CHAPTER 13

RESULTS: REFLECTIVITY/ IMPULSIVITY

Background

Cognitive impulsivity usually cannot be predicted from observation of classroom behaviour (Bjorklund and Butter, 1973). Various works with young children and in particular with five and six year olds verify the identifiable presence of different dimensions of cognitive style in children from this age group - Shlechter and Salkind (1979) gave clear evidence of differences in conceptual tempo when response uncertainty was present; Ward's (1968) data from Kindergarten children gave support to the "generality and pervasiveness of reflection/ impulsivity as a dimension of individual differences in cognitive style " (p.372). Kagan, Pearson and Welch (1966) report data from work with six year olds that extends an assumption of a tendency toward reflectivity/ impulsivity when responding to problems with high response uncertainty.

Reflectivity and Cognitive Control

The two distinct concepts of attention span and cognitive control referred to in the literature, have already been described in Chapter 7. The capacity for attending is part of the Luria model of individual differences used in the study and was assessed by computer-based tests.

There also exists the concept of attention as it relates to the process of attending to a particular task normally referred to as attention span (Lindsay & Norman, 1977). The literature on reflectivity/ impulsivity, when referring to attention usually implies the concept of attention span as expressed through motivation to attend. (Denney, 1973; Zelniker et al., 1972; Mack Drake, 1970; Kagan et al., 1964). In general, each of these studies supports the notion that that there is a relationship between impulsivity and lack of motivation to attend. Zelniker et al. (1972) showed that it is possible to increase a child's ability to sustain attention on task and that improved attention span leads to improved performance on the Matching Familiar Figures Test.

The Measurement of Reflectivity/Impulsivity

The construct validity of the Matching Familiar Figures Test (MFFT) as an instrument for measuring the presence of reflectivity/ impulsivity has been established through the work of Kagan (1964) and a variety of associates (Kagan, Pearson and Welch, 1966; Kagan and Messer, 1975), Eska and Black (1971), Block, Block and Harrington (1974), Messer (1976) and Duryea and Glover (1982). They used a wide variety of tasks relating to cognitive development to demonstrate the presence of the dimension identifiable as "reflectivity/impulsivity" as classified by the analysis of latency scores and error counts on the test of Matching Familiar Figures (MFFT). At the outset of the study, all children were given the MFFT and their profiles in relation to the dimensions of reflectivity/ impulsivity were determined before any work with the Logo group was commenced.

Classification on the MFFT was established by calculating the time taken for the first response (latency) and the error totals for all children. A median split, based on the combined Logo and Non-Logo groups' scores on both dimensions resulted in the following classifications:

* those *ABOVE* the median on errors and *BELOW* the median on latency are impulsive

* those *BELOW* the median on errors and *ABOVE* the median on latency are reflective

* those *BELOW* the median on errors and *BELOW* the median on latency are fast/accurate

* those *ABOVE* the median on errors and *ABOVE* the median on latency are slow/inaccurate.

This classification ensured that all subjects were included, thus overcoming the difficulty raised by Block, Block and Harrington (1974) who found that if subjects were only classified as reflective or impulsive, and not as fast/accurate and slow/inaccurate, up to 40% of the sample could be omitted in a study. Analysis of MFFT scores previously carried out by Clements and Gullo (1984), Shlechter and Salkind (1979), Zelniker and Jeffrey (1976) and Eska and Black (1971) has established the value of examining the individual components of latency and error count to assist in the assessment of any change that might occur in subjects between pre- and post-testing. Similar analyses of the individual components were used for this study.

Frequencies of errors and latency together with mean latency and mean error counts are given in Table 13.1.

Table 13.2 shows the resulting profiles for the Logo and non-Logo groups using the method of classification described above.

FREQUENCIES AND MEANS FOR LATENCY AND ERROR COUNT ON THE MATCHING FAMILIAR FIGURES PRE-TEST FOR LOGO (N=32) AND NON-LOGO (N=58) GROUPS.

	Logo Group	Non-Logo Group
LATENCY		
Range	3 - 36 secs	3 - 14 secs
Mean	9.62 secs	6.67 secs
S.D.	7.46 secs	2.59 secs
ERRORS		
Range	8 - 39	7 - 31
Mean	23.09	20.72
S.D.	8.06	6.21

Table 13.1

CLASSIFICATION OF LOGO (N = 32) AND NON-LOGO (N = 58) GROUPS ON MEASURE OF REFLECTIVITY/IMPULSIVITY FROM PRE-TEST OF MATCHING FAMILIAR FIGURES TEST

	Logo Group	Non-Logo Group
Impulsive	14 (43.75%)	22 (37.93%)
Reflective	9 (28.13%)	16 (27.58%)
Fast/Accurate	3 (9.37%)	17 (29.31%)
Slow/Inaccurate	6 (18.75%)	3 (5.18%)

Table 13.2

The percentage of children classified as "reflective" in each group was almost equivalent, with differences occurring in the category of the Fast/Accurates and Slow/Inaccurates. The non-Logo group had a higher percentage of children in the Fast/Accurate category, and also had a lower percentage of children in the Slow/Inaccurate category.

Results Following Logo Experience

At the completion of the study all children were again given the Matching Familiar Figures Test. Validity of the pre-test post-test use of this test had been established by Messer (1976) (see Chapter 4). Procedures used for both administration and scoring of the test were identical with those of the previous testing. Frequencies of error count and latency together with mean latency and mean error counts for post-testing are given in Table 13.3.

FREQUENCIES AND MEANS FOR LATENCY AND ERROR COUNT ON THE MATCHING FAMILIAR FIGURES POST-TEST FOR LOGO (N=32) AND NON-LOGO (N=58) GROUPS.

	Logo Group	Non-Logo Group
LATENCY		
Range	5 - 27 secs	4 - 11 secs
Mean	10.88 secs	6.72 secs
S.D.	6.62 secs	1.56 secs
ERRORS		
Range	4 - 24	11 - 34
Mean	11.16	23.26
S.D.	4.18	4.61

Table 13.3

Table 13.4 shows the resulting profiles on this occasion.

CLASSIFICATION OF LOGO (N = 32) AND NON-LOGO (N = 58) GROUPS ON MEASURE OF REFLECTIVITY/IMPULSIVITY FROM POST-TEST OF MATCHING FAMILIAR FIGURES TEST

	Logo Group	Non-Logo Group
Impulsive	0 (0%)	39 (67.24%)
Reflective	15 (46.88%)	5 (8.63%)
Fast/Accurate	16 (50%)	4 (6.89%)
Slow/Inaccurate	1 (3.12%)	10 (17.24%)

Table 13.4

Table 13.5 is the result of observations made in comparing the pre and post-test group profiles from Tables 13.3 and 13.4 .

This shows that, for the Logo group, there were quite dramatic shifts away from impulsivity towards both reflectivity and the fast/accurate classification. In contrast, children in the non-Logo group moved towards impulsivity and the slow/inaccurate classification and away from the reflective or the fast/ accurate classifications.

As hypothesised therefore, children in the Logo group developed a more, reflective style of thinking than their peers in the non-Logo group. The extent of the differences in these results indicated that further analyses were required and so multivariate analysis using the three factor model of individual differences with scores for latency and number of errors committed as dependent variables, was carried out.

COMPARISONS BETWEEN CLASSIFICATIONS OF LOGO (N = 32) AND NON-LOGO (N = 58) GROUPS ON PRE- AND POST-TEST MATCHING FAMILIAR FIGURES TEST

	LOGO				NON-LOGO			
	IMP.	S/I	F/A	REF.	IMP.	S/I	F/A	REF.
PRETEST	14	6	3	9	22	3	17	16
	(44%)	(19%)	(9%)	(28%)	(38%)	(5%)	(29%)	(28%)
POSTTEST	0	1	16	15	39	10	4	5
	(0%)	(3%)	(50%)	(47%)	(67%)	(17%)	(7%)	(9%)

Table 13.5

There was a significant ($p < .001$) interaction between the use of Logo and the cognitive control factor when latency and error count were used as dependent variables. This is shown by the following results using the pre-test latency and error count from the Matching Familiar Figures Test as covariates. The same analysis was carried out without using these covariates and these results are contained in Appendix H. There are no real differences in the two sets of results.

MANOVA: MODEL OF INDIVIDUAL DIFFERENCES AND MATCHING FAMILIAR FIGURES TEST WITH LATENCY AND ERROR COUNT AS DEPENDENT VARIABLES USING PRE-TEST ERROR COUNT AND LATENCY AS COVARIATES

df = 1,72

	Multivariate		Univariate Tests			
			Latency		Error Count	
	F	p	F	p<	F	p<
Group x Sim x Suc x CogCon	2.3	n s	4.13	ns	1.53	n s
Group x Suc x CogCon	.26	ns	.01	ns	.51	n s
Group x Sim x CogCon	1.92	n s	.88	ns	3.70	n s
Group x Sim x Suc	1.54	ns	1.73	ns	.63	n s
Group x CogCon	8.14	.001	16.21	.00	2.52	.12
Group x Suc	.23	n s	.02	ns	.47	n s
Group x Sim	.85	n s	.55	ns	.73	ns

Table 13.6

To distinguish the effect of the cognitive control factor, estimated means for latency which was the significant component, were examined for both the Logo and non-Logo groups. These are shown in Table 13.7.

ESTIMATED MEANS FOR POST-TEST LATENCY ON THE MATCHING FAMILIAR FIGURES TEST (USING PRE-TEST LATENCY AS A COVARIATE) FOR LOGO (N=32) AND NON-LOGO (N=58) GROUPS WITH THE COGNITIVE CONTROL FACTOR

	LOGO		NON-LOGO	
	High Cog Con	Low Cog Con.	High Cog Con.	Low Cog Con.
Pre-Test	9.15	6.48	10.34	6.60
Post-Test	7.75	14.09	7.22	7.09

Table 13.7

There were no real differences in latency scores on the MFFT between the children in the non-Logo group with high cognitive control scores (7.22) and those in the non-Logo group with low cognitive control scores (7.09). Furthermore there was only a minimal difference in latency scores between the children in the non-Logo group and the children in the Logo group when the children had high scores on the cognitive control factor. The most dramatic variation in latency occurred for those children in the Logo group who were low on the cognitive control factor. These children were spending almost double the amount of time on each picture that their non-Logo peers were spending. They were also spending more than twice the amount of time on each picture that they had spent during the pre-testing before the commencement of the study. These children whose capacity to sustain attention was limited, were focussing attention on the task at hand, for longer than anticipated and double the time spent by their non-Logo peers.

The latency scores for the Logo group then seem to indicate that those children who at the commencement of the study were low on the cognitive control factor, were by the completion of the study, not only taking longer time on the items of the Matching Familiar Figures Test, but were also getting more items correct and so were more likely to be classified as reflectives, whilst many of those who had been high on the cognitive control factor, became quicker and more accurate, and moved to classification as fast/accurate.

As stated above, the reflectivity/impulsivity literature in its reference to attention is usually referring to attention span as distinct from the capacity for attention or cognitive control which is measured by the factor of cognitive control in the Luria (1973) model of individual differences. However, Mack Drake (1970) and Siegelman (1969) have suggested that there are important differences in the way that reflective and impulsive subjects actually deploy attention and that there is no sense in which the reflectives just "do the same thing" as their counterparts for a longer period of time. They suggest that the two groups engage in very different scanning activities.

Whilst Zelniker et al. (1972) suggest that impulsivity is characterized by an inability to sustain attention, they also showed that it was possible to increase children's interest in a task and in so doing to improve their spans of attention, or to force a more effective strategy which allowed the children to arrive at the correct solution within their usual span of attention. Kagan et al. (1964) also found that impulsive subjects displayed momentary lapses of attention during involvement in school tasks, but agreed that such deficits could be enhanced by getting these children to care more about the quality of production of the task at hand. Finally Denney (1973) reports on training studies aimed at increasing latencies of children who had performed poorly on the MFF Test by increasing more efficient deployment of attention. Here the child was taught to distribute attention more evenly and impartially across alternatives.

These findings confirm that it is possible to enhance some of the attention-related deficits of children who have been classified as impulsive. It is possible then to suggest some explanations for the increased latency scores of the children in the Logo group who were low on the cognitive control factor. It could be proposed that the use of Logo had increased the interest level of the children, and that this increase resulted in improved attention spans for those whose original capacity to attend was low. Such findings are consistent with those of Zelniker et al. (1972). It could be further speculated that it was the children's capacity to attend that the use of Logo had developed and enhanced. Perhaps the use of Logo helped the children also to develop more care about the tasks they engaged in, and then as Kagan et al. (1964) suggested, some of the momentary lapses of attention were overcome. Observation of children at work on Logo tasks would confirm that they were exercising great care on the "projects" with which they were involved. It seems reasonable to suggest that it was the use of Logo that had a positive effect on the children whose capacity for cognitive control was low when measured by the Luria (1973) model of individual differences.

It was, in fact, impossible to distinguish between whether change had actually occurred in the children's capacity to attend, or whether they were simply more motivated and so had their attention span lengthened. What was important, however, was that they did attend to tasks for longer periods of time, and as a result experienced more success on them. This ability to attend to tasks for longer periods of time led to the development of what could be viewed as a more reflective style of thinking. It would then seem to be the interplay of both of these aspects that led to such dramatic movement by the children in the Logo group from the classification of impulsive to the reflective and fast/accurate classifications. Another dimension that may have been at work here, was the effect of the social interactions in which children had engaged during their use of Logo. It would seem that where children had worked together on Logo tasks, they had acquired the skill of focussing more directly on the task. In addition, their conversations with others, and at times with themselves, may have led to their being more in control of their own thinking. Cognitive control may well have been influenced by social interaction, and may have contributed to the move towards reflectivity described above.

Observations made whilst the children were engaged in Logo activities confirmed that the children were exercising great care and thinking reflectively when trying to achieve their goals using Logo. For example, during the introductory activities - both off-screen and on-screen - children were given mazes of increasing complexity through which they had to walk the turtle to its home (see Appendix I). Although it was obvious that these activities contributed to and developed the children's spatial skills, children were also confronted with having to make particular choices when several alternatives were available to them. Reasons for taking the chosen path were interesting and confirmed that such choices were not purely chance. The following anecdote illustrates this:

> At one junction point in the maze where it was possible to go either right or left, the children called a left turn. It was quite obvious visually that the left turn would enable the more expedient path. However the child who was operating the computer exclaimed that he wanted to go right. The other children (there were five in the group) told him that left was the "short-cut". He declared that he knew that but that he wanted to go the "long way". As this was one of the children who was high on both the

> simultaneous and successive dimensions of the model of individual differences the researcher asked why this was so. Matthew replied that it was just more interesting if he went the "long way round".
> (August 18th, 1986.)

The fact that Matthew, the child referred to above, is classified as high on both dimensions of the model of individual differences leads to speculation that there was some definite interplay between these dimensions and the use of Logo. Children were also given a list of commands that they could use and they then engaged in "free" programming activities. They readily began to draw all types of lines and combinations of these. One child set about a systematic task - drawing a set of steps- and it was on seeing her product that many of the others began to produce pictures that were somewhat ordered. Spontaneously, children began to "analyze" their own drawings - to plan, to execute, to debug.

After several weeks of "free" programming which had resulted in the use of increasingly more complex commands and procedures, children were given sets of commands and asked to execute the drawing on paper before moving to the screen. Similarly they were given simple drawings and asked to list the commands in the order that would produce such a drawing on the screen. Examples of these may be found in Appendix I. The following observations were made:

* children varied greatly in their approach to the task and the degree of difficulty with which they perceived it

* a number of children commenced at what they saw as a "starting point" and worked systematically to the "end point", whereas others identified parts that they "knew" and began there

* some children were at pains to get it "right" on the first attempt, whilst others did not seem at all worried by the number of attempts that were necessary

* some children could identify the commands that were necessary to achieve their goals, but could not order the sequence correctly

* some children could not do the tasks. When told to try it on the screen, they were successful. These children were observed to be debugging each step as they went.

Further programming exercises were developed and children during the second year of the study were directed to engage in drawing, planning and executing their desired "pictures". Many instances of children using totally different strategies to arrive at the same end were recorded (See Appendix I), and children began to develop their own personal styles of programming. Closer examination of each individual's work revealed that the information processing abilities of some of the children who were using different strategies were also different. This appears to confirm the proposal of Zelniker and Jeffrey (1976) that one distinguishing difference between reflective and impulsive thinkers could be expressed in analytic and global processing. They pointed out that both groups succeed on the task but that quite different strategies were used.

Similar results were also found by Papert et al. (1979) who showed through collecting children's programming protocols that some children ending up with almost identical processes actually arrived at them via very different processes. Zelniker and Jeffrey (1976) verified that a difference between reflectives and impulsives could be shown through the reflectives' tendency to focus on a single dimension whilst the impulsives scanned several dimensions simultaneously. Wright 's (1976) research shows that the reflectives' programming would be characterized by making less mistakes.

From the behaviours that were observed when the children were using Logo, it might be concluded that at least some aspect of the differences they displayed in ordering commands and arriving at the end-points of their "programming" tasks could be explained firstly in terms of the children's reflectivity/impulsivity, and secondly in the way that it related to information processing.

Given that there are two components of reflectivity/impulsivity - latency and error count - an investigation of the scores on error count for both the Logo and non-Logo groups was now carried out, as the relationship between latency and cognitive control had already been established by the previous analysis shown in Table 13.6.

The estimated means for error count for the Logo and non-Logo groups are shown in Table 13.8.

ESTIMATED MEANS FOR ERROR COUNT ON PRE- AND POST-TESTING OF THE MATCHING FAMILIAR FIGURES TEST FOR LOGO (N=32) AND NON-LOGO (N=58) GROUPS.

	LOGO	NON-LOGO
Pre-Test	21.21	20.98
Post-Test	10.67	23.53

Table 13.8

The significantly lower error count of the children in the Logo group further confirms the shift by them towards the reflective and fast/accurate classification on the MFFT. Some children in the Logo group had not only decreased their error count but had also been able to decrease the time they took to recognize the correct picture, as shown by the analysis above. This accounts for children in the Logo group shifting towards the fast/accurate category. Similar significant differences in error count were found by Clements and Gullo (1984) in their work, and they attributed the differences directly to the use of Logo. They also investigated the possibility of whether the use of Logo had enhanced the visual discrimination of the children sufficiently to give them an unfair advantage over their non-Logo using peers, on error count. However, by the use of Computer- Assisted Instruction packages that also enhanced visual discrimination, such an explanation seemed unlikely. Similarly, the children in the study who were not using Logo had engaged in sufficient visual discrimination exercises to eliminate possible bias on this occasion also.

Conclusions

When account is taken of the fact that the differences in both latency and error count occurred only within the Logo group, it seems reasonable to conclude that some aspects of this effect must be attributable to the use of Logo by these children. There was a shift away from impulsivity by the Logo group and this is shown by their lower error count and higher latency on the Matching Familiar Figures post-test. This may be accounted for either by an increase in the children's attention span, perhaps due to their being more motivated in the carrying out of the tasks, or by showing that there was improved capacity to sustain attention or exercise cognitive control, demonstrated by those who before their use of Logo, were low on the factor of cognitive control as measured by the Luria (1973) model of individual differences.

These results are similar to those reported by Clements and Gullo (1984) in their work with six year olds. Their subjects were given pre- and post-tests on the Matching Familiar Figures Test after one group had worked on Logo and the other on CAI. They report that the latency time increased and the number of errors decreased for the Logo group. They conclude that

> the nature of programming in Logo necessitates thoughtful advanced planning, reflection on one's thinking, and explicit analysis of errors in "debugging", all of which may have accounted for the increase in latency time.
> (Clements and Gullo, 1984, p.1056).

There are some other facts that may enhance the evidence for change to a more reflective style of thinking by children in the Logo group. Firstly, in the actual carrying out of the post-testing on the Matching Familiar Figures Test, children in the Logo group were observed to be more careful in making their response selections. This was particularly obvious in those instances where they were told that they did not have it correct on the first attempt. They then proceeded to engage in rather obvious visual matching techniques, such as pointing to characteristics with their fingers, or running their fingers down lines on the key picture and the one under investigation. The children were taking longer to make their selection, in what seemed to be an obvious attempt to keep their error score low.

Some children talked aloud to themselves saying "This bit is different" or "This is the same, but that is different". In Chapter 3, the funtions of speech in relation to planning and guiding have been discussed. The situation described in the testing of the Logo group on the Matching Familiar Figures Test seemed to be an example where the children were using the process of talking to themselves to guide them through the tasks at hand. Levina (1979) and Wertsch (1979) have both alluded to the metacognitive dimensions of such use of speech and Vygotsky (1978) had described the planning function of children's speech as making their actions more reflective. The further consideration is that particularly the children who were low on the cognitive control factor in the Luria (1973) tests, had this capacity increased through social interactions and speech during their use of Logo. This increase in cognitive control in turn led to a movement towards reflectivity, as children were able to sustain attention for longer periods and actually control their thinking as they engaged in such tasks as the MFFT.

Children in the non-Logo group simply did not behave in the same way. When told their first selection was not correct, a majority of them *did* respond impulsively by going along the line of alternatives, saying "that one, that one, that one" - it seemed as though any answer would do, with their major objective being, to get the task completed. They did not take time, they did not talk to themselves or show any real desire to succeed on the tasks.

Finally, the age and status of the subjects involved at the different testing times would seem to be important. At the first testing children were still easily "controlled" within the classroom setting because most of them were exploring the whole concept of school and its social dimensions. Therefore one might assume that the measures of reflectivity /impulsivity were fair measures of the children's "natural" tendency to be reflective or not. On the other hand by the time of the final testing, the children had reached the stage where they were secure in both their concept of school and their social contacts and teachers readily described them as being "ready to respond quickly to everything." It could be speculated that the use of Logo had indeed made children aware that in some circumstances, there were choices that could be made, and that in particular situations it was advantageous to "stand back", to reflect, before making a decision or giving an answer.

CHAPTER 14

RESULTS: CONSERVATION ABILITIES

Conservation Abilities

The background to children's conservation abilities is examined in Chapter 5 and reference is made to the relationship of Piagetian developmental levels to children's ability to use Logo successfully (Rieber, 1983; Munro- Mavrias, 1983). In particular, Rieber (1983) states that ability to conserve length is a pre-requisite for acquiring geometric concepts in Logo. This is based on the fact that in using Turtle Graphics, the child is forced to deal with shapes and lines. For example, in using rectangular shapes, one must recognise and be able to apply the similarities and restrictions of the lengths involved. The child who cannot conserve length views objects in a topological way and sees lines as being fluid and able to be bent. However when using the Turtle, the child experiences lines that do not bend or distort. The child must tell the Turtle *exactly* where and how far to go, or it will never get there.

Clements and Gullo (1984) reported that in their work with six year olds using Logo, increased performance on Piagetian conservation tasks was observed.

Conservation Testing

Ability to conserve *length* was chosen for investigation for the reasons given above, namely the relationship of conservation of length to use of Turtle Graphics. Ability to conserve *number* was also chosen because it seemed most appropriate for the age of the subjects in question and because as Wohlwill and Lowe (1962) point out that:

> in this domain the problem of conservation can be readily related to development in other aspects of the number concept (e.g. counting, arithmetical skills etc.) rather than

> constituting the somewhat isolated, sui generis problem which conservation appears to represent for such dimensions as weight and volume.
> (Wohlwill and Lowe, 1962, p.153).

At the commencement of the study, children were given a test of conservation tasks which is described in Chapter 9. Analysis was done using the individual items in the test and not the summated scores. Frequencies of correct responses for both groups of children on this test, are given in Appendix G.

From the frequencies of correct responses and from behaviour observed during test interviewing, it seemed that in general, none of the groups of children was conserving either number or length and that the vast majority of children were at a pre-operational level. For example, when shown two lines of dots which were equal in length and equally spread out, children quickly responded that the two lines were the same. When shown the same lines with one of them compressed or spread out, they just as quickly responded that they were different. (Figure 14.1)

They did not appear to stop to think about the question, because in their minds, if the lines looked the same, they *were* the same, and if they looked different, they *were* different. Similarly on the questions relating to conservation of length, the children very quickly agreed that the two rods were the same length initially, and then just as quickly agreed that the same rods were different when placed at different angles. (Figure 14.2)

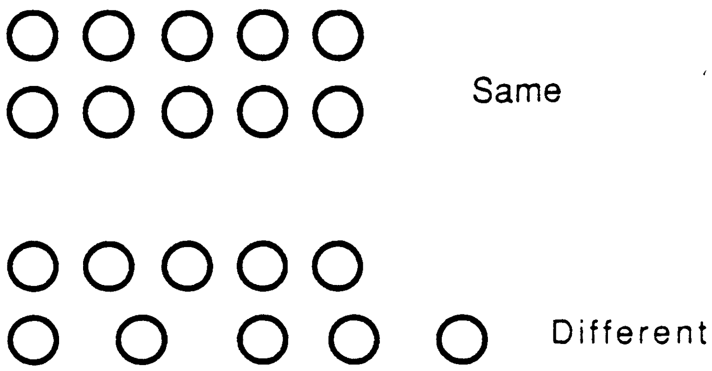

Figure 14.1

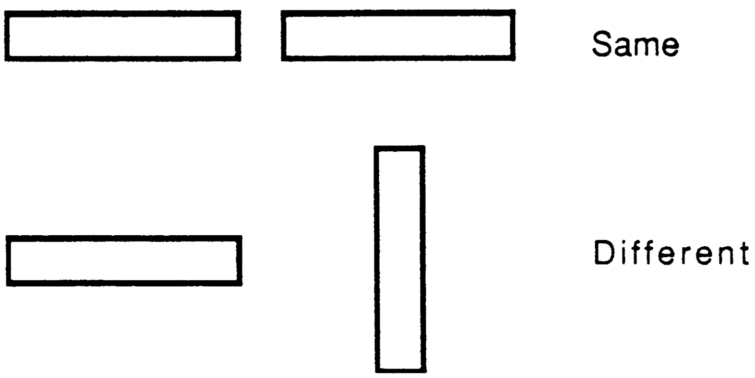

Figure 14.2

In fact in the Logo group, no child answered any of the questions relating to conservation of length successfully, whilst in the non-Logo group only three children answered all questions correctly and one other child answered two questions correctly.

Piagetian Development and Logo

Most educators agree with the Piagetian theory that experience plays a role in the development of young children's skills. This seems particularly true in relation to conservation and Wadsworth (1984) says

> according to Piaget, conservation structures cannot be induced through direct instruction (teaching) or reinforcement techniques. Active experience is the key. (Wadsworth, 1984, p.87).

It has already been established (see above and Chapter 5) that ability to conserve has been viewed as a pre-requisite skill for the use of Logo. However, the children involved in the study were according to the pre- test described above, unable to conserve. Yet from the very first time that they sat at the computer to use the screen Turtle, they were able to draw lines and move the Turtle from place to place, and get it to go where they wanted it to go. The children *were* guided initially in their use of Logo, yet the reality was that they did *not* experience any difficulty in their use of Turtle Graphics - a difficulty that may well have been anticipated based on their apparent lack of conservation skills. Perhaps, it could even be speculated that it was the very use of Logo that may have provided the "active experience" of conservation referred to by Wadsworth (1984), that was needed to develop conservation skills. This is the environment that Papert (1980) referred to - an environment where children can "mess about" and have "objects to think with".

Analysis

At the conclusion of the study all children were given the same test as they were given at the commencement of the study. Interestingly when questioned at the outset of the testing interview, no child could recall having done the test on the previous occasion!! Frequencies for each of the items for both groups are given in Table 14.1.

FREQUENCIES OF CORRECT RESPONSES OF THE LOGO (N = 32) AND NON-LOGO (N = 58) GROUPS ON THE POST-TEST OF CONSERVATION ABILITIES

	LOGO GROUP	NON-LOGO GROUP
ITEM 1	32 (100%)	56 (94.9%)
ITEM 2	24 (75%)	27 (46.6%)
ITEM 3	16 (50%)	7 (11.9%)
ITEM 4	15 (46.9%)	6 (10.2%)
ITEM 5	25 (78.1%)	36 (61%)
ITEM 6	23 (71.9%)	34 (57.6%)
ITEM 7	31 (96.9%)	50 (84.7%)
ITEM 8	17 (53.1%)	28 (47.5%)
ITEM 9	21 (65.6%)	31 (52.5%)
ITEM 10	19 (59.4%)	27 (45.8%)

Table 14.1

The responses indicated that children in the Logo group were conserving and that this was happening more frequently than for their non-Logo peers.

To further investigate this, multivariate analysis using the three factor model of individual differences with the Test of Conservation Abilities Test was carried out. The responses to the ten item post-test were used as dependent variables and the responses to the ten items of the pre-test were used as covariates. There was a significant effect for the Logo group ($p < .012$) as shown in Table 14.2. The same analysis was carried out without the use of covariates and these results are contained in Appendix H. The results on this occasion were essentially the same, although the result for Item 7 was significant, although that for Item 9 was not.

From the test (see Appendix E) it can be seen that Items 2, 3 and 4 deal with conservation of number and Item 9 relates to conservation of length. Therefore there seems to have been a direct relationship between the results on these items and the use of Turtle Graphics by the Logo group of children.

The frequencies of correct responses for the groups as shown in Table 14.1 above, reveal that on these items (2, 3, 4 and 9) children in the Logo group were conserving more often than their non-Logo peers. The findings are consistent with those of Rieber (1983) who gave clear evidence of children performing tasks with Logo which required conservation skills at levels beyond those anticipated for the age of the children in his study. He pointed out that although the children's attempts at some Logo tasks should have been fraught with frustration, quite the contrary was true. No child withdrew because of frustration, and children saw "Logo time as a treat, and it appeared that no student seemed to be at the saturation level with the Logo experience" (p.31).

MANOVA AND UNIVARIATE TESTS FOR MODEL OF INDIVIDUAL DIFFERENCES BY GROUP WITH ITEMS OF POST-TEST OF CONSERVATION ABILITIES AS DEPENDENT VARIABLES AND PRE-TEST ITEMS AS COVARIATES

Effect	Multivariate F	p≤
Group x Sim x Suc x CogCon	.83	n s
Group x Suc x CogCon	.80	n s
Group x Sim x CogCon	.77	n s
Group x Sim x Suc	.88	n s
Group x CogCon	1.40	n s
Group x Suc	1.55	n s
Group x Sim	1.22	n s
Sim	.94	n s
Suc	1.08	n s
CogCon	1.14	n s
Group*	2.43	.01

* Univariate Tests for Significant Group Effect df = 1,64

Variable	Variable									
	1	2	3	4	5	6	7	8	9	10
Univ F	2.43	6.22	13.79	10.46	3.90	1.20	3.40	1.24	4.10	1.14
p<	n s	.015	.001	.002	n s	n s	n s	n s	.047	n s

Table 14.2

Rieber's (1983) findings and the results here gained with the Logo group of children are not consistent with the work of Munro-Mavrias (1983) who found significant correlation between conservation ability and children's ability to use Logo. However, she did find that children who were in the *process* of leaving the pre-operational stage performed better than those who were clearly pre-operational. Such results could suggest that the children in the Logo group were in the process of moving out of the pre-operational stage right from the commencement of the study. Such a position endorses the notion that it was the very use of Logo by the children that could have promoted the movement from the pre-operational stage, as their pre- test results had shown that they were clearly pre-operational before their use of Logo.

Behavioural observation of the children involved in the study further validated the statistical findings. Children while using Logo used language in their conversations that implied the use of conservation skills.

For example:

* this line is the *same* length as that line (Andrew)
* I need the *same* number of steps (Melanie)
* how many more steps do I need to make the lines *equal*? (Jonathan)

Furthermore, a number of the tasks that children were asked to engage in through their use of Turtle Graphics, actually required them to conserve length in more complex ways, for example, in the drawing of a set of steps (Figure 14.3)

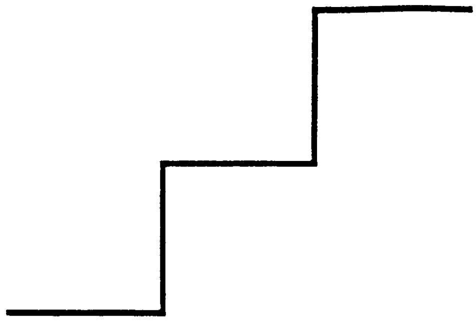

Figure 14.3

Children were observed to be calculating the number of FORWARD steps needed by measuring their drawings on the screen with their hands. They also showed that they knew that they could achieve symmetry in their drawings by having lines of *equal* length, as shown in this example where two squares were placed together, in the knowledge that all sides were of equal length.

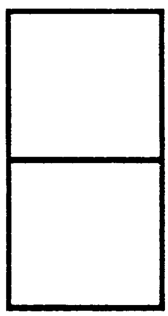

Figure 14.4

They also showed their individuality by the variety of different ways through which they achieved their goals - some counted, some measured, some guessed on the basis of visual appearance - but all understood what the tasks were requiring them to do.

In the post-testing session, children were asked an additional three questions to indicate how sure they were that they were correct on the answers they had given on the last three items of the test relating to conservation of length (Items 8, 9, and 10). Children were given the choice of rating that they were "very sure" they were correct, "sure" they were correct or only "a little sure" of being correct. During the testing it became obvious that most children in the Logo group who *were* conserving knew that there was no other possible answer to the questions they were being asked and therefore they responded that they were "very sure" of being correct. Comments made by the children indicated this surety. For example:

* Of course, it's that one. (Damien)
* It can't be any of the others. (Michael)
* You'd have to cut some off to make them different. (Therese)

Table 14.3 is drawn from the analysis of Frequencies for Items 8, 9 and 10 and the ratings of surety of correctness. For both the Logo and non-Logo groups, the percentage of children who in the first instance had the item correct and then the percentage of children indicating that they were either "very sure" or "sure" that they were correct, is given.

Reliability of the levels of surety was .75. Children in the Logo group who were conserving were on most occasions, sure that they were conserving. They quickly responded that they were "very sure" of being correct, often adding comments such as " I've told you they are the same." Just as importantly, the children in the Logo group who were not conserving were somewhat aware that their answers were incorrect, even though they obviously did not know the correct ones. They made comments such as "I don't think I'm right" or " I think I got it wrong." Quite aside from issues relating to conservation, it was noticed that children in the Logo group did not appear to be worried by the fact that they knew they were wrong. Perhaps, they *had* learnt the lesson that Papert (1980) declared came from the use of "debugging" techniques - that is, that "getting it wrong" is acceptable, and that this simply creates an opportunity to try again. The children in the Logo group were also keen to gain feedback - they wanted to know whether they were in fact, correct. Again this may have been directly related to their Logo experiences where they were continually being made aware of whether what they were doing was appropriate or not. They always knew, through drawings that appeared on the screen, or through error messages, whether they were correct or not.

PERCENTAGE OF CHILDREN IN LOGO (N=32) AND NON-LOGO (N=58) GROUPS INDICATING SURETY OF CORRECTNESS ON 3 CONSERVATION TASKS

	Logo		Non-Logo	
	% Item correct	% Knowing correct or not	% Item correct	%Knowing correct or not
Item 1	53.1	99.8%	47.5	60.98%
Item 2	65.6	90.55%	52.5	70.38%
Item 3	59.4	82.61%	45.8	54.01%

Table 14.3

The children in the non-Logo group on the other hand were conserving less often than their Logo peers but seemed to be unaware that they were not correct on these tasks. Children who did not conserve often answered, with great surety that they were "very sure" they were correct! There was also a lack of concern for feedback - it did not seem to be important to them to know whether in fact they were actually correct or not. More children than in the Logo group were indecisive. More children answered that they did not know whether the two rods were the same or not, exhibiting a reluctance to perhaps give an incorrect response.

Conclusions

The hypothesis that by the completion of the study, children in the Logo group would demonstrate better performance on Piagetian conservation tasks than their non-Logo peers was clearly confirmed. Furthermore it seemed that children in the Logo group had a better understanding of their own conservation abilities than their non-Logo peers. The children in the Logo group knew when they were correct on conservation tasks, when no other answer was possible, but they were also aware when they could not conserve, when they knew their answers were not correct. This was in contrast to the non-Logo group, who in general, did not have this understanding of their own abilities.

As in previous studies, (Rieber, 1983; Clements & Gullo, 1984) the children's inability to conserve length at the outset of the study, did not seem to have inhibited their use of the Logo language through Turtle Graphics. In addition there is both statistical evidence and data from observational behaviour showing that the children using Logo were using conservation abilities that were beyond the level, according to Piagetian theory, expected from children of age five and six. Furthermore, the possibility of children displaying conservation skills without fully comprehending what they were doing, was eliminated by the level of skill demonstrated in the execution of Logo tasks - conservation of length was not merely fluked or guessed but was arrived at by demonstration of a variety of measurement techniques and appreciation of symmetry. Such observation was enhanced by the statistical evidence of levels of surety that the children gave in affirming the correctness of their answers.

CHAPTER 15

RESULTS: SPATIAL DEVELOPMENT

Spatial Skills

Piaget and Inhelder's (1956) views about young children's spatial abilities which are reported in Chapter 6 have been generally accepted by educators for the past thirty years. They held that children under seven are egocentrically bound to an understanding of space from their own viewing positions and therefore are incapable of successfully completing spatial coordination tasks. Yet Shlechter and Salkind (1979) report that the results of other studies (Borke, 1975; Fishbein, Lewis and Keiffer (1972); Shantz and Watson 1970, 1971) show 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, 1979, p.1092)

It is pertinent to note, however, that none of the researchers actually identified what the environmental factors that would promote such development might be, and so there were no prototypes against which to assess the suitability of the Logo environment for the promotion of such development.

Shlechter and Salkind (1979) do note however that spatial egocentrism is highlighted when there is response-uncertainty. This is important because it is when response-uncertainty dominates, that conceptual tempo becomes identifiable. Some investigation of relationships between results on the Matching Familiar Figures Test and results on the Spatial Tests therefore seemed appropriate.

The developmental model of spatial reference understanding in Logo put forward by Roberts (1984) (see Chapter 2) clearly indicates that children using Turtle graphics in Logo are engaging in a variety of different levels of spatial activity. The question then arises of how appropriate it is to try to "test" spatial skills outside of the Logo environment. On the other hand, it can simply be acknowledged that in testing spatial skills, it is not the specific spatial skills children displayed *while using* Logo that are being tested, but more general spatial skills. Yet, testing spatial skills outside the Logo environment raises the issue of transfer of skills. Papert et al. (1979) who have been ardent critics of the instances of research with Logo which have endeavoured to find evidence of transfer of skills, state that in the Brookline Project which they monitored very closely, there *was* evidence to suggest genuine change in children's work on geometric tasks, but they were less declarative about the nature of what it was that changed.

Clements (1985) states that with Logo, the transfer issues have not been settled and says that there has not been the appropriate research to either confirm or disprove whether the learning of Logo has potential transferability to other areas of learning or not.

Testing and Analysis

At the completion of the study, all children were given three tests of Spatial Ability, which are described in Chapter 9. Spatial Test 1 was a test to identify triangles within a given figure; Spatial Test 2 was a test matching congruent figures, whilst the third test related to mazes. The reliabilities of the tests were: Spatial Test 1 = .44, Spatial Test 2 = .74 and Maze Test = .8552.

Multivariate analysis was carried out using the three factor model of individual differences with the Spatial and Maze Tests. The total scores for Spatial Test 1, Spatial Test 2 and Maze Test were used as dependent variables. There was a significant effect for group ($p < .001$), indicating that for the children in the Logo group, there was some relationship between spatial abilites and the abilities examined through the Luria tests (Table 15.1).

It is of some interest to note that for the Logo group of children, the only test that did not produce a significant effect was the Maze test, although this test was the one that was most similar to the children's actual use of Turtle Graphics. However, as was stated in Chapter 9 the children in the non Logo groups had also spent a deal of time doing maze work as part of their normal classroom activities, and obviously this work had been successful in eliminating any special bias towards the children in the Logo group on this test.

Further clarification of the results was sought through examining the estimated means on both Spatial Tests 1 and 2 for the Logo and non-Logo groups. (Table 15.2)

These figures show significant differences between the scores of the Logo and non-Logo groups and as hypothesized, the Logo environment developed in its users a capacity for more effective spatial processing than was the case with the non-Logo group. Further investigation using multivariate analysis and the three factor model of individual differences and each individual response to the three tests as dependent variables, was carried out. No significant effects or interactions were found in any of the covariance analyses.

MANOVA: MODEL OF INDIVIDUAL DIFFERENCES WITH SPATIAL AND MAZE TESTS AS DEPENDENT VARIABLES

df = 1,74

	Multivariate		Univariate Tests					
	F	p <	Test 1		Test 2		Maze Test	
			F	p <	F	p <	F	p <
Group x Sim x Suc x CogCon	1.26	n s	1.82	ns	.54	ns	.38	ns
Group x Suc x CogCon	.92	n s	.62	ns	5.73	ns	.18	ns
Group x Sim x CogCon	1.24	n s	1.25	ns	.43	ns	.48	ns
Group x Sim x Suc	.76	ns	.01	ns	.80	ns	.01	ns
Group x Cog Con	1.86	ns	.17	ns	2.94	ns	3.99	ns
Group x Suc	1.3	n s	.83	ns	6.62	ns	.01	ns
Group x Sim	1.04	n s	.22	ns	1.85	ns	.06	ns
Group	12.61	.00	37.80	.00	16.21	.00	1.53	.22

Table 15.1

ESTIMATED MEANS FOR SPATIAL TESTS 1 AND 2 FOR LOGO (N=32) AND NON-LOGO (N=58) GROUPS.

	LOGO GROUP	NON-LOGO GROUP
Spatial Test 1	1.75	0.66
Spatial Test 2	10.50	8.8

Table 15.2

Correlational analysis was performed on the children's test results and factor scores on the simultaneous factor in the model of individual differences. This was investigated because of the known relationship between spatial processing and this dimension of Luria's model. As no correlations were significant, no further analysis was carried out.

As with Rieber's (1983) results on the spatial tasks, the differences in the means is not staggering from a teacher's point of view, but the fact that there is a statistical difference does make it important, when account is taken of the fact that the tasks themselves are supposedly outside the range of skills of young children in this age group. These results are consistent with those of Fishbein et al. (1972) who concluded that task complexity did not increase the incidence of egocentric errors.

Based on the work of Shlechter and Salkind (1979), correlation analysis was carried out to check for any relationship between latency or error count as measured by the Matching Familiar Figures Test and the Spatial Tests. There were no significant correlations and this could be at least partly due to the fact that there were not high levels of response uncertainty in the items on the Spatial Tests.

Observations of the Use of Spatial Skills

Clements and Gullo (1984) reported that six-year old Logo users were superior to non-Logo users in describing directions and Gregg's (1978) investigation of children's spatial abilities through the use of Logo led to his proposing some denial of Piaget's concept of egocentrism.

Rieber (1983) noted that there were no "reliable dependent measures of basic geometry concepts for young children" (p.18). However, both he and Munro-Mavrias (1983) point out that observation of young children actually using Logo, points to quite sophisticated understanding of spatial concepts and ability to observe fixed and rigid shapes - both abilities that Piaget's developmental theories deny the pre-operational child.

Similar observations were made of the children using Logo in the study. For example, after several months of using Logo in a variety of tasks designed to improve skills of direction and size of variable inputs, children began to show that they had learned a number of geometric/spatial facts. Children who made an incorrect turn either right or left, spontaneously corrected it by reversing the command and doing it twice. Children began to show that they knew well the properties of squares and rectangles and what the differences between the two shapes were. Michael showed his understanding of these concepts by announcing that if he just put a line down the middle of the square and cut it in half, he would have two rectangles! (Figure 15.1)

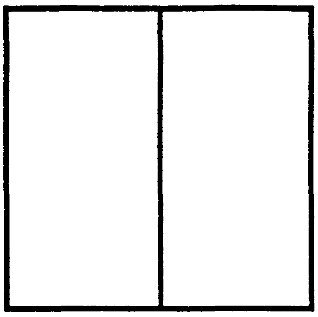

Figure 15.1

Amy showed quite early in her work that she had "discovered" that a RIGHT 90 would land her in the same place as a LEFT 270. (Figure 15.2)

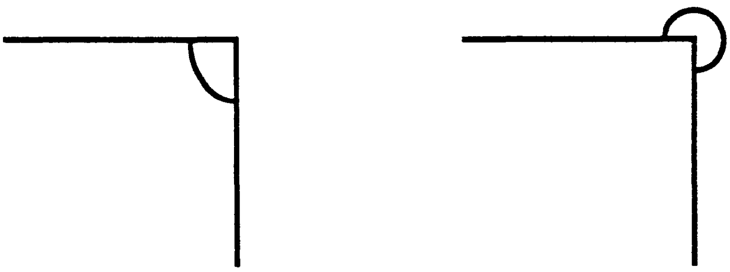

Figure 15.2

Of course, she could not articulate this in terms of circles and 360 degrees, but she could well describe her "theories" in terms of turtle moves of right and left - "look, three left corners are the same as one right corner" (Amy, December, 1986).

Through exercises of free and then ordered patterning, children came to appreciate the properties of symmetry, and how symmetry could be achieved in their own drawings. The variety of ways children found to achieve these goals showed that they had really grasped the concepts in "their own way" rather than it being structured by the teacher. Other observers in the computer room - other teachers, the school principal, academics - commented on the degree of sophistication displayed by the children, and there was some sense that their skills were consistent with Papert's (1980) comments about giving children powerful tools to allow them to do powerful things and think powerful thoughts.

Conclusions

It seems that in general, the children in the Logo group had more enhanced spatial processing than the children in the non-Logo group. Observation of children actually working with the Logo language points to their use of some sophisticated spatial concepts. Any comparison of the use of such concepts was impossible however, because their peers did not use the Logo language. However, the fact that the children using Logo were exposed to concepts usually considered beyond their grasp, and that the children not using Logo were not exposed to them, are facts worthy of consideration in themselves. The skills and knowledge demonstrated by the children using Logo is consistent with Papert's (1980) philosophy of the Logo environment where he proposes that children can perform "powerfully" when they are in possesion of such powerful tools as computers.

CHAPTER 16

RESULTS: SOCIAL DEVELOPMENT AND LOGO

Background

Much of the reported research relating to Logo has made reference to the development of the social relations of the group. Taking this into account and because of the anticipation that the social dynamics of this group of children may be of interest in the total study, sociometric tests were carried out at the outset of the study and again at its completion (Hargreaves, 1975).

On each occasion each child was asked two questions:

- Who are two people from this class that you would like/do like to work at the computer with?
- Who are two people from this class that you like to play with in the playground?

Observations at the Commencement of the Study

Given that the children had only been together at school for about six weeks, the answers to these questions were not surprising in that the children made choices which seemed to be based on the personality factors that had already become obvious.

The first result that was observed was that on this occasion boys chose boys to both work and play with and likewise, girls chose girls to both work and play with.

Of the seventeen boys in the sample two were not chosen by anyone as computer workmates and one of these was also the only boy not chosen by anyone as a playmate. This child was observably unco-operative in class often being called by the teacher to focus on the task at hand. He was a child who was observed to "mess up" games and activities.

The "stars" chosen for both computer workmates and play mates were the extraverted, fun-loving children. It would seem that at this early stage children had not made judgements about one another's academic ability.

Of the fifteen girls in the sample three were not chosen by anyone as computer workmates, and two were not chosen as playmates. One of these girls was in both of these categories. She was from a non-Australian background and in a class that with two other exceptions had no evidence of any multi-cultural influence. The other girl who was not chosen as a playmate was also not from an Australian background.

As with the boys, the "stars" chosen on both occasions were the extraverted, and at times sophisticated little girls who had fashionable hair-cuts and wore jewellery. Thus even at this age, the girls seemed to choose those who were most socially acceptable.

Observed Social Behaviour While Using Logo

During the first weeks when children were working at the computer in pairs, workmates were assigned by the teacher. Most children worked happily and co-operatively, taking turns at doing the keying and providing the required information. However, there were some notable exceptions. The boy who had been rejected as a work mate and a play mate in the results of the sociogram

(Michael), was continually rejected. Children complained that they did not want to work with him because "he mucked it up." When permitted to work alone, he carried out all the tasks quickly and correctly, confirming Damon's (1981) assertion that not all children do benefit from the problem-solving context being a social one.

When the children became more familiar with what they were doing, they were permitted to choose their own partners. Hawkins (1983) notes that children prefer to choose their own partners, rather than have one assigned by the teacher, and that children generally choose a partner that they feel will "help" them. Again Michael was always left without a partner - a fact that seemed to make him happy. This was not true of the girl who had been rejected in the sociogram - when she was left without a partner, she became distressed and the teacher then "imposed" on another girl to accept her.

What followed over the ensuing months was not only of interest, but confirms much of the reported research. Children began to articulate their "problems" to one another, to explain to one another what was happening with the Turtle, and even more importantly, *why* some things were happening. They planned their sequence of commands, they trialled them, they negotiated the correction of errors, and kept each other focussed on the task. (Renshaw & Garton, 1984; Cooper, 1980; Levina, 1979). Vygotsky (1978) referred often to the planning function of speech and to the role that speech could play in helping children accomplish difficult tasks. Levina (1979) actually said that actions could become more reflective, when "they are prepared by a verbal plan." Reference has already been made to the likelihood of this having happened in Chapter 13, in the reporting of the post-testing of the Logo group on the MFFT.

Two other developments are of interest. The first concerns the fact that when children were doing exercises in patterning, many of them wanted to work alone, a fact that might be attributable to the nature of the task. Children wanted to be able to exercise their *own* creativity and not have to wait their turn with their partner. Some children were prepared to wait, but these were the less able, less enthusiastic members of the group. Perhaps, the children who wanted to work alone had made what Wertsch (1979) refers to as the transition from "other-regulation to self-regulation." Perhaps the skills that they had first practiced with others were now available at the intrapersonal level (Vygotsky, 1978).

Secondly, as some of the set tasks became more difficult, children were often observed to make very careful choices of partners. Particular children wanted to work with other specific children, children whom they knew would succeed in the task. It was noted that these were instances where children who were high on the simultaneous dimension of the model of individual differences, were deliberately choosing other children who were also high on the dimension. Damon (1981) quoted Mugny & Doise (1976) as proposing that problem solution was more likely to occur when children chose partners with different cognitive strategies. However, the choice of partners with similar cognitive processing styles could be attributed to the nature of the task in which they were involved. As Clements & Nastasi (1988) point out, success in the use of Logo demands that children resolve differences in strategy as quickly as possible in order to achieve problem solution. The process of establishing a collaborative problem-solving dyad (similar to that put forward by Renshaw and Garton, 1984) was not an easy one, and perhaps the children in the study had learned that collaborative interaction would be most efficiently established and resolution most easily reached, when working with others who resolved the problem in similar ways, that is with children with similar information processing styles working together. Contrary to the research of Hawkins et al. (1982) a couple of girls were chosen by boys on these occasions, because they were perceived as being very competent. A number of children, when hearing the task explained to them realized that it may be too difficult for them. They then tried to claim other children whom they perceived as being likely to succeed on the task as partners (Hawkins et al., 1982). In these instances, children who were low on the simultaneous dimension of the Luria model were choosing those who were classified as high on this dimension. Some resisted, but in the instances where these dyads were formed, the subsequent interactions were very much of the type described by Cooper (1980). The more able children had to create the situation for responsive interaction and collaboration, before being able to tutor and persuade their partners. In this way, the more able children played a metacognitive role, and any reluctance to co-operate initially shown by the partners soon disappeared when they realized that these children could indeed help them to achieve success.

Finally, children were observed to be monitoring each other's thinking. (Day et al., 1985; Clements and Nastasi, 1985; Hawkins et al, 1982; Brown & French, 1979; Vygotsky, 1978). A typical conversation is reported here:

Stephen:	You did it wrong.
Tim:	Yeah, well.
Stephen:	I'll fix it.
Tim:	No, it's my turn.
Stephen:	Well, I'll help.
Tim:	O.K.
Stephen:	Well, the first bit is O.K.
Tim:	Yeah, but..
Stephen:	See, you went LEFT and the BACK is too small.
Tim:	So...
Stephen:	You have to go RIGHT.
Tim:	Why?

Stephen:	Because you have to go that (pointing on the screen) way.
Tim:	O.K. I can fix it...BACK, LEFT, LEFT ..
Stephen:	Good. Now watch what I'll do next.
Tim:	O.K.

(March, 1987).

It could be assumed that on this occasion the confidence and self-esteem of both Stephen and Tim had been enhanced. (Brown & Rood, 1984; Fire Dog, 1984; Kull et al., 1984). It also seems reasonable to suggest that Stephen was working within Tim's "zone of proximal development" as Tim's abilities were definitely in the process of maturing. Brown and French (1979) and Day et al. (1985) anticipated cognitive and metacognitive growth for the novice partner in this type of situation. Investigation of the information processing styles of Stephen and Tim confirmed that they did differ. Stephen was high on simultaneous information processing ability, whilst Tim was low on this. Mugny and Doise (1976) had suggested that problem solution was more likely to occur when children with different cognitive strategies worked together. This certainly seemed to be true on this occasion, and it is even more interesting to note that the anticipation that the child with high simultaneous information processing ability would perform better on a Logo task, was confirmed.

Observations at the Completion of the Study

At the completion of the study the results showed that after eighteen months of being and working together, these children now saw each other very differently and their choices indicated that they were working from their shared experiences rather than just perception.

Unlike when the children were in Kindergarten, there was now some evidence of mixing of sexes with one girl being chosen as a computer workmate and playmate by a boy, and two boys being chosen by girls as computer workmates and one boy being chosen by a girl as both a computer workmate and a playmate. In every instance these children were personable, intelligent and perceived to be "good" at work in the classroom environment. Observations made during computer usage and during class time confirmed that the one girl and one of these boys were the *highest* achievers in both Logo and classroom tasks, and that these two children had actually crossed the "sex barriers" and chosen each other both as playmates and as computer workmates. Observation further verified that this actually happened not just on one or two occasions, but on an on-going basis. These two children were also recognized by the class as the "stars" in the use of Logo. Whenever a "Logo problem" arose within the group, inevitably the whole class would turn to Amy and/or Matthew for the solution.

At the completion of the study, two boys were not chosen by anyone as computer workmates, although none was omitted from the list of playmates. One could speculate that boys are quite accepting of each other in the play environment, but slightly less tolerant in the work environment. The two boys who were not chosen for computer workmates had been observed on a number of occasions, to be reluctant to co-operate with the partner and it would seem that this had not gone unnoticed by their peers. Interestingly, these were not the same boys in this category at the beginning of the study, but rather they had moved into this category because the others now knew them better. The boy who had previously been rejected as both a computer workmate and playmate (Michael) was now highly acceptable as both, and this is probably due to the fact that he appeared to have settled a great deal and was often the recipient of teacher praise. Interestingly, Michael was often observed to still be choosing to work on his own and this probably confirmed that he was a child who genuinely could benefit from working on his own (Damon, 1981).

Now the "stars" were made up of two groups - those who were personable and had attractive personalities and those who were obviously succeeding in their use of the Logo language. Some boys could be slotted into both of these categories, whilst some most definitely could only be classified as one of these.

At the completion of the study, three of the fifteen girls were not chosen as either computer workmates or playmates. Of these, one was in this category last year - the child mentioned as being of ethnic origins. Discussion with the teacher revealed that upon arrival at school each morning the girl always cried for at least the first twenty minutes - this would seem to be an obvious reason why other children were not attracted to her. The other two girls not chosen were described by the teacher as being "bossy", again indicating reasons for rejection by the group.

The "stars" were again those who were both personable and perceived to be competent, with more bias in the girls' choices being given to the competence factor, than had been evident in the boys' choices.

In general there was a shift over the period of the study, in the children's choices being based more on what actually happened in the school environment than purely on appearance, and consistent observation verified that the children, when in the real situation, chose those whom they actually reported to choose.

Conclusions

Muller and Perlmutter's (1985) suggestion that "computers can provide a focus for children to work together" would seem to have been verified on this occasion. There also appears to be substantial evidence that the use of the Turtle graphics screen with its high visibility of what is actually happening provided an opportunity for the children to focus their activities and to monitor the thinking of others. This focussing on activities could be directly related to the results reported in Chapter 13, where children in the Logo group seemed to have developed the capacity for greater cognitive control than their non-Logo peers, when confronted with tasks such as the MFFT.

Based on the experience and observation of these children working with Logo, there would be support for the statement made by Clements and Nastasi (1985) that:

> the social interactions that occur in a Logo environment may be qualitatively different from those in other environments. For example, besides promoting cooperative work, these interactions may also enhance the development of problem-solving skills, effective motivation, and metacognitive abilities. In fact, child-child interactions during Logo programming may be as significant for cognitive development as are the child-computer interactions.
> (Clements and Nastasi, 1985, p.27).

There was evidence that children had passed through the transition from "other-regulation to self-regulation" (Wertsch, 1979). Children were often observed to be "talking" to themselves - socialized speech was being turned inwards with the child "appealing to the self" (Vygotsky, 1978). This "self-talk" was also observed during post-testing on MFFT and is reported in Chapter 13. Children were observed to be employing skills in social interactions that they could not use in isolation (Day et al, 1985), and the planning function of speech certainly seemed to contribute to the accomplishment of some difficult tasks (Vygotsky, 1978). For many of the children, instruction had taken place within their "zones of proximal development" - a little, but not too much in advance of their development. For the most part, this instruction had been accomplished through social interaction with peers, whilst working on Logo tasks. The nature of the high visibility of the "Turtle", the object of discussion, as noted above, appears to create a unique circumstance for social interaction to produce cognitive and metacognitive growth and reflective thinking.

CHAPTER 17

SUMMARY CONCLUSIONS AND IMPLICATIONS FOR TEACHING AND FURTHER RESEARCH

The Logo Environment

The educational philosophy of Logo's main developer, Seymour Papert could probably be summed up in saying that his main concern was to develop intellectual structures that supported learning. He (1980) argued that the computer and particularly the use of Logo type environments, could concretize and personalize that which has been considered to be 'formal learning.' Papert (1980) saw Piaget's stage theory as being conservative and sought to develop the more revolutionary Piaget as expressed through his epistemological ideas of expanding the bounds of the human mind. Papert (1980) saw that the computer could make this possible.

The findings of the study in part support Papert's philosophy. In learning to control the computer, through the use of Turtle graphics, the children in the Logo group learnt to build and analyze little programs, and through the process of doing this, often "invented" different methods for achieving their goals. These various methods in turn seem to have led to their thinking about other problems and even about their own thinking. They continually built on what they already knew and the computer provided a context in which their thinking could expand.

Solomon (1980) made the point that Papert's work does not seem to fit standard evaluation methods for several reasons, not the least of which is the difficulty of knowing which questions to ask. However the steadily increasing volume of research provided a focus for the current research and suggested the formulation of six hypotheses for the study, five of which were supported by the data.

Summary of Results

Reflectivity/Impulsivity

The investigation of reflectivity/impulsivity yielded the most dramatic results. Children in the Logo group shifted quite definitely away from impulsivity, either towards reflectivity as measured by the MFFT or towards being both fast and accurate. For many children in the group, there were significant increases in latency scores (indicative of reflective responding) as well as significant decreases in the number of errors they made. Observation of behaviour indicated that children were taking time to assess their options before making decisions. Moreover, if their initial decisions were not correct, they were able to attempt to find better solutions. Generally, children were seen to be engaged in planning activities - often talking to themselves - which enabled them to "review" their thinking, if at first they did not achieve the desired results.

The model of individual differences provided a means of identifying children in the Logo group who had made significantly greater gains in reflectivity than their non-Logo peers. The fact that it was the children who were low on cognitive control who had increased latency scores was one of the results that could impact classroom practice. If it can be concluded that Logo environments can actually develop children's capacity for cognitive control, as well as heighten the level of interest that they are willing and able to give to certain cognitively demanding tasks, there are positive implications for the use of Logo in classrooms. This is particularly true for classrooms of young children, where development in these areas can be influenced.

Logo can provide an environment where children can generate ideas for projects of their own making, and where their ideas become their goals. In this way, the use of Logo enhances the development of children's abilities to decide on the nature of problems and select mental representations for them that will lead to problem-solution.

Spatial Development

The development of spatial skills was an area which appeared to be an obvious one for investigation because of the geometric and spatial nature of Turtle graphics. However, because of the scarcity of previous research in this area with children of this age group and because of the necessity to ensure that the non-Logo group were not in any way disadvantaged in this testing, the measurement of the development of spatial skills was not easily quantified. Yet, multivariate analysis revealed a significant effect for the Logo group on two of three Tests of Spatial Ability. The real significance perhaps lies in the fact that Piaget and Inhelder (1956) would have cautioned that the cognitive demands of the tasks were outside the scope of the spatial development of six year olds. Yet despite this, the Logo group *did* succeed on the tasks and outperformed their non-Logo peers. This difference would seem to have resulted from the activities involving Logo.

Although subsequent analysis did not yield further insight into the superior performance by the Logo group, observation of the children's behaviour while using Logo revealed some interesting conclusions. Children showed their understanding of the concept of 360 degrees in a circle in a variety of ways associated with making the turtle turn right and left and knowing that they could get it to land exactly where they wanted it. They also exhibited quite a thorough understanding of the properties of squares and rectangles. They grew in their appreciation of symmetry and how this could be achieved in their Logo procedures. They *had* grasped sophisticated concepts in their *own* ways - learning was not being imposed. While actually using Logo, the children demonstrated superior spatial processing. Although they also exhibited superior spatial processing on the Spatial Tests given at the completion of the study, it would seem reasonable to suggest that this superiority was not shown to the same level that was obvious when observing the children using Logo. The children were given a powerful tool which seemed to afford them the opportunity to think powerful thoughts and do powerful things (Papert, 1980).

Conservation Abilities

The nature of Turtle Graphics within the Logo language seemed to necessitate that its users would be able to conserve both number and length. Some research had already investigated young children's conservation abilities in relation to the use of Logo (Rieber, 1983; Munro-Mavrias, 1983; and Clements and Gullo,1984). Therefore, the study sought to assess the ability of the children to conserve both number and length. In general, neither the children in the Logo group nor the non-Logo group could conserve at the commencement of the study. At the completion of the study, multivariate analysis indicated that children in the Logo group were conserving more frequently on nominated conservation tasks, than their peers in the non-Logo group, and were also more certain of whether or not they were correct.

Behavioural observation further revealed that children in the Logo group were using language to describe their tasks, which implied they actually understood the principles of conserving . Use of words such as "equal", "same number", "same length" showed an understanding based on ability to conserve.

The levels of surety of correctness would seem to confirm that the children in the Logo group not only *were* conserving more often than their non-Logo peers, but actually *understood* the processes involved in the conservation tasks and were aware of when they could or could not execute them.

Social Dimensions

The literature has also given prominence to the role of social interaction in the development of children's cognitive and metacognitive abilities. Observations made during the study seemed to confirm the importance of social interaction and in particular the usefulness of the Logo language to promote productive social and verbal interaction was confirmed.

Observation showed that the "planning function" of speech so often referred to by Vygotsky (1978) and Levina (1979) was active as children discussed how they would get the Turtle to do what it was *they* wanted it to do. Actions which had been prepared by verbal plans then tended to be more reflective. Once speech is used in this way, the social milieu out of which the representation of actions arises, must assume even more importance. The children moved through stages of revealing *future* actions, carrying out, and finally acquiring verbal mastery over their own behaviour (Levina, 1979).

Children using Logo engaged in qualitatively different social interactions. From observations it was clear that conversations were more focussed and were oriented towards the articulation and solving of problems, problems which were often of their own making. Furthermore, the choice of more "capable" peers by children who foresaw that they may have difficulty with the task at hand, seemed to have resulted in those children being moved to work within their "zone of proximal development" (Vygotsky, 1978), and as a by-product, the self-esteem of all children involved was usually enhanced.

The research of Day et al. (1985) proposing that the most effective teaching takes place within the child's zone of proximal development would seem to be given general support by the study. In particular, the use of Logo appeared to provide an opportunity for children to move one another into this arena during the course of their social interactions.

Implications for Research

The study confirms the need for on-going research into children's use of the Logo language and Logo type environments. Based on results gained in the study, a number of areas would seem to be particularly worthy of investigation.

The study seems to imply that at least in the development of general problem solving ability, there is no direct transfer of skills from the use of Logo. However, such issues are clouded by the lack of suitable instruments for evaluating the development of *general* problem solving abilities. It would therefore be useful, to develop tests of these abilities that do not involve the use of skills that are obviously influenced by the use of Logo - spatial skills, conservation skills, planning skills. Such tests would provide an opportunity for the investigation of whether any more generic problem solving skill development could be attributed to the use of Logo. This would also provide for the identification of these skills through the use of mediums other than the Logo language itself.

Similarly, it would seem to be of interest to find out why skills in spatial processing *do* seem to transfer from the use of Logo to paper and pencil testing, but not to the same level of skill that children demonstrate when actually *using* Logo. Such issues lead to questions relating to whether it in fact *is* the actual use of the computer in Turtle Graphics that produces spatial skill levels beyond those that can be normally anticipated, whilst the other question that arises is whether the skills are actually diminished when the children are asked to transfer them from one example to another? On-going investigation of such issues is needed for teachers to be able to appropriately implement the use of the Logo language in the classroom.

Some further analysis of the elements of the Logo language might lead to a clearer explanation of *what* it is in its use that has such an influence on levels of reflectivity/ impulsivity of children in the five and six year old age group. Children appear to be more discerning and exercising more care in the choices they make, when more than one option is available to them. Is it the use of debugging techniques that promotes this? Or is it the fact that through the graphics screen children can scrutinize the effects of their own thinking, and this leads to real metacognitive development? Perhaps, it is the social interaction that takes place as children discuss with one another or tutor each other in the solving of their problem tasks, that gives rise to the development of planning skills and moves children into their zones of proximal development, and this in turn leads to the development of qualitatively different capacities in their thinking skills. The real answer probably lies in some amalgam of all these factors.

These seem to be questions that should be addressed if the educational community at large is going to realize the benefits of using Logo to enhance the quality of education.

Finally, the major area about which debate continues to occur, is that of " how can and should children's use of Logo be assessed?"

Walker (1987) affirms Papert's (1987) position that it is impossible to evaluate an educational program "that sets out to challenge the prevailing system" in terms of the goals of the already exisiting system. Papert has therefore relied heavily on anecdotal evidence and case studies, arguing that empirical research tries to place the use of Logo within the confines of traditional educational expectations. However, Walker (1987) is then quick to point out that use of case studies and anecdotes alone also have their shortcomings and limitations. He says:

> In the earliest stages of experimentation with a new educational program, case studies are likely to be more valuable; as we gain experience with the program we should be able to pose more focused questions that deserve the confirmatory power of experimentation. (Walker, 1987, p. 9).

The issues pertaining to Logo, its "effects" and the "empirical evidence v's. the anecdotal evidence" debate have been aired for the past few years now, with the main players in the arena being Papert (1987) himself and Pea (1987). Becker (1987) tried to evaluate both sides of the debate and found shortcomings in both, but added that

> the answer to imperfect research is better research, not no research.
> (Becker, 1987, p.16).

The results of the present study *do* indicate that there is information to be gained about what children do with the Logo language both from behavioural observation and statistical evidence. It appears that neither is quite complete without the other and that the behavioural observation is needed to understand and interpret the statistical data usefully. The further insight gained in the study through the use of a model of individual differences indicates the value of relating detailed task analyses to psychometric measures.

There still remains some difficulties associated with the testing of young children, both in terms of their limited concentration spans and their restricted capacities for reading and writing. Individual testing may always remain the most accurate way, but it is inordinately time consuming and poses some major problems in the ordinary school environment both for a teacher and a researcher. Development of unobtrusive computer- based tests with analytical record keeping facilities would seem to be extremely worthwhile objects for research.

There is within the educational community a great need to understand the role of Logo in the educative process. It is the research community that can satisfy this need. Becker's (1987) final message is appropriate:

> Thank you, Seymour Papert, for inventing Logo. I find it a stimulating intellectual activity. But Logo, discovery learning, and the more concrete ideas embodying these concepts must be held to the same standards that we hold other hypotheses about cause and effect. If the theory has

> testable consequences for school-age children in school settings, let us first test them in a variety of systematically varying settings before proselytizing for Logo's use around the world.
> (Becker, 1987, p.16).

Implications for Classroom Learning

There is already a substantial body of evidence that suggests that Logo is being used in schools with children of all ages, abilities and nationalities. How it is actually being used and whether all children are benefitting from its use are questions that remain unanswered. Therefore the necessity for research with Logo is great and the implications of such research for teaching could be far- reaching.

The outcomes of the present study suggest some avenues that teachers using Logo with young children may wish to explore. It seems that Logo may be used firstly to develop certain abilities and capacities in young children, and then secondly to actually teach some knowledge and concepts that they need to acquire.

The Development of Children's Abilities and Capacities Through The Use of Logo

The two main areas of development relevant to teaching that seem to have been impacted by the use of Logo in the present study are the development of conservation abilities and the enhancement of cognitive control that enables children to be more reflective in their thinking.

As noted earlier (Chapter 14), at least three studies have provided evidence of enhanced conservation abilities related to use of Logo (Clements and Gullo, 1984; Rieber, 1983 and Munro-Mavrias, 1983). It would seem that the children using Logo in the study actually developed conservation abilities in number and length because they *needed* these abilities in order to be successful in their use of Turtle Graphics. Therefore far from being a pre-requisite for the use of Logo (Reiber, 1983), conservation abilities which provide the child with a framework where logic as well as physical principles can be applied, can be developed in the Logo environment. Murray (1982) stated that alone, the physical contents of a task are not sufficient to promote conservation. Piaget (1965) viewed children's movement into the stage of complete conservation as one reliant on cognitive development. It may well now be possible to view the use of Logo as a stimulus for the cognitive development that is needed to accomplish conservation.

The other area in which there has been development related to the use of Logo, is that of metacognition. Education for the society of the future dictates the development of critical thinking. This in turn demands that children develop a capacity to examine their own thinking and to attend to the matter at hand. At least two other studies besides the present one have shown that the use of Logo develops reflective thinking in children (Young, 1982 and Clements and Gullo, 1984). The teacher who wants to promote such a quality in younger children particularly, is faced with the difficulty of the children's inability to engage in abstract thinking and subsequent inability to scrutinize their own thoughts. Logo provides a vehicle for allowing children to *see* the results of their own thinking in their Turtle drawings. Furthermore Logo affords them the opportunity of changing and adjusting their thinking if necessary, in order to arrive at the desired result. This seems to be a unique opportunity offered to children in a Logo environment, and one which could contribute to the development of many skills needed for the future into which they will move.

The further aspect that emerged from the use of Logo with the children in the study, was the movement towards reflectivity of the children who had been seen to be low in cognitive control. Such children are usually fairly easily identified in the classroom setting, and the teacher is confronted with finding tasks in which the children can engage with sufficient interest to enable them to practice sustained concentration. Although the reasons why the particular children in the study shifted towards reflectivity are not completely clear, the statistical evidence showing a relationship of reflectivity to cognitive control was significant. It can be speculated that Logo provides the motivation that such children need to apply themselves in a more focussed manner, to the task at hand. It would also appear that the use of the Logo language can provide opportunities for children to form dyadic relationships which engage the partners in conversations which promote metacognitive development. The use of Logo further seems to "encourage" children to use the planning function of speech (Levina, 1979), sometimes together in pairs, and often when working alone. Children were often observed to be talking aloud to themselves, when trying to devise or refine their little programs. Such findings and considerations have implications for the teachers who have to decide which children might have priority in using the computer in the classroom, and more particularly, the way the computer is used in the classroom, and the type of activities and programs that they assign to it.

The Development of Children's Knowledge

Quite apart from the many changes that curriculum development has undergone in the past decade, and the even greater change that it might undergo in the next decade, there remains a core of knowledge that most educators agree, all children need to develop. Methodologies for developing the related skills have changed dramatically over the past years, and studies of the use of Logo seem to suggest that there may be the option of even further change.

Although the present study did not focus intensely on the development of such skills, observation of certain behaviours displayed by the children while using Logo, suggest that its use may have implications for their development in the classroom.

There is a growing body of evidence showing that the use of the word processor can improve spelling abilities (Porter, 1988). The use of Turtle Graphics demands the correct spelling of the commands being given; otherwise the Turtle responds with "I don't know how to.........." Observation of children using Logo reveals that they will continue to try different versions of the word until they finally spell it correctly and the Turtle responds with the desired movement. This may make the use of Logo with reluctant learners highly desirable.

A concept that traditionally has been outside the grasp of young children is that of large numbers. Gelman (1982) has shown that although young children *talk* about large numbers, they do not understand their meaning. The initial use of Logo by the children in the study certainly verified this fact - they thought any number more than nine was large!! However, the necessity to make the Turtle move further than the steps of a single digit would take it, and also the desire to make this happen "quickly" rather than through repeated moves, prompted them to ask about larger numbers and subsequently to experiment with them. Through the use of Turtle Graphics children can "see" how the addition of another one or another ten increases the size of the Turtle's move. Therefore they can develop concepts of larger numbers in relation to smaller numbers, a development that is not always easy to achieve in the classroom environment.

Related skills can also be acquired during the experimentation with large numbers - the skills of estimation. The movement of the Turtle on the screen requires that the user be able to estimate the number of Turtle steps that will need to be taken in order to get the Turtle to its destination. Estimation too, is traditionally a skill which young children find hard to develop. The use of Turtle Graphics gives children repeated opportunities to develop this skill, and because they are doing it not only with Turtle steps but also with the turns for right and left (angles), they are introduced to the fact that the numbers can have different values, depending on their functions. Observation of the children using Logo in the present study showed that they became quite "expert" in being able to estimate the size of the move or turn that was required.

The development of an appreciation of symmetry is obviously related to the acquisition of spatial skills. The notion of symmetry is a very difficult one to convey to young children, due to their inability to achieve perspective in their own drawings. However, the use of Turtle Graphics provides children with an opportunity to achieve the symmetry they would not otherwise be able to achieve without the use of rulers and geometrical instruments, the manipulation of which is not possible for young children. Children come to the understanding that symmetry is sometimes achieved through ensuring that lines in rigid shapes are the same in length, and that angles in rigid shapes are the same size. This assists them in their efforts to achieve symmetry in shapes which are not rigid.

The findings of the study suggest that the children's spatial skills were enhanced. This was not surprizing given the nature of Turtle Graphics, and was also consistent with the findings of other studies (Rieber, 1983; Clements and Gullo, 1984). Teachers could allow all young children to work with Turtle Graphics, to teach identification of basic shapes and their properties. Slightly older children who were experiencing identifiable difficulty with the development of spatial skills could be placed in a more structured Logo environment, where the emphasis could be placed on a logical development of such skills.

Finally, there would seem to be some evidence that young children also acquired planning skills through their use of Logo. Children were often observed to be planning their drawings in advance, both at and away from the screen, alone or engaged in conversation with others. (The planning function of speech has already been reported in Chapters 3, 16 and earlier in this Chapter). As children see the direct success of their planning through the desired drawing appearing on the screen, they realize quite quickly the benefits of their planning exercises. It would appear that it is the fact that the use of Logo allows children to see the effects of their planning so directly, that makes it an ideal medium for developing these skills. If children can recognize the value of planning when using Logo, it would be possible to extend such planning skills to other areas of activity.

Conclusions

There appear to be many areas of concept attainment and skill development, where the use of Logo in the classroom would be an appropriate mechanism for accomplishing these goals. One of the most significant features of Logo which makes it so appropriate is the instant response and feedback that children gain when they use Turtle Graphics and the quality of social interaction that can be evoked through it. Teachers who could try to integrate Logo into their total classroom environment, rather than simply just *do* Logo, would appear to be able to draw benefits from such an environment across a broad array of desired curriculum goals.

In summary, the words of Marvin Minsky (1986) written as a Preface to "Logoworks" (Solomon, 1986) seem to sum up the potential of Logo for the classroom.

> Programs...make things come to be, where nothing ever was before. Some people find a new experience in this, a feeling of freedom, a power to do anything you want. Not just a lot - but anything. I don't mean like having a faster-than-light spaceship, or a time machine. I mean like giving a child enough kindergarten blocks to build a full-sized city without ever running out of them. You still have to decide what to do with the blocks. But there aren't any outside obstacles. The only limits are within yourself. (Minsky, 1986, Preface).