floor mazes to develop their knowledge of FORWARD and BACK and RIGHT and LEFT. (see Logo Program, Appendix A).

Children were then gradually introduced to the screen turtle as a character that they could manipulate. Reference was constantly made to the games of turtle that they had been engaged in and they were given the opportunity to move their own turtle round the screen. After becoming proficient at this, children were introduced to screen mazes. Children worked in small groups and over a period of time all were confident in both calling the moves to be made to move the turtle through the maze, and in executing the commands on the computer.

Literacy and Logo

There was no attempt in the study to promote the development of literacy or language. However, the use of Logo as with the use of most other resources or tools in the Kindergarten and First Grade, brought with it a "special" vocabulary. The use of the computer also required the use of correct spelling for inputting commands, as Turtle Graphics will not accept spelling errors when commands are being given.

At various stages in the development of the Logo sequence, children were required to input the following words:

* FORWARD	* PENDOWN
* BACK	* HOME AND CLEAR
* LEFT	* STAR
* RIGHT	* CIRCLE
* PENUP	* BELL

Initially the children were given cards with these words written on them, and these were used so as to key in correct spelling. However it was obvious that a number of children soon abandoned the cards, as they simply did not take them to the computers.

The vocabulary associated with the use of Logo is somewhat specialized and assumes an understanding of a number of concepts related to both the computer itself, directionality and a number of geometric shapes. The issues of the children's understanding of directionality and geometric shapes is addressed earlier in the Chapter in relation to Spatial Concepts whilst the testing of Basic Concepts is addressed in Chapter 12.

Numeracy and Logo

As with Literacy, the study did not attempt to actively promote the enhancement of children's numeracy skills, but of necessity the use of Logo engaged the children in the use of numbers.

From the beginning of the Logo sequence, before the children ever went to the computer, they began to quantify the number of steps that would be needed to move either the toy turtle or the human "turtle" to the desired point. Generally it is true to say that young children often "use" large numbers in their conversation without ever having any concept of their meaning, but on these occasions they were required to count out the number of steps they were suggesting. Initially some children could not count beyond ten. After one month of this type of work, when children were ready to use Turtle Graphics on the computer screen, they began by inserting numbers with the commands FORWARD and BACK. They did this quite spontaneously and freely experimented with different sized number inputs. A few children accidently inserted numbers like 2000 instead of 200, and discovered that the turtle wrapped around the screen. The children found this a source of great amusement, and many of them then tried it. One child exclaimed that the turtle would get very tired going round and round like that!! During this time concepts of larger numbers were being built up.

Another exercise involved the placement of three dots on the computer screen in such a way that the children could make rectangles of a variety of sizes using the dots and the turtle's "home" at the centre of the screen. Children were given the task of moving the turtle around the screen so as it moved from one dot to another to form the rectangle. For example:

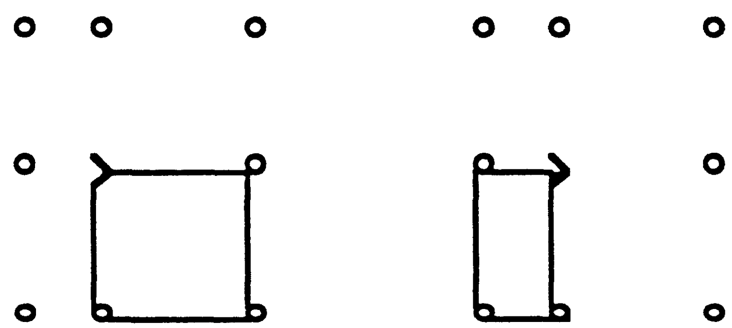


Figure 10.1

The task was designed to give the children the experience of estimating turtle distances, and they were shown they could use a combination of moves (e.g. FORWARD 30, FORWARD 20 = FORWARD 50) to reach their desired destination. In this way they were building up a concept of addition of numbers.

After an extended use (two months) of One Key Logo for the purpose of doing work with mazes, the children were moved back to the full version of Logo (LTT Logo), although One Key Logo continued to be used throughout the study for some particular purposes. Using LTT Logo children were then given maze tasks which required them to input numbers with their commands. All of the children, regardless of ability began by inputting numbers less than 10. It was pointed out that the turtle moves would be more effective if larger numbers were used. In general children showed that they had no real concept of what "large" numbers were - for example, if they had first used a number, say 4, a larger number was thought to be 6 or 7. When they were prompted to go above 10, some of them counted aloud 11, 12 etc. Some children kept reverting to their use of smaller numbers, and did not recognize visually, the size of the number they needed. On the other hand, other children, once they used larger numbers, realized that the use of these numbers would enable them to reach "home" more quickly, and so continued to experiment with numbers larger than 10. It is of interest to note that these children using the larger numbers were all ones who had been classified as "high" on the simultaneous dimension of the model for individual differences, whilst those children who kept using the smaller numbers were those who were "low" on the simultaneous dimension. This facility with numbers demonstrated by these children is consistent with examples given in the definition of simultaneous processing in Chapter 7. The children who were high on this dimension were able to synthesize the number sets more quickly and with greater ease than those who were low on the dimension. Children used numbers between 10 and 20 quite competently, but numbers above 20 only seemed to be used as multiples of 10 e.g. 30, 40, 50 etc. One boy asked if there was such a number as eleventy. This showed that children still had quite faulty concepts of numbers beyond 20, even though they did indeed use them in their conversations. This can be related to the findings of

Gelman (1982) who reported several incidents of children *talking* about concepts which they could not effectively use.

Children continued to work on these types of tasks, using a variety of games, based on the same principles. They showed continued competence in using larger numbers than they were using in their formal mathematical work. Children began to show that they were becoming aware of the relationships between some of the numbers. For example, they began to use their fingers on the screen to "measure" the size of the move they wanted to make, and in so doing realized that it was only half as big, or twice the size of other moves they had made previously. Invariably they asked what twice forty was, or what was half of 90. They would then use these numbers to make the desired moves, and were obviously delighted when their schemes for calculation worked!

Continued use of the Logo language was maintained and children became more adept at inputting numbers which were appropriate. By the completion of the study, they showed on numerous occasions by choice of the correct number on the first occasion that they really *knew* what size number to input in order to complete the task at hand.

CHAPTER 11

THE MODEL OF INDIVIDUAL DIFFERENCES AND OVERALL LOGO PERFORMANCE

The Model and the Logo Language

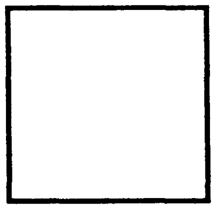
The choice of the Luria model of individual differences was, as stated in Chapter 9, a specific attempt to provide a model of individual differences not based on intelligence testing, against which any changes in young children's performance as they interacted with the Logo computer language could be interpreted. It was further seen as a vehicle for trying to understand why some children and perhaps not others, might show facility with or be attracted to the use of the Logo language. It is this last idea - some particular children's success with Logo - that this Chapter seeks to address.

The descriptions of the dimensions of the model of individual differences - simultaneous information processing ability, successive information processing ability and cognitive control - given by Luria (1973) and interpreted by other researchers (see Chapter 7) lead to some speculation about the potential relationships that might exist between the dimensions and performance using the Logo computer language. Das et al. (1979) said that simultaneous information processing

> refers to the synthesis of separate elements into groups, these groups often taking on spatial overtones. The essential nature of this sort of processing is that any portion of the result is at once surveyable without dependence upon its position in the whole.
> (Das et al., 1979, p.49).

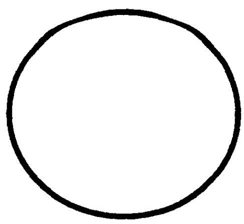
The "spatial overtones" of Turtle Graphics are well established, as it is a geometrically based aspect of the Logo language. However the writing of any Logo procedure using the medium also relies on the "synthesis of separate elements into groups." For example the procedure for drawing a square requires the use of either the FORWARD or BACK commands and the RIGHT or LEFT commands. Each of the commands is an element in its own right, and is identifiable as such regardless of its position in the square. Yet it is only the synthesising of the set of commands that eventually produces the square.

```
FD 50
RT 90
FD 50
RT 90
FD 50
RT 90
FD 50
RT 90
```



Similarly the construction of a circle requires the use of the same FORWARD or BACK commands and RIGHT or LEFT commands. Again each of the commands is an element in its own right, and is identifiable as such regardless of its position in the circle, but as with the forming of the square, it is only the synthesising of the set of commands that eventually produces the circle.

```
REPEAT 36 [ FD 20 RT 10]
```



It would seem reasonable to conclude then that if one accepts Das et al's. (1979) definition of simultaneous information processing, the use of Logo

Turtle Graphics by its very nature engages the user in this processing. However it could be argued that the manner in which children actually carry out the sythesizing of the elements to form a square or circle could just as well be related to successive information processing as to simultaneous.

Logo Tasks and Their Assessment

During the study children were engaged in a variety of Logo tasks. There were however four major areas where their facility with Turtle Graphics could be assessed. These areas were :

1) knowledge of commands and their functions
   for example: FORWARD, BACK, RIGHT, LEFT, PENUP, PENDOWN, REPEAT, HOME

2) children's ability to use the commands to create ordered designs
   for example: square, rectangle, set of stairs

3) their ability to engage in programming exercises to produce any drawing they wished

4) their ability to "order" their programming to produce a specified product.

Children's work on the tasks was assessed by the researcher without reference to the results of the Luria tasks, and for the purposes of the study, a mark was awarded to each child in each of the four areas and a total score calculated. (For examples of marking scheme, see Appendix I). The scores ranged from 3 - 12 with a mean score of 8.125 and a standard deviation of 2.3947.

Results and Conclusions

Univariate analysis using the three factor model of individual differences with the score for the Logo tasks as the dependent variable was carried out. The hypothesised relation between success with Logo and simultaneous information processing was significant ($p < .02$) as shown in Table 11.1.

The hypothesis that children with high simultaneous information processing ability would perform better on Logo tasks than their peers with low simultaneous information processing ability was supported ($F = 6.22$; df 1, 24; $p < .02$).

Examination of adjusted means for simultaneous information processing ability gave the results shown in Table 11.2.

Closer examination of the profiles of the children in the Logo group who were high on simultaneous information processing ability showed that of the 12 subjects who were in that category, 9 were boys and only 3 were girls. Furthermore of the 9 boys, 5 had actually been classified as reflectives on the Matching Familiar Figures Test, whilst the other 4 were fast/accurates. The 3 girls however, had all been classified as reflective on the MFFT. This suggests that there was some implicit relationship between the child's capacity for reflectivity and high simultaneous information processing ability, although initially no statistical correlation between information processing abilities and reflectivity/ impulsivity was significant. Such relationship was confirmed by classroom observation.

ANOVA: MODEL OF INDIVIDUAL DIFFERENCES AND SCORES ON LOGO TASKS

df = 1,24

	F	p <
Simultaneous	6.219	.02
Successive	.585	.45
Cognitive Control	.328	.57
Sim x Suc	.826	.37
Sim x CogCon	1.024	.32
Suc x CogCon	.514	.48
Sim x Suc x CogCon	.328	.57

Table 11.1

ADJUSTED MEANS FOR LOGO SCORE FOR HIGH AND LOW SIMULTANEOUS INFORMATION PROCESSORS

High simultaneous	Low simultaneous
9.6875	7.5238

Table 11.2

Observation in the classroom did confirm that these children with high simultaneous information processing abilities had been the "stars" of Logo activities and that the children who were also classified as "reflectives" were those who had worked more cautiously and made less errors than those who were classified as "fast/accurates," although there was one boy who was fast/accurate who had also been noted for his care and precision. In general, these children were also the ones who succeeded in all classroom activities and who were considered by the classroom teacher, to be those who acquired new skills with ease. The notion of some relationship existing between high simultaneous information processing ability, Logo performance and ease of acquisition of new skills is one that would be worthy of further investigation.

CHAPTER 12

PATTERNS OF DEVELOPMENT OF LITERACY AND NUMERACY AND ASSOCIATED BASIC CONCEPTS AND PROBLEM SOLVING

Background to These Studies

Although the development of skills in literacy, numeracy and problem solving was not the major focus of the study, it was important to monitor the development of them to eliminate any interpretation of results in terms of differences in developmental factors that might occur between the children in the Logo group and those in the non-Logo groups. The monitoring of the children's familiarity with certain basic concepts was especially pertinent as children in the Logo group may have been afforded opportunities to develop concepts which were not available to children in the non-Logo group, and it was obvious that such biases had to be eliminated. Furthermore research done by Hines (1982) had found that the use of Logo with five year olds had produced significant enhanced effects on their ability to identify numbers, number quantities and letters. These findings reinforced the need to control for any similar effects on the children who were working with Logo in this study.

Literacy

The test used to establish children's ability to recognize letters at the commencement of the study, is described in Chapter 9. The reliability of the test was .93. The following Table shows the means and standard deviations of the total pre-test scores for both groups.

MEANS AND STANDARD DEVIATIONS FOR TOTAL SCORES FOR LOGO (N = 32) AND NON-LOGO (N = 58) GROUPS ON PRE-TEST OF LETTER IDENTIFICATION

	Logo	Non-Logo
Mean	10.03	9.17
S.D	3.00	3.34

Table 12.1

There were no significant differences between the two groups in their ability to identify the given letters at the time of the commencement of the study.

At the completion of the study, all children were given the ACER Primary Reading Survey Test described in Chapter 9. The reliability of this test had been proven through repeated use with large population samples. (See Manual, p.6)

Table 12.2 shows the means and standard deviations of the total scores for both groups.

As at the commencement of the study, the differences between the two groups, Logo and non-Logo users, were not significant. Furthermore, comparison of these scores with the local norms that had been developed for the test showed that both groups of children were in the average to above average range of six year olds in the State of New South Wales. The absence of any measured differences indicated that there had not been any significant development in the area of literacy skills by the children who were using Logo that had not also been made by children who were not using Logo.

MEANS AND STANDARD DEVIATIONS FOR TOTAL SCORES FOR LOGO (N = 32) AND NON-LOGO (N = 58) GROUP ON POST-TEST WORD IDENTIFICATION TEST

	Logo	Non-Logo
Mean	12.81	13.07
S.D.	3.71	2.61

Table 12.2

Behavioural observations indicated, however, that some children in the Logo group were displaying skills of literacy beyond their usual capacity when they were actually working with Logo. The class teacher commented on a number of occasions that some of the children who were keying words into the computer correctly without the use of the spelling cards, could not spell the same words correctly when away from the computer. Six of these children who had been identified by the class teacher were asked to write down the words "FORWARD", "PENUP" and "BELL". None of the six could complete the task. When asked if they could spell the words without writing them down, still no child was successful. The children then went back to the keyboard and were asked to key in the words in order to use the Turtle, and four of the children keyed all three words correctly, whilst the other two keyed two words correctly. It might be concluded that the presence of the letters on the keyboard prompted the children, and that perhaps the use of the Turtle Graphics motivated them, but that at that point in time, no transfer of these skills to other environments was evident.

Numeracy

At the commencement of the study all children were tested on their ability to count using one-to-one correspondence techniques. This test is described in Chapter 9. The reliability of the test was .87 and Table 12.3 shows the means and standard deviations of the total pre-test scores for both groups.

MEANS AND STANDARD DEVIATIONS FOR TOTAL SCORES FOR LOGO (N = 32) AND NON-LOGO (N = 58) GROUP FOR PRE-TEST OF COUNTING ABILITIES

	Logo	Non-Logo
Mean	8.19	8.62
S.D.	1.33	0.93

Table 12.3

There were no significant differences between the two groups in their ability to engage in one-to-one correspondence and counting at the time of the commencement of the study.

After the Logo program had been completed, all children were given a test to assess their ability to solve arithmetic word problems. This test attempted to distinguish between problem solving errors and errors of calculation and therefore related directly to numeracy skills. It was used because the three teachers responsible for the teaching of the children involved in the study indicated that it was not feasible to give the children a test of numeracy skills as such, as the differences between what the three classes of children had actually been taught through formal mathematical instruction were too numerous to eliminate.

Problem Solving - Testing and Analysis

The test used, as described in Chapter 9, was a version of that used by Carpenter and Moser (1982) in their research. The reliability of the test was .56 and the Means and Standard Deviations for each of the groups were as follows:

MEAN SCORES AND STANDARD DEVIATIONS FOR THE LOGO (N = 32) AND THE NON-LOGO (N = 58) GROUPS ON THE POST-TEST WORD PROBLEM TEST

	Logo	Non-Logo
Mean	8.44	8.50
S.D.	3.58	3.32

Table 12.4

The results indicated that no significant differences existed between the Logo and non-Logo groups. Subsequent multivariate analysis using the three factor model of individual differences with responses to the seventeen item test as dependent variables, yielded no significant interactions or effects. Analysis of scores relating to errors of comprehension and errors of calculation also showed no significant differences between the Logo and non-Logo groups.

Therefore, despite the fact that the literature cited above may have led to the anticipation that some differences in ability to solve arithmetic word problems could emerge as a result of the use of Logo by one group, no differences in either the ability to solve word problems or ability to perform arithmetic calculations were significant between the Logo and non-Logo groups.

Closer examination of data revealed that unlike the work of Carpenter et al. (1981) cited above, these children *did* appear to be choosing the wrong operation on occasions. Discussion about the test with all groups of children confirmed that with the exception of the three children in each group who had scored in the range of 15 - 17, most children had not comprehended the actual tasks that were being put before them, and they were grappling with both the semantics of the word problems and the abstraction of them that was necessary for problem solution. For example, one problem uses the term "some lollies" - children asked "but how many is some?" They could not understand the indeterminate nature of "some". Other children showed quite clearly in the more difficult examples that they were performing the wrong operation and adding instead of subtracting. For example:

Test Question:	There are 6 boys and 8 girls playing a game. How many more girls than boys are there playing?
Answer:	14. (Cameron)
Test Question:	Tim has 6 fish. This is 2 more fish than Jane has. How many fish does Jane have?
Answer:	8.

Such examples confirmed that the children could perform arithmetic computations, but were as De Corte and Verschaffel (1985) said, working from an "incorrect text base." So, the use of Logo had not unexpectedly enhanced the children's ability to comprehend difficult statements and deal with problems of semantics.

Boehm Test of Basic Concepts

The Boehm Test of Basic Concepts, described in Chapter 9 was seen as being appropriate for use in this study as some of the concepts - top, centre, side, beginning, right, left, forward, above, equal - were particularly pertinent to concepts which were frequently used by the children engaging in the use of Turtle Graphics in their Logo activities.

Smith (1986) is critical of the validity of the Boehm Test of Basic Concepts, but acknowledges that

> global scores may indicate the standard of performance reached by groups of pupils, relative to other groups, where the criteria are defined in terms of particular knowledge or skills.
> (Smith, 1986, p.333).

Furthermore, her final analysis of the test after extensive research and validity studies, states that the components that contribute to a child's total score on the test are:

* mature conceptual understanding,
* partial conceptual understanding,
* lexical knowledge,
* facility with complex syntactic constructions
* auditory receptive and association skills,
* visual receptive and association skills,
* the abilities to quantify, compare, order and seriate,
* reversible thinking.

(Smith, 1986, p.343).

Such findings suggest the validity of the use of this test in the study. Reliability analysis of the test gave a coefficient of .7228. The Means and Standard Deviations for each of the groups on post-testing are given in Table 12.5.

There was no significant difference between the Logo and non-Logo groups on the test. Multivariate analysis using the three factor model of individual differences with responses to the fifty item test as dependent variables also yielded no significant interactions or effects. Analysis of scores of specific items relating to spatial concepts also failed to yield any significant differences between the groups.

MEAN SCORES AND STANDARD DEVIATIONS FOR THE LOGO (N = 32) AND THE NON-LOGO (N = 58) GROUPS ON THE POST-TEST BOEHM TEST OF BASIC CONCEPTS

	Logo	Non-Logo
Mean	46.88	44.72
S.D.	4.00	3.06

Table 12.5

These results confirmed that in fact there were no significant differences between the Logo and non-Logo groups, in the development of the specified concepts. The particularly high mean scores of both groups does however suggest that the general cognitive development of all children was in the high order of development. This would seem to be consistent with the socio-economic status of the children concerned and the extensive range of experiences that they were exposed to both in and out of the school environment.

Conclusions

The investigation of the development of the children's literacy and numeracy patterns, together with their general problem solving ability and the development of basic concepts, suggests that in these areas there were no real differences between the groups, regardless of the use of Logo by one of the groups.

Such findings are consistent with those of Clements and Gullo (1984) who found that no differences existed between the six year olds using Logo and those who were not. This was true in the areas of cognitive development and operational competence (right-left orientation, verbal ability, numerical ability, and draw-a-design) as measured by the McCarthy Screening Test.

It does seem that children engaged in the use of Logo were sometimes *observed* to be using skills beyond their usual capacity, as evidenced by the accounts cited earlier in this Chapter. However in the final analyses, there was no evidence of transfer of these skills in the tests of literacy and numeracy.

Such findings of equality confirm that children in the Logo and non-Logo groups were consistently parallel in many aspects of their development.