

UNIVERSITY OF CAPE TOWN

FACULTY OF EDUCATION

"An investigation into the behaviour of a group
of Primary School children when using selected
mathematical software."

A DISSERTATION
PRESENTED IN (PARTIAL) FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF EDUCATION

by

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SEPTEMBER 1987

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A B S T R A C T

Very little is known about how young children think and behave when faced by computers and the broad array of mathematical software available. Much of the software has been developed by adults in the way adults see young children reasoning.

A class of twenty English-speaking boys of approximately 12 years of age were exposed to carefully selected mathematical software without adult (teacher) interference, to clarify how these pupils would react to that software. Special focus was placed on the interactions of three children throughout the series of twenty lessons, using two video cameras to record their behaviour. The size of the groupings was changed to consider the effect of group size on the pupils' interactions. Various 'themes' evolved out of reviewing the video recordings. These 'themes' were then linked to Research data.

It appears that these pupils had great trouble in reading and interpreting instructions accurately. Also, the software made assumptions of what the pupils could do. The interaction and collaboration by the boys seemed at its best when they were in a group of two as 'peer equals'. The class recognised and used the services of those boys they considered 'experts' in the use of computers.

The video-recordings showed that the pupils preferred having pencil and paper available to record information and their estimations, rather than having to rely on memory. It seemed to give permanence to their thoughts and make these more explicit and organised. An

analysis of the data also showed that the software and the boys' reaction to it was distinctly sexist. The names of the software (SNOOKER, PILOT, MATHS - CARS IN MOTION, etc.) can be seen as male. The boys gave the computer a 'personality' and referred to it as a 'he'. Also, a disturbing tendency among these pupils was the way they interpreted the software and reacted to it in a distinctive military fashion. This can be attributed to the boys having to battle, explode or bomb their way to victory; to shoot something or be shot in much of the software available.

My role of being 'non-expert' was an extremely difficult one as the pupils had expectations of me, and the shortcomings in the software obliged some form of interference. My conclusions are that the mathematical software needs to be appropriate and relevant to what is being done in the class rather than to exist on its own outside of it, and that it could aid the pupil to think about his thinking.

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I N T R O D U C T I O N

"It is not technical methods but the association of man and his tools which transform society."

Octavio Paz (1957)

The improvement and development of computers has continued in great leaps forward since their first invention, and with each successive generation they have become more powerful and reliable, cheaper and thus accessible to everyone. Now in its fourth generation (Bredell, 1985), this technology is beginning to play an important role as a data-processing instrument in educational institutions and is being used more frequently by teachers and their pupils. As this technology continues to become more available in schools and to children, the immense potential of the use of computers as a teaching tool will only be realised if there is quality educational software for the pupils to use. Despite the vast amount of commercial software Brack (1984) and Self (1985) states that there is a limited amount of 'good' educational software available at present. The unqualified use of this mass of software can have a potentially good or bad effect on the way children think, react and come to view their world.

This potential effect is what I feel concerned about as an educationist. According to Jones (1984), when we consider computers in education we are in a situation of change without choice regardless of the criticisms that it is rather hurried. Clements (1985) maintains that there is a need to show how computers can be used and that educationists need to raise issues concerning how computers should be used with young children. He further states that 'cute' activities which have not been adequately considered in the light of what children need to learn, and of how children learn it, are the bane of early education.

In order that educators do not blindly endorse nor needlessly reject computer technology, they need to be knowledgeable about its potential and its applications. Knowledge of how computers can help develop important goals and promote achievement, positive attitudes toward learning, the self and social behaviour, would ease undecided educators out of this high-tech catch 22 situation (Komoski, 1984). All of these can only be proven when based on established theory generated from adequate research.

Several extensive reviews of the research concerning the effectiveness of computer-assisted instruction have been conducted (Billings, 1983; Lavin and Sanders, 1983; Bracy, 1982; Forman, 1982; Chambers and Sprecher, 1980). There is general agreement that the learning of mathematics is more effective and done in less time than when using traditional instructional methods and that the creative process is not stifled, neither are computers dehumanising. The benefits of learning how to use the computer effectively are said to prevent today's pupils from developing into the functionally illiterate of tomorrow. The non-use of the most powerful tool yet created will exclude much of society from contributing at an unacceptable social and psychological cost, as most occupations are beginning to involve the use of computers (West, 1983; Molnar, 1981). Turkle (1984) expresses no doubt about the unique impact of computers on young people and that any child in a computer culture is touched by the technology in ways that will separate it from previous generations. Then, too, there are the claims that using the computer has the potential of expanding the intellectual capabilities of learners, making them inventors of their own intellectual tools (Olds, 1981) and of amplifying and liberating their human power and potential (Dwyer, 1980). Minsky (1970) maintains that programming will eventually become more important than mathematics in early education.

Most mathematics teachers agree that computers can help in the teaching of mathematics. Two schools of thought are :

- (1) computers can individualise and motivate practice in computational skills; and
- (2) that computers will help to remove the tedious computation of school algorithm.

Clements (1985) states that both views are missing the point and that computers should be used to develop problem-solving abilities in a broader view of mathematics. Piestrup (1982) found in a pilot study that children did benefit from and did interact with mathematical software. Kraus (1981) reported that pupils were more successful in the use of addition after having played a computer game over a two-week period.

Against this evidence many educationists warn of the dangers of using computers with children, as the machines create an isolated, mechanical child, dehumanised and mesmerised by its effects. Gardner et al (1973) claim that the move to computers is because of their ability to store information, rather than perform obtrusive mathematical calculations, and thus they are modifying society. This has little direct bearing on the primary school child and it is the peripheral developments such as flow charts and systems that are more likely to be of interest. Many of the sceptics see computers destroying 'traditional' education and the resultant loss of physical, social and artistic skills and an even further widening of the gap between the 'have' and 'have not' society (Pontiel et al, 1984). Shallis (1984) maintains that allowing a teaching machine to take over teacher-functions causes the pupils to lose out on real human relationships leading to an atrophying of human senses because of the lack of emotional contacts. Weizenbaum (1976) also points out many of the dangers in the uncritical application of computers. Illich (1983) maintains that just as

traffic calls for policing, so computers will demand even more, and in even more subtle forms. Then again, there is the uncritical pressure of parents who are striving to ensure that their children are not condemned to a miserable future of extreme hardship because of being computer illiterate.

Where does mathematics fit into all of this? Mathematical software is playing an increasingly important role in the use of the microcomputer in the teaching of mathematics in primary schools. There is now a wide variety of software available for teachers to use. In fact, there are probably more mathematical programmes than for any other part of the school curriculum. There are also many ways in which the computer can be used, ranging from drill and practice, the electronic blackboard approach and through to investigations, simulations and adventure programmes. Much of the quality is variable though some good programmes do exist. It is thus necessary that the type of software and the way it is used should be closely considered and any of the harmful effects, be they social or educational, avoided. There is a need to consider pupil reactions to the software.

When I was asked to monitor the group in the computer room for the year I felt that it was an ideal opportunity to consider many of these issues. At that time my position in the debate was fluid, though for some time I had been extremely concerned about how little I personally knew about the potential effects of the computer and mathematical software on young children - be they positive or negative. I hoped that through my observations and monitoring many of these issues would be noted and remarked on - whether using the computer and mathematical software does indeed make children anti-social or do they collaborate and share more frequently. Do, or can, children take control of their own learning? Also, I hoped to be clearer in my own mind as to what could be considered

as appropriate mathematical software, what motivates children, and how the computers can be integrated into the mathematics classroom.

Mathematical software will come to play an increasingly important role in the future perspectives and potentials of the computer in terms of its influence in the social and educational domain. If the future possibilities of the computer can be accepted, then all that can be done, should be done. When the Nobel Prize winner H.A. Simon was interviewed by the Paris newspaper "Le Mond" on 2 April 1984 concerning the future potential of computers, he responded :

Simon : "There is no one thing I could state as being definitely outside the present or future potential of the computer."

Reporter: "A robot, may it reason like Einstein, write like Proust?"

Simon : "Possibly."

Though the future of the computer has been so dramatically spelt out by Simon, Postman (1983) believes the crux of the matter is whether the relentless pursuit of computer technology will continue to erode the ever-shrinking limits of the incunabula of childhood and the control of the schools. He feels that the need for childhood can be sustained by the technology of the computer and that it is the only modern communications medium that will prevent the relentless slide of childhood toward oblivion. The very essence is that the child needs to learn a computer language and its associated analytical skills in order to be able to use the technology. Also, the only social institutions strong enough and committed enough to make use of this potential of promoting sequential, logical and complex thought among the mass of people, are the schools. He, too, clearly warns that the medium can be made equally impotent by the misuse or abuse it is put to in schools.

CHAPTER ONE

"In educational research the first great aim is that of narrowing the gap between fact and fiction, between truth and falsehood in educational knowledge".
(Kevin Rochford, 1983)

1.1 SETTING THE SCENE

The computer room that I was to be using during the time of my observation had already been set up in one of the standard lecture-rooms in the Education Faculty of the campus of the University of Cape Town. The equipment in use consisted of one BBC Econet system having 10 work-stations with colour monitors as user areas, and one additional file server with a 10-megabyte hard disk drive (Winchester) and one dotmatrix printer for hard copy. This allowed for each keyboard to be used by only two boys in a group at a time. The file server and printer were placed at one end to prevent possible corruption by the pupils or any other unauthorised people. The start-up procedure, user numbers and password were all predesigned and done by the Teaching Methods Unit of the University of Cape Town, as was the transferring of the software onto the network.

The proceedings would be videotaped. (The resultant tapes were later studied and interpreted.) My primary intention at this stage was to select mathematical software that would be both interesting and exciting to the boys, while at the same time be considered as good mathematical software.

1.2 TOWARDS A STRUCTURE

According to West et al (1984), educational software must be efficient, user friendly, tested, well-documented and must blend with the established school curriculum. Nicolson et al (1984) state that, when selecting software, the contents can be classified into four broad non-independent categories namely :

- (1) instructional (format and answers relatively fixed - structured reinforcement)
- (2) conjectural (make hypotheses and use the computer to test)
- (3) emancipatory (using the computer to do the donkey work)
- (4) revelatory (learning by discovery using simulations)

My intention was to use these categories when reviewing and then selecting the mathematical software that I intended using, while observing the pupil reactions to the same. Using the magazine reviews in Educational Computing and Micromath, I was able to select the software that I felt was the most appropriate for the purposes of the research.

In order to make an appropriate software selection, I used structured reinforcement as a beginning because it has the most securely established use (Jones, 1984), and because it was naturally the most closely related software to the mathematics already being taught in the primary classroom. The intention was to use the kind of software that encouraged interactive drill and practice and discussion in a meaningful context, where the pupils could apply previous knowledge and skills in unfamiliar ways so that the range of applications would be extended. I also hoped to reduce teacher-supervision to a

minimum. The boys could also practise basic computer skills such as following a sequence of instructions precisely. I felt that the ILEA MICRO SMILE package, with some 47 games, (SMILE 1-3 and NEXT 17) had many games which were very suitable for the top end of the primary school. They are nicely packaged with good documentation. Marshall (1985) maintains that this software fits the principles of developing a positive attitude to mathematics as an interesting and attractive subject and that the children love it. Goldstein (1982) maintains that the SMILE games are all self-explanatory and simple to use. I felt it suited my purposes in answering the instructional requirements of drill and practice through structured reinforcement.

I then intended to move the pupils on to hypothesis-testing and problem-solving. I would use LOGO as the vehicle for the pupils to experience 'real' problems and help them develop their confidence in solving such problems. It would also hopefully involve them in taking the initiative in their own learning and provide them with the motivation to solve the problems that they themselves have raised. Teacher-supervision would be minimal. I elected to use LOGO for the second stage of the research to provide the pupils with the opportunity where they could develop their ideas and gain an insight into the nature of variables. I also hoped that it would encourage the collaborative work in their pairs and allow them to explore and share together and be provoked to look beyond the immediate task. (The eventual reason for not extending the LOGO lessons beyond the first one was the extremely negative reaction of the boys to doing it.)

Thereafter my intention was to move on to software that encouraged information handling skills in a larger group context where the computer did the donkey work. I was hopeful that the pupils would interact, collaborate and debate with others, asking questions and questioning tentative conclusions (Jones, 1984) and, when necessary, drawing new ones.

For the introduction to activities in larger groups I chose to use CAPITAL MEDIA and Longman's ITMA Collaboration Going on Learning and, more specifically, SLYFOX, where scenes or contexts are created and then later explored or searched. The pupils would use the prepared contexts in small groups before creating their own material in larger groups. This software allows for collections of information to be grouped and involves the structuring, storing and retrieving of data required in the development of simulations. It is different to LOGO in its creation of pictures and scenes as the pupil is obliged to use pencil and paper to give the scenes a logical structure.

I wished to end the series of lessons by observing problem structuring and solving skills as well as discovery learning in a large group using a simulation programme which created a representation of a reality or a framework within which the pupils would be required to react and overcome the copied constraints or problems of the 'real' world situation. These problems should not be contrived or trivial but demand meticulous attention to rules and details. According to Marshall (1985), CARS-MATHS IN MOTION is one of the finest packages he has ever used in a school, mixing the hugely motivating interest of sport, competition and the computer. There is a great deal of

mathematics involved in this simulation and needs to be done by the pupils using worksheets. The groups would also use calculators to assist them in their calculations when adjusting their 'cars' in their practice laps. Only their final details would then be entered into the computer programme for the simulated race.

Figure 1. Software Selection

SOFTWARE SELECTED	SMILE 1 to 4	LOGO	CAPITAL MEDIA SLYFOX	CARS - MATHS IN MOTION
NON-INDEPENDENT CATEGORIES Nicolson (1984)	Structured reinforcement Interactive drill and practice	Hypothesis testing Problem solving	Information handling Strategy development	Simulation Problem structuring and solving Discovery learning
	INSTRUCTIONAL	CONJECTURAL	EMANCIPATORY	REVELATORY
SIZE OF GROUPS OF PUPILS USED	Small groups (two/three)		Large groups (four/five)	

A STRUCTURE OF THE MATHEMATICAL SOFTWARE USED

1.3 GROUPING OF THE PUPILS

The pupils that came up to the campus were 19 boys aged between eleven and twelve years and all in standard four. The class was all English-speaking. It was multi-racial and all the boys were from middle-class environments. They had all had previous computer experience in using LOGO, but the software I intended using was new to them. They were required to work together in groups of two. At no stage was I wanting to interfere in the grouping of the boys and left

NUMBER OF LESSONS	DATE	PLACE	ACTORS	SOFTWARE	REASONS (AN EMERGING STRUCTURE)
1.	1.	UNIVERSITY OF CAPE TOWN - Computer Room	Byron, Paul	Smile 1	(a) Structured reinforcement (b) Drill and Practice (interactive) in a meaningful situation (c) Operations and techniques (d) Concept programmes (e) Mastering smaller skills leading to greater intellectual freedom and creativity (f) Child on own - reduce teacher as expert
	2.		Byron, Paul, Colin	Smile 1	
	3.		Byron, Paul, Colin	Smile 2	
	4.		Byron, Paul, Colin	Smile 2	
	5.		Byron, Colin	Smile 3	
	6.		Byron, Colin	Smile 3	
	7.		Byron, Colin	Next 17 Smile 4	
	8.		Byron, Colin	Smile 1-4	
2.	9.	UNIVERSITY OF CAPE TOWN - Computer Room	Byron, Colin	LOGO	(a) Children play and explore their own thinking processes (b) Self-motivation in completing task (c) Develop procedures and make concrete and manipulatable (d) Problem-structuring and problem-solving (e) Decision-making and hypothesizing (f) Communication Math Language Estimation and measuring (g) Learning programming ideas Discovery learning and debugging
3.	10.	UNIVERSITY OF CAPE TOWN - Computer Room	Byron, Colin, Fernando	Capital Media	(a) Information handling (b) Greater intellectual freedom by creating their own game (c) Collaborating with others (d) Generalise information (e) Practise skills Collect data, then enter it and save Thereafter test (f) Teacher as helper (g) Give practice in procedural thinking
	11.		Nigel	Smile Capital Media	
	12. (Two videos)		Byron's group Simon's group Paul's group	Slyfox (1)	
	13. (Two videos)		Byron's group Simon's group Paul's group	Slyfox (2)	
	14. (Two videos)		Byron's group Simon's group Paul's group	Slyfox (3)	
	15. (Two videos)		Byron's group Simon's group Paul's group	Slyfox (4)	
	16. (Two videos)		Byron's group Simon's group Paul's group Taylor's group	Slyfox (5)	
	17. (Two videos)		Byron's group Simon's group Paul's group	Slyfox (6)	
4.	18. (Two videos)	UNIVERSITY OF CAPE TOWN - Computer Room	Byron's group Chewwha's group Simon's group	Cars - Math in Motion (1)	(a) Teacher as participant - observing, deciding, implementing (b) Simulation - creation of a real situation (c) Keep accurate records (d) Motivation through competition via competence and working with others to achieve an objective (group interaction) (e) Sue and I became co-racers (f) Enjoyment doing Math
	19. (Two videos)		Byron's group Paul's group	Cars - Math in Motion (2)	
	20. (Two videos)		Byron's group Simon's group Chewwha's group Paul's group	Cars - Math in Motion (3)	

TABLE 1

this selection entirely to them. When the larger groups were formed I insisted on the same procedure and the boys in some instances were obliged to form larger groups. These groups were not fixed and the composition could be easily changed. Freedom of movement within the class was not restricted at all. Neither was the conversation between any of the boys stopped or prevented. The video camera initially concentrated on the group of Byron, Paul and Colin which soon reduced itself to Byron and Colin only. Paul's activities while out of this group were monitored. This small group then grew into the larger group of Byron, Colin, Fernando and Karl. Despite this concentration, many of the other members of the class and other groups were recorded as well and reported on, as they too had an influence on the group. Table 1 is an outline of the recorded lessons and the groups within the lessons and the software that was used.

1.4 THE RESEARCH DESIGN

The very nature and aspect of the topic I had chosen to investigate determined the choice of research perspective and approach. The topic was 'in process' and as such required a qualitative analysis. I was recording an on-going classroom interaction using the video camera, interviews and a survey to try and gain an insight into what was really happening. Rather than change the situation, I hoped to observe, analyse and interpret and define the not immediately visible forces which were acting in this specific situation and which were having an effect on the boys' learning and their handling of the computer software. I hoped to place these problematic forces centrally for open scrutiny, rather than striving for "...the clean conditions of objectivity and controlled measurement" (Morphet, 1983) contained in an orthodox scientific research style. I had no wish to end up in the words of Pilsworth and Ruddock (1982) "... by possessing

a wealth of facts and figures about specific aspects of the educational process, yet understand even less and less about human behaviour".

I was directly involved through my selection of the software which I considered to be ideal for the purpose. Through analysing the recordings and dialogue I hoped that a concentration of focus would lead to the emergence of key issues (themes) that are central to the dynamics of children using mathematical software. I also hoped that these themes would not be trivial but would be fundamental and part of that hidden curriculum needed to be understood by educationists when considering the use and creation of mathematical software.

I wished to use the video camera as a means of gathering heuristic and accurate audio-visual data for analysis and interpretation. The recordings would also allow me the opportunity to repeatedly review situations and be able to consider and re-consider the behavioural patterns, both verbal and non-verbal, of the boys over a long period of time. I also used the questionnaire (see appendix) to provide me with additional individual information.

In research of this nature I was more concerned with cases than samples. It did thus require a methodology more applicable to understanding the problematic situation, rather than one based on predicting outcomes within the confines of an already existent and tacitly accepted social system (Hopkins, 1985). Further, the methodology employed had to be reliable and coherent in analysing the research data. This meant I had to use a workable and acceptable framework.

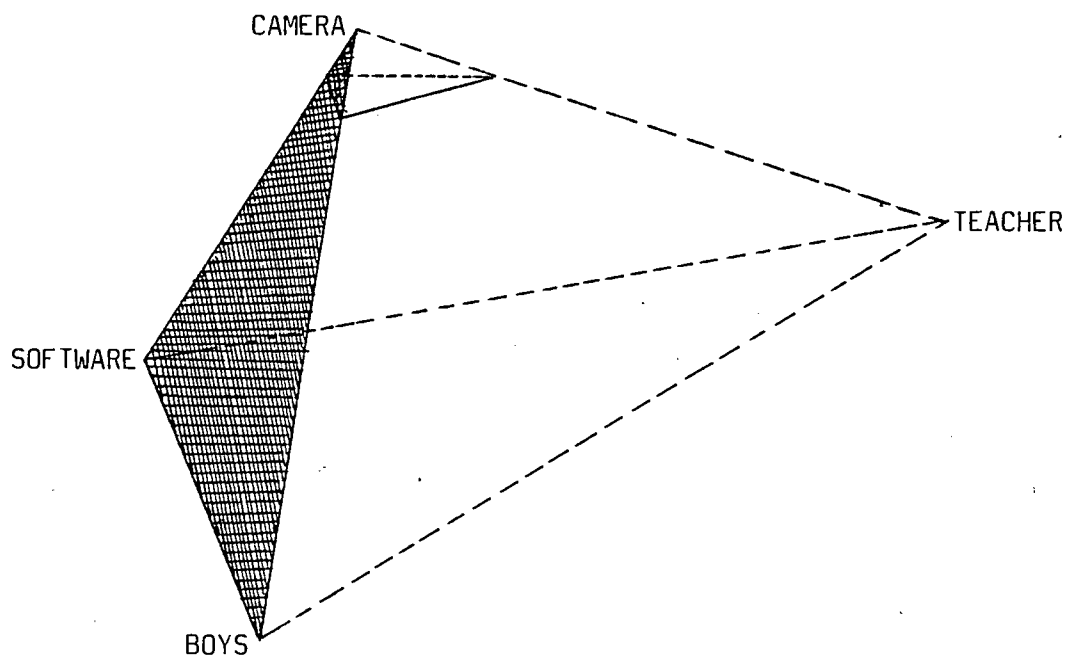
The dynamic constant comparative method of Glaser et al (1967) with its four generic stages, I felt, best suited my needs for analysing the qualitative field data that I would gather.

Figure 2. Fieldwork Methodology (Based on Hopkins, 1985)

GLASER & STRAUSS	CLASSROOM RESEARCH
* Compare incidents applicable to each category	* DATA COLLECTION and initial generation of hypotheses (themes)
* Integrate categories and their phenomena	* VALIDATION of hypotheses (themes) using triangulation
* Delimit theory	* INTERPRETATION of hypotheses (themes) by referring to published research
* Write theory	* PLAN FUTURE ACTION - suggestions and recommended improvements

While collecting the data I hoped hypotheses (themes) would be generated by what was happening in the classroom. I intended to use a system of triangulation to flesh out these themes and give them a high degree of authenticity. The three points of the triangulation I saw as being the video camera, the boys and the software, with myself as the observer. According to Hull (1985) the video-taped image is an 'arrest' of the learning experience around which can cluster articulated remembrances. These can then be exposed to examination and the pupils can be called on to question and explain their actions. Thereafter I would need to validate the hypotheses (themes) by seeing if they fitted within a researched frame of reference by relating these to the already published theory. In this way I hoped to create meaning out of my discrete observations and constructs (Hopkins, 1985). My future action would result from what surfaces during the research.

Figure 3. A schematic representation of the classroom interaction



1.5 THE ROLE OF THE RESEARCHER

The class teacher at no stage interfered and, because of her 'limited' ability on the microcomputer, the pupils tended not to use her as a resource. During the entire proceedings I tried not to allow myself to be used as a resource either. I concentrated on seeing to it that the equipment was always functional. This task did take up a large portion of my time and made it easier not to interfere in what the boys were doing. The set of earphones I regularly wore also made it difficult to hear what the boys were asking. The intention was to break the routine of the boys using me as a reference to their queries or whenever they became stuck. Also, I had to destroy my want to play the role of expert. The video camera assistant would not allow herself to be used as a resource either. These roles became progressively more difficult to adhere to as the year moved on.

Throughout most of the year I was able to make use of two cameras - one to monitor the reactions of the boys and a second camera to record what was being done on the VDU or monitor. Most of the interviews I held with the class were also recorded. The occasional gremlin prevented a total recording of all the sessions.

During the series of twenty lessons the boys were left largely alone to work on the software given to them. There were occasions when the boys reacted to the recording equipment showing that they considered it to be an intrusion. At times they played with the microphone and the video camera and then ignored both completely. There seemed to be no real reserve when facing the camera. I deliberately did not interfere.

The way I structured the lessons was to encourage the boys to take control of their own learning. I hoped they would effect it in such a way that I could record and later review their learning on video. At the end of each session my purpose was to interview the whole class and find out what they felt about the software, their interactions with the software and each other, and the proceedings in general.

I chose this method of approach as I believe that as an educationist I can only come to understand pupils' learning through talking to the pupils about their learning experiences and sharing these. I also needed to have the means to record this information and to be able to consider their actions again and again, if necessary, until the learning or non-learning displayed by the boys in their behaviour and language had been accurately interpreted and recorded by me.

1.6 THE THEMES

The themes that gradually evolved out of the recordings were not deliberately chosen, but rather grew out of the viewing of the videos. Over time the themes seemed to divide into twelve areas, though no doubt many more could be considered. For the purposes of this dissertation I elected to remain with the twelve. They are -

- * Access to the software and reading instructions
- * Turning the computers on and off (hard break)
- * Using the software
- * Use of the software by the class
- * Problems with the programmes
- * Grouping in the class
- * Paul as expert
- * Use of the teacher as expert
- * Teacher nudging and interference
- * Tendency for military usage
- * "Personalitying" the computer
- * Interviewing the boys

During the course of the research, the twelve themes I initially recognised evolving out of the recordings of the boys interacting with the computers and the software were telescoped into the eight I have considered in this dissertation. Out of necessity these themes have been organised into the main chapters that follow.

In addition, I also designed and applied a questionnaire to find out and confirm many of the boys' attitudes and feelings they held about their ability to do mathematics and handle computers. I also had them confirm whom they considered as the 'expert' in their class in

these two areas. The questionnaire was self-administered with a structured questioning schedule and I used a seven point scale. The boys did the answering in private and the results were later collated. The interpretations are recorded in chapter three.

CHAPTER TWO

"The theorization of knowledge is indispensable for the existence of general compulsory education and is at the same time a great problem to the school. The appearance of the computer will not and should not change this at the core, but will bring about new opportunities as well as new difficulties. The social consequences of computers may be very serious indeed and may oblige everybody, teachers as well as mathematicians, to reflect on what they are actually doing to an extent which may seem unusual and quite extraordinary to some."

(Michael Otte, 1985)

2.1 INTRODUCTION

The most significant considerations I was faced with initially were two-fold. One was, having all the recorded information that I had gathered during the twenty lessons at my disposal, I had to decide what form the writing up would take. The second was, would it make sense and have meaning to others. The themes that appeared non-trivial to me could well be transparent and meaningless to others. My writing and eventual interpretations make no claim to being the absolute truth, but simply leave themselves open to scrutiny and analysis.

Something which struck me immediately and caused great concern among the boys in the class, was their apparent inability to read and correctly interpret instructions. This inability stayed with the class throughout their year under my supervision. Much of the software assumed that the pupils had mastered certain pre-requisites and made no attempt to fulfil this function.

2.2 READING OF INSTRUCTIONS

There were two areas of concern here. One was for the boys to gain access to the E-NET first. Then secondly, for them to read the instructions before playing the games or doing the investigations. Both these areas provided the boys with endless problems and Byron's group particularly had trouble.

2.2.1 Reading instructions to gain access to the software

From the very first lesson the groups experienced difficulty in gaining access to SMILE in the E-NET due to the involved series of instructions they had to use. These instructions had been designed by the Teaching Methods Unit to protect the material stored in the network. This issue was important as it clouded the real interaction of the boys and their use of the computer. It created a barrier which first had to be noticed and then overcome. Initially it took Byron and Paul 12-1/2 minutes to find the menu. Both boys tussled with it with a growing sense of frustration. "File not found" and "can't retry" constantly appeared on the screen. They tried information previously gained from handling software such as Granny's Garden and strategies gained from their previous use of the computer to no avail. Paul resorted to constantly turning the computer on and off whenever the instructions they typed in were rejected. Remarks such as the following were heard -

Byron: "Aw gee, this is weird"

The rest of the class seemed to share the frustration that these two were experiencing.

Byron: "Just searching and searching and haven't found it yet....hey you guys..have you found it?"

The general negative response from the rest of the class showed that everyone there appeared to be experiencing the same problem. At this stage I decided to provide some form of information to assist the class and wrote the necessary instructions on the chalkboard. It seemed to provide many in the class with new incentive. Despite these instructions neither Byron nor Paul succeeded in gaining access to the menu. By then many of the other groups had begun to play the games on the programme. There was a growing frustration in Byron's group in their not being able to gain access to the software.

Paul: "I don't know how the hell you got into that!"

Both boys were also becoming distracted by the sounds emanating from the other groups and the visual images being displayed on the screens around them. The two often appealed to me for help.

Paul: "Sir, this is going contrary to our logic."

Despite the odd teacher nudging, Paul left the keyboard in frustration muttering the words 'bonkers' and 'thickness'. Byron, on his own, even resorted to an indiscriminate form of typing, possibly hoping that by some quirk of chance he would gain access to the software.

At one stage Paul suggested that I turn off the hard disk to get rid of the 'can't retry' that appears on their screen. It was probably a method tried before that had proved successful.

It worked and they again began typing in the instructions - this time with a great deal more care.

Byron: "Now we've got to get this."

In spite of their care and determination and even with the access instructions clearly set out on the chalkboard, the group had difficulty. The group even tried to get the information from me.

Me : "Right, now enter your number....okay what's the password?"

Paul : "Password is SMILE"

Me : "Hang on...before you push SMILE, what is the password?"

Byron: "We don't know"

Paul : "1234.....can't retry"

Byron: "Can't retry..what's that?"

Byron then resorted to a strategy being used by most of the class when blocked and turned off the computer. Finally, after a number of attempts, a great deal of trial and error and a fair degree of frustration, Byron and Paul were able to play the games displayed on the menu of SMILE 1.

Throughout the second and third lesson matters did not improve much at all. The groups were still experiencing problems of gaining access to the software. Only handling the computers once a week possibly had an inhibiting influence on the actions of the class, as there seemed to be very little carryover of information from one week to the next, although the instructions were clearly set out on the chalkboard. All that was required of the pupils was to read and copy correctly. The problem the boys were having

hadn't been helped by a change in the instruction procedures on four occasions without warning. When the boys had been informed of these changes, they did not seem able to adapt to them. When Byron asked Colin about how to gain access to the software his response was -

Colin: "I don't know either, I just guess."

Later Byron shouted for joy, "We got it!" when they were only partly successful in getting to the menu, indicating the degree of difficulty they were experiencing.

It was during this session that it became obvious an alternative had to be given to the class as too many were experiencing problems. I also had no intention of gaining access for them either. After giving them the alternative system, which I wrote up on the board, Paul tried to type it in with Byron's help.

Byron: "That thing over there is meant to be a dot?"

Paul: "I know. I'm trying to make it a dot but it doesn't want to become a dot. (Finds the caps lock)...Thank you".

After painstakingly typing in the required information, Paul was once again confronted with the statement "file not found". He became frustrated and asked Byron to try and type in the instructions. "I don't know how to", was his response. This remark could be as a result of the constant failure to gain access to the menu and the fact that, if Paul couldn't do it, what chance did he have. The end result was Paul resorted to turning off the computer.

Once the group had gained access to the games the problem of freedom within the software still existed. After looking at the instructions of the first game they attempted, and deciding that they made no sense, Colin responds -

Colin: "I don't know how to get it off."

Byron kept tapping the keyboard indiscriminately hoping that luck would favour him. There were also instructions on the screen that they did not understand (eg. the letters MG).

In frustration, Paul said: "We're going to have to break it", and with that he raised his foot and planted his heel on the break key. This senseless strategy of pressing the break key led to a return to the menu and the further use of it to get out of a game, rather than the old system of switching off the computer every time in order to start again.

By lesson six the situation had improved and the time taken to gain access to the software was reduced. Both Colin and Byron still needed to read the instructions for logging on to the network, but they were doing it so quickly now and without the problems encountered previously. They seemed more comfortable using the instructions and no longer resorted to the switching on and off of the computer.

The seventh lesson seemed to have reverted to the chaos of before. The access codes or instructions of gaining entry to the E-NET had again been changed. It required putting up the new instructions on the chalkboard on each occasion, which

wasted much time and added to some of the confusion that the boys felt. Many of the groups tended to ignore the new instructions, trying the old set of procedures or an amalgamation of both the old and the new. The groups persevered despite the fact that these instructions were seen not to work and the new ones were in full view. In particular, it took Byron and Colin more than ten minutes to gain access to the software and led to a lot of frustration. Byron tried to gain access without the requisite instructions much to the consternation of Colin.

Colin: "We've made a mess-up."

Byron denies this and later says,

Byron: "Well, let's just try."

The boys used the hard break of switching off the computer whenever they felt that they had reached a deadlock. In the end Byron allowed Colin to try.

Byron: "Oh, a mistake" (in frustration).
"Oh man, we don't get in" (in anger).

The group resorted to the hard break in order to get started again. As the teacher, I was required to nudge them toward a solution and suggested that they try *LOGON. They became very impatient when the computer kept responding "file not found". I was now required to intrude again to show the duet the mistake that they could not see. Then ...

Byron: "Now we have to do it over again."

Simon: "But surely you can delete" (this said from the computer next door - again a kind of sharing which is ignored).

Byron: "No, I don't think..."

and then proceeds to hard break (switch off the computer) in order to start again.

During lesson eight Byron noticed that many of the other groups were playing games other than SMILE 4 and asked the teacher how one gained access.

Me : "Look, you did it ... you did it before, didn't you? And having done it before, you should be able to do it again."

I was deliberately trying to keep to my role of not playing the expert who simply told the boys what to do. After a short period of time in this session without the boys making any headway, I asked the group how they would set about finding the information they did not know.

Byron: "But there are so many things that you've got to ... we don't know, do you work it in BASIC or ... I don't know..it's not fair that they don't want to share it with others."

This was a direct reference to the lack of a sharing done by the boys in the class and the different groups.

During the ninth lesson Byron's group were again required to read the instructions off the chalkboard, and, in spite of this, Colin was heard to remark, "What do you do now?". The group was helped by Nigel from the console next door. In fact, as late as the tenth lesson, the boys were still using incorrect procedures, even though the correct ones were placed on the chalkboard for everyone to see and their attention specifically drawn to it.

Even when I had spent some time asking the group why they could not gain access and then making a number of suggestions of how to proceed, they seemed to pay scant attention to what I was saying. There also seemed to be little carryover from playing the previous SMILE games. The group was told how to get into the catalogue and then told which file to chainload. Perhaps this method was not understood, as a short while later they were still struggling and I was obliged to repeat the instruction.

Me : "I told you which one to chain"

and then

"The file is called? Look carefully. What's it called?"

Meanwhile, Fernando had joined the group and had been trying to gain access for them. The only response he was capable of getting was "file not found". Colin shoots him and says "Bang, you're fired". Byron repeatedly resorted to Rhoald for information without success. Fernando tried again, crossed himself and once again failed to gain access.

Colin: "File not found. Every time you make a sign of the cross it never works. Can't you just stop doing that."

Fernando appeared stumped. Paul returned to the console and after typing in the instructions said "Humhum! nothing's happening". All the boys who were attempting to gain access here are using faulty procedures when typing in the instructions.

During SLYFOX these problems still evidenced themselves and at the start of lesson seventeen the boys were still finding access to the software a problem. The numbers required to gain entry had changed yet again. The user numbers were different which, together with the mid-year holidays, served to frustrate and delay the boys' entry to the software. While some members of the enlarged group were trying to solve the problems, others tended to move around. Byron, for instance, moved away and then returned and sat for a while only. He eventually got up and moved off with his face a picture of boredom. Karl, meanwhile, had given up and was trying to play SMILE games without success. Colin and Fernando could not gain entry either, and Fernando muttered :

Fernando: "This is really weird."

Despite this, they did appear on task and eventually Fernando left to find out what they had to do to continue. He returned and tried what he gained from the other groups. In the end they resorted to the hard break. Colin then resorted to shooting the screen and pressing a variety of keys telling the screen to self-destruct. He also muttered that he felt like doing LOGO. The programme kept responding "can't retry."

Colin: "We're trying to make a game and we can't even get into it."

and later

Colin: "The only way to do it is kill it" (and turns off the computer and on again). "Still there."

then later

"Ah ha, I got rid of it."

In frustration, Colin joined Karl who was now playing LOGO, but soon returned to try again. Paul rejoined the group and showed them how to do a soft break. After entering their number and password they at last gained access.

Even toward the end of the year, and in the nineteenth lesson, the group found difficulty gaining access to the software. They began this session by having an argument about the car number which they had previously agreed on. Karl typed in the information and got "file not found".

Colin: "I told you Karl."

There was an inability to translate the instructions on the chalkboard into the correct instructions needed by the computer. This led to some insecurity. Karl typed in the required user number and then deleted and typed it in again to make sure.

Colin: "It's going to be wrong because you put it down twice."

Byron: "He deleted it."

Later

Byron: "File not found...Ed, look at this. I mean, all the others are on to it, you know."

The boys, and particularly Byron's group, seemed to have no idea of the need to concentrate on the detail required when instructing a computer. Spacing was ignored, as were inverted commas and fullstops.

2.2.2 Reading instructions within the software

During the course of handling the software, there were many instances where, after reading the instructions, the boys either misunderstood these or ignored them and decided what rules they would use, often to the detriment of playing the game. During the playing of SMILE games, the boys were often unsuccessful because they could not remember the rules or because of their misunderstandings and 'own rules'

The first game selected by Byron's group appeared to be randomly chosen and based on the attraction of the name. When first playing the game ELEPHANT, Byron's group were also intrigued by the graphics and did seem to read the instructions. Despite this reading, Byron immediately asked the group next door, "What have you got to do here?". The group further showed its uncertainty by randomly selecting the co-ordinates they use. Byron suggested a strategy -

Byron: "Let's go in boxes. Go to this one and then to that one."

Byron suggests another -

Byron: "Go in multiples or like six-six, eight-eight."

It would seem that at this stage both these boys are conversing, co-operating and collaborating. The game was played aimlessly for quite some time and with limited success.

At this stage Paul noticed the prompters placed to the right size of the screen.

Paul : "But why are they giving this?"

He tries a set of co-ordinates.

Paul : "They are giving us all of these though - which ... I don't know what the heck is going on."

Byron: "What's going on?"

Paul: "Distance from it ... aha!"

It seemed at first as if the group had at last discovered how to use the clues given to them by the programme after each of their entries. It was soon evident that they did not use the clues correctly and still relied on a large element of luck through guessing.

Paul : "Try here, we are getting closer and closer all the time."

Byron: "I bet you it's somewhere up here."

Paul : "Now I think we've got it...I think."

Paul and Byron finally discovered the elephant after 32 tries. Byron said to Paul later, "We could have got it in five as well, but we didn't know what the distance was for, hey?". A direct reference to the prompts the programme gave after each of their attempts and which were mentioned in the instructions.

When the group played this game again in a subsequent lesson, they ignored the instructions and the clues provided by the programme to help define the area where the elephant was hidden. Paul ignored these and resorted to excluding some of the options by using "eeni, meeni, mini, moh" and "my mommy says you must be out" before giving the co-ordinates he felt would uncover the elephant. The group used their own

procedures and strategies and not those explained in the instructions, thus reducing the game to one of aimless guessing.

While playing the game called BOXES the group again paid little attention to the instructions. Byron stated, "I bet Boxes are junk", and left Paul, and missed reading the instructions. Paul continued to read the instructions on his own. Paul eventually called Byron back explaining that the game resembled one armed bandit machines. This description appealed to Byron who returned but soon said, "I don't know what to do".

Paul did not provide Byron with the explanation and Byron was obliged to follow what he was doing.

Byron: "Oh ... you've got to ... oh..."

Byron soon showed his understanding of the game when he remarked, "Now you are in trouble, ek sê". He was soon discussing the game with Paul and remarked, "This is a lekker game". Byron soon shared his interpretation of the rules with Simon on the next computer and ended his explanation with the words, "Okay, just watch us for a while". The group seemed to develop their own rules and instructions for the game based on their understanding of that game. At the end of the game Byron read off the computer, "You have boxed seven, well done", and remarked, "So what's so good about that?"

Paul responded, "Don't know".

Some of the games are ignored after seeing what they entail.

When trying CIRCLES both read the instructions and after a brief contemplation -

Byron: "Ag no man."

Paul : "Junk!"

Short and sweet their evaluation of this particular game.

The group constantly reverted to the menu to try a new game before really completing the previous one. The method used was to do a hard break by switching off the computer. This method changed when the group elected to play JUGS. They read the instructions and discussed them.

Paul : "Oh yes, I know this one."

Byron: "Ag no, let's get out of this."

Paul : "I wonder if you can quit on this game?"

Paul decided that the only way to get out of the game was to play it. A change from switching off the computer. There was general excitement at their success in solving the problem presented in the game.

Byron: "Hey, we did it!"

Paul : (amazed) "Sherbet! I solved the problem".

It was as if their success was not expected. Byron then accused the group next door of solving the game JUGS only after they had seen how he and Paul had solved it.

The group used a different strategy when they played the game GUESS. Once the group had read the instructions -

Paul : "I now understand."

Byron responds: "Explain to me please, what's factors? ...
what's factors, Paul? ... Just explain to me
first."

Both discussed it. Paul seemed to understand factors, Byron
didn't.

Byron: "Okay, let's get out of this."

It was obvious that Byron had little understanding of what the
requirements were in this game or of factors. He was relieved
when the game ended. Again, Byron was quite happy to share
information of how to end the game with Simon and Beukes on the
computer next to them.

When playing one of the other games, ANGLE 90, the group's
 cursory reading of the initial instructions led to their
misunderstandings.

Byron: "Ag no, Paul, this is ridiculous."

Paul : "Now what the heck is going on here?"

Byron: "They don't even tell us the rules."

Byron wanted to return to playing GUESS and suggested a
strategy for ending the game ANGLE 90.

Byron: "Just type in a number between 5 and 50."

In order to end the game they were obliged to play the game and
expressed relief at ending it.

When the boys decide to play the game NIM, a game based on "Matches", the following happens :

Paul : "What's NIM?"

Byron: "I don't know."

Paul : "Let's find out."

Colin is not considered in these deliberations. All three read the instructions carefully.

Byron: "Oh, I see."

They don't see, because, having selected a pile, they did not type in the number of matches taken. The computer programme therefore did not respond. They then tried the other two options which didn't appear to work either, leading to Paul's statement -

Paul : "Does one work? No! Nothing works!"

There was a growing sense of group frustration and when the programme asked whether they wanted to quit or not, they all elected to quit immediately. The group then moved on to the next game. There was a later occasion when I responded to Byron with the following remark -

Me : "You played PILOT and then NIM?"

Byron: "Ja, but we quit NIM because it was stupid."

Me : "You didn't like NIM?"

Byron: "No."

Me : "Why didn't you like NIM?"

Byron: "Because.."

Me : "There must be a reason?"

Byron: "They ask you stupid questions."

Me : "They ask stupid questions?"

Byron: "Ja. You can't get through to it. I don't understand this and I don't understand that."

Byron was talking about the inability of the programme to interpret their responses. Yet the group ignored the fact that their responses were inaccurate because of the poor reading and understanding of the instructions required to play the game.

This fact became clear while they were playing PILOT - a game concentrating on the eight points of the compass. At a certain stage the game changes levels and in order to complete the directions the boys had to have a very clear grasp of what was expected of them. It was clearly not evident, as the group become confused by their initial (mis)understanding of the directions given by the programme and the way in which the programme reacted to their typed-in responses.

Colin: "Ah, but this is crazy."

Byron: "First direction west. I don't catch this."

Paul did attempt to come to grips with it, but without a record of the original directions produced by the programme it became difficult. In fact, the easiest way to ensure the information was remembered, was to write it down on paper (pencil and paper). Byron some time later solved this problem by resorting to the use of pencil and paper. After some time of tussling with it, Paul seemed to be the only one of the group who at this stage had mastered what was required.

Paul : "Oh yes. Now I understand it."

Byron: "I don't catch this."

Colin: "I think it's boring."

The two allowed Paul to complete the game, which he did.

Another confirmation of his status of expert?

A short while later, while playing the game RACEGAME, the following happened. The boys were attracted by the graphics, but were unable to complete the game because of their not understanding vectors. The group battled on until Colin said -

Colin: "Oh no, this line's junk."

The reading of the instructions leading into the game were obviously little understood, and without a fair understanding of these rules their playing was confusing and difficult.

Byron: "What you gotta do?"

Colin: "We don't even know how to play it."

Byron: "Ja, you said you would give us the information."
(This said to Paul, again confirming his role of expert.)

Even having played the games several times, or when playing new games requiring similar strategies, the group appeared to be unable to interpret the rules correctly. The group was also not inclined to go back to the instructions to read these again to clear up their misunderstandings. While playing the game LOCATE, which uses unconventional co-ordinates, the group was intrigued by the graphics and seemed to read the instructions in a very cursory fashion to the point of being slapdash.

Colin: "Ah, it's like that ELEPHANT game."

He read the instructions and then commented -

Colin: "What do we do?"

It appeared that, although the instructions were read, very little was internalised. Paul typed in the co-ordinates without the required comma in between. He was obliged to put in the commas and expressed his frustration at the programme's insistence that the numbers be separated.

During the third lesson the group repeated playing the game MASTER. In spite of having played it before, the instructions/rules of this game were still not fully comprehended and Paul asked Simon, of the group next door, for advice concerning the placings of the numbers. There was a totally random guessing of which numbers to use. A comparison was made to the game MASTER MIND, yet they did not use any of their experience gained in that game to help them find the numbers in the new one.

Colin: "Let's type in anything ... type in anything."

It was quite obvious that Colin was prepared to leave the correct choice of the numbers to chance. Byron and Paul discussed the game and were obliged to confirm the instructions again with Simon, as they were still uncertain of them. Paul resorted to writing down the rules of the placing of the numbers. The lack of ability in seeing which was the correct number is concerning. Byron's arguments did not convince Paul

either. Paul became increasingly frustrated. Byron repeated a series of numbers already tried. There was very little logic at this stage and the group began talking about quitting. Paul said, "Quit, quit" and later -

Paul : "Can you quit this game?" (pushing the keys). "No, you can't."

Paul : "This is junk. You're never going to get this number."

Byron: "Okay then, you try and break it."

Paul pressed the break key and the menu was read. A serious concern was the continuing tendency among the groups to change games without successfully completing them. Anything that required concerted effort to complete was avoided. The game MASTER was played again the following week and the group still had problems in understanding it.

Me : "Have you sorted out your game?"

Byron: "Nope. I don't catch this game."

Colin: "No."

Me : "Hum."

Byron: "I don't catch this game."

Me : "Why, what is the problem?"

Byron: "We don't understand it."

Me : "You don't understand it. Why don't you understand it?"

Byron: "Because we don't understand it ... because we've tried every number ... that it says that block because it is a correct number in the right place and then they gave us a white block which means it is a right number in the wrong place."

Me : "Right ... so?"

Byron: "The computer's wrong."

At one stage the trio decided to play the game QUEENS. After reading the instructions slowly, they began to play. It is soon evident that their reading was very superficial.

Byron: "I don't understand this."

Paul is meanwhile singing to himself.

Colin: "Where are we? What are you doing hey? What are we meant to do? Type in 'Edit' and see what it does."

The trio soon agreed to end the game and do something else. They returned to the menu and elected to play MASTER again. The instructions were read and Paul stated that he wanted to write down the rules and asked for a pen.

Byron: "I don't catch this, but anyway."

The group used the word 'guess' while beginning to type in their solutions and referred to the rules that they had written down. Paul and Byron discussed the game while Colin did very little. There was a deal of playing with the numbers and trying different combinations and options. Sometimes repeating ones already done. Paul left and I attempted to provide clues for them and nudge their thoughts in a more correct direction. They still had trouble conceptualising what was required. It seemed as if this group had evolved a system or procedures which had the in-built mistake that this game was a guessing one and so they continued to use it. Byron said that they simply went up and down the numbers until they hit the correct one, though Colin remarked -

Colin: "Guessing doesn't get you anywhere."

Even though the instructions at the beginning of the games were carefully set out, the boys still considered the games to be guessing ones and thus had developed procedures based on chance and they were sticking to them.

When asked what made the two decide on using a piece of paper with the compass bearings drawn onto it, when playing SNOOKER in lesson five and six -

Colin: "Well, we used it last time as well."

Byron: "Because last time ..."

Colin: "To remember the bearing."

Byron: "We always forget the instruction so we got that ... so we got that and we have come up with this."

During lesson seven the boys had moved on to the SMILE games called THE NEXT 17. A game that attracted the group immediately was one called DARTS. Soon -

Byron: "I don't understand this."

Me : "What do you mean, you don't understand?"

Richard then came across from the computer next door and explained to Byron how to get a bull's eye in the game. His response was -

Byron: "So you get a bull's eye, so what ... so what."

Me : "Why don't you like the game?"

Byron: "Because all you do is a bull's eye and it goes into the bull's eye."

Colin: "Ja, if you just type in bull's eye..."

Me : "But surely there must be something more to the game than that?"

Byron: "I don't know."

Even after the instructions had been read, the boys still encountered problems in playing the game. The duet read the instructions and decided on playing solo. Despite having read the instructions carefully and Colin's "Oh yes, I think I know", Byron turned to Richard -

Byron: "Hey, what have you got to do?"

This showed the group's uncertainty. Richard came across and explained the game to both of them.

Byron : "What's a double?"

Colin : "That means two of us."

Richard: "You must get a double to start."

Not knowing the rules of playing darts and the associated vocabulary led to Byron asking later what a treble (triple) was. Both state an apparent understanding.

Byron: "Is this a treble here ... this thing around here?"

Colin: "No. A double is how many players you've got. A single for one person, a double and a treble ..."

The group went on to play the game and eventually, after a lot of explaining by the other boys, rather than the instructions included in the programme, they were able to play, although not complete the game.

Later the group decided on playing the game JUMPING. The graphics of this game amused them and after reading the instructions, they elected to ignore them and attempted to win the game by jumping to the end on their first go. They soon became aware of the meaning of the words "illegal move" put out by the computer.

Colin: "You dumb computer."

Byron: "This is junk, ek se."

Despite these comments, the two were interested in the game and proceeded with it. Byron was the typist and both made predictions as to where the computer was going to move to.

Colin: "Now he's going to go ahead of us I bet."

The boys played the game a second time and they seemed to be far more au fait with the rules and what was expected of them.

Byron: "Oh, you have to choose a target."

Both were very amused and shared with others the computer's response that their elected numbers had made it too easy for them to win. A measure of computer control? The boys appeared to have understood the game. They elected to go first and talked about the prospect of winning. Throughout the game they continued to test the upper limits of the game and were not put off by the "illegal move". It appeared that even after reading the instructions the group set up their own instructions based on their understanding of what was required.

During the interview after the lesson, I asked the groups to

discuss any problems and provide explanations if they could.

Byron responded that he didn't understand DARTS and when asked why, responded -

Byron: "I don't know ... just ... I mean that something to subtract your score and all that when it gave you the introduction."

Byron's feeling was that more detailed instructions were needed. When asked whether he had found out himself, he openly said, "No, I asked Richard", and that Richard was able to explain it to him. Richard was then asked how he had found out.

Richard: "... We threw the darts but we wondered why we weren't getting it in the one we asked for ... the number we asked for. So then we knew what you got to like you aiming for it and sometimes you will miss it and we didn't know how to subtract so we ... (laughter), I mean we didn't know how you must subtract ... we looked at the bottom and it said, what is your score and then ... oh, so then we subtracted the three numbers we had and then we got our score."

Me : "So you worked it out, in fact."

During the interview after the eighth lesson, Chew-Wha was asked what he had learnt that morning which was of extreme value. After some teacher interference and direction came the reply -

Chew-Wha: "Because we thought ... that we didn't like read the instructions properly."

During the tenth lesson the class was allowed to tackle a new set of software called CAPITAL MEDIA, and Byron's group elected to work on EXPLORER. The game does require a careful reading

of the instructions. The boys almost immediately used a variety of risque inputs and paid little attention to the instructions. When it came to attempting to print their inputs at the end of the lesson, Paul was called to help the group as he was the only member of the class with printer experience. Paul tried and pressed F for finish rather than *FX5,2 for print, even though the instructions stated what needed to be typed in. The group were stuck on using the F procedure. The group had not saved their information either. This was a requirement for the continuation of the program. Thus all their input had been lost.

Byron: "It doesn't work, anyway. It doesn't matter."

Colin: "Just type in anything. It's no big deal."

Although Colin was insistent that they could not save, Byron continued, saying -

Byron: "I'm just doing it for fun."

Meanwhile another group in the class told Byron that they were the only ones that could print. Colin said to Byron that their information hadn't been saved. Byron responded by continuing to look for the input -

Byron: "Well, maybe it's been saved on this thing" (the computer). I want to see what it's saved."

He then typed indiscriminately and became obsessed with looking for what might have been saved. After a time the group gave up and changed games. Again the problem of not reading the instructions carefully presented itself. The boys tended to ignore the instructions written on the chalkboard as well as in

programme. This prevented the group from setting up the correct procedures for completing the game and printing the results.

The eleventh lesson saw the class being allowed to consider any of the software they had handled to date. As both Byron and Colin were absent, it was an ideal opportunity to observe some other group in the class. Nigel elected himself by using the console that was under the camera. He began by working on his own doing ROBOT of CAPITAL MEDIA. He was one of a group comprising Rhoald and Simon. Nigel read the instructions and then tried several random co-ordinates before giving up and calling Chew-Wha to help him get into ROBOT. Chew-Wha did so and said, "If it doesn't work, tell me". Nigel soon called him again and Chew-Wha gained access for him. Chew-Wha was not put out by the computer's response of "file not found". Chew-Wha pointed out the flashing instructions to Nigel and then left. Nigel ignored these clues and was soon stumped again. Rhoald watched from next door and came across and said -

Rhoald: "Wait, man, let me show you how."

This Rhoald did, and Nigel attempted on his own with Rhoald giving advice every time Nigel said, "Rhoald, now what?". Nigel slowly progressed until he remarked, "Oh, now I catch it." He continued playing and encountered problems when trying to pick up the article, and slowly became rather frustrated and then remarked -

Nigel: "Jeez, man, I can't pick up this blooming thing!"

Simon then came across and proceeded to help Nigel to continue the game. It was at this stage that Nigel began writing down the instruction words as a source of reference. Thus, he too began using pencil and paper. Both Simon and Rhoald kept a watchful eye on Nigel while continuing their game. Nigel on the other hand did not hesitate to ask for help when he became stuck. Nigel tired of the game and pressed break and then battled to get back to the game. He remarked, "Oh, shit!" and then called Chew-Wha, and not the two next door, for the number on the menu which would give him access to ROBOT. This could be his acknowledgement or recognition of Chew-Wha as one of the 'experts' in the class. Later, while Nigel played the game WORKINGDAY, he was thrown by the instruction "Start the tape" , and even after assistance from Chew-Wha, he decided to break and go back to DATABASE. When asked what he was doing, he remarked -

Nigel: "We are doing the best thing you can find."

He then broke immediately and went back to WORKINGDAY. It was interesting that Nigel went from the one piece of software to the other without actually playing the games.

Lessons 12 to 17 were taken up in the boys doing SLYFOX.

Because of the problems encountered in the previous lessons and the resultant waste of time, there was a fair amount of input from me to ensure that the class understood what the programme required of them. I explained in full what the expectations of the software were and how the groups were to gain access to

the programme. The boys were also to be divided into larger groups consisting of four and five members. To ensure that they fully understood, a game of SLYFOX was played by each of the small groups (of two) before the class reorganised themselves into larger groups. I hoped that the larger groups and the additional personal inputs would help in ensuring that the correct procedures were understood and followed.

- (1) Each step of the game was explained.
- (2) I confirmed that they knew what was expected of them.
- (3) Handouts of scenes and scene-planners were handed to each group.
- (4) The boys played a game first to explore what was required.
- (5) Those groups who were uncertain were allowed to play the game again.

In the case of Byron's group, this course of action seemed to have failed. Once again the instructions had been clearly spelt out. After their trial run of the game, Byron's group went off and still developed its own procedures - deciding what they would do rather than attend to the instructions required by the programme. They ignored the warnings made by myself and the other pupils alike. Often was heard Byron's plaintive cry -

Byron: "I don't understand. She explained to us but we still don't understand."

Because of their not reading the instructions and remembering what to do, the group didn't save and lost all the information that they had typed in. The group seemed to have forgotten the lesson learnt from their not saving the information when using the CAPITAL MEDIA software.

Byron: "Ah, now we have to do it all over next week."

In a later lesson, and despite having spent a considerable time on the exercise -

Byron: "Now, look here, when we are on the second ... when we are on the second line it doesn't want to go ... Look here." (Demonstrates trying to put in additional information.)

Me : "Well, then, what is happening?"

Byron: "It won't do anything ... I don't know what's happening."

Me : "What does it say?"

Byron: "End section. Last change entry. I don't know what it means."

Me : "What have you got to do?"

Byron: "I don't know."

During the interview that followed the boys were asked if there was anything upsetting in the SLYFOX programme. There was a chorussed yes.

Paul : "Yes, exactly ... yes, terribly ... I mean you print down printer ... how am I to smell the printer doesn't work and then you have to print the whole thing out again."

Byron: "And then we don't get onto the second line and then you have to re-do everything."

The warning that was later clearly spelt out by Chew-Wha to Byron went unheard.

Chew-Wha: "He doesn't understand how to carry on. The problem with everybody is the scene, sir."

During the next lessons the group was given additional help. There were periods of distinct interference by me; mainly to still the growing despondency of Byron's group, as well as the fact that all the groups except for Byron's would have finished their game by the end of that session. When I asked them what the most important thing to do was, they answered "save it". The final interference was done after the boys had left and Sue the researcher adjusted their information so that their game could be played.

In the end the group worked against itself, arguing among themselves when they did not have sufficient time. There was some collaboration. While Karl typed in, Colin read for him. The others in the group walked around despondently. During this session the penultimate group, which was Chew-Wha's, achieved print. There was only Byron's group left to go, now hopelessly off target and going further away. Any further work on their game would be pointless. They still wanted to use the teacher as their source of information. I deliberately avoided their approaches. The group then resorted to Chew-Wha as their source. A good choice as his group had had to edit and rework their own information. The group listened while he explained to them how to do it. After Chew-Wha had done some extensive talking and checked their map and sceneplanner, he told them that both were wrong and the group would have to re-do them both.

Chew-Wha: "Re-do, sorry!"

There was almost disbelief by the group that all their effort had been wasted. Colin typed on for a short while, before accepting the words of Chew-Wha and turned the computer off, using the hard break.

Colin : "I hate to do this, but we have to do it."

Fernando: "Let's give up."

Colin : "Turn off."

Fernando: "We'll never finish today ... never."

And this group never did.

During the penultimate lesson the simulation CARS-MATHS IN MOTION was used. The class was again given a very carefully prepared handout, which included all the necessary instructions and explanations. The boys were asked to prepare a car to race, using the handout. The boys were then given the opportunity of improving their 'circuit' performances after a trial lap. The 'cars' were allowed to practise and each team was accorded a pole position based on the best recorded circuit time. The class did the simulation over three lessons.

Despite the whole year's exposure, Byron's group were still having problems at this stage and had difficulty gaining access to the software. When the group eventually did gain access, and were confronted by the software and the related instructions, they seemed to remain uncertain and confused. I did give the group a measure of guidance and nudging. While the groups were busy putting in their improved details the following happened -

Me : "Chaps, think about it. How are you going to get out of that?"

Karl : "Finish."

Me : "Try it and see what happens."

Byron: "Oh, then we go all over" (despondent).

Me : "Are there any other teams?"

Karl : "No."

Me : "Listen. Are there any other teams? If you say yes, what do you think the computer will do?"

Colin: "Enter in their data."

Me : "Right. So are you interested in that?"

Karl : "No."

Me : "So what do you put?"

Karl : "No."

Me : "Right. So you're sure you want to finish?"

Karl : "Yes."

Colin: "That's stupid."

The group is later still confused.

Me : "Right, now how are you going to the next?" (There is a long pause before I interfere and type the correct key - BREAK.) "Hell, it's so easy, hey."

Byron: "We always do that when our games up the ... we get 'file not found'."

A short while later this group was at a standstill and uncertain of what to do next. Again I interfered and nudged the group toward the correct procedure.

Me : "Now you've got to hold it. What does it say?"

Byron: "Password SR."

Me : "SR for 'Start Race' ... see what happens when you read the instructions."

The group then had an argument about what user number to use. They appealed to me to give them the information, despite their knowing it.

Me : "Don't look at me. It says to look into your team details. What is your team number?"

Paul, too, seemed to have problems. He was separated from his group and working on his own. He appeared unable to read and interpret the instructions given by the programme into an action that the programme would respond to.

Paul : "Ed, help us, please."

Me : "Paul, what's the problem?"

Paul : "I can't get in."

I then helped Paul while he did the typing. He gained access under some supervision.

Me : "Come on, Paul, all you have to do is follow instructions."

During the interview after the lesson had ended, the class was asked what they felt about that morning's proceedings.

Yaneck : "Very exciting ... much better than last week."

Me : "Why?"

Yaneck : "Don't know."

Simon : "I don't know."

Richard: "Typing in the improvements and making changes to those not all that good."

Colin : "And also we knew what we were doing this time. We knew sort of what to do as soon as we got there."

Me : "Colin, do you reckon that this makes quite a difference, knowing what you are doing?"

Colin : "Ja, knowing what to do you actually ... you actually have more time and you can go straight into it."

Me : "How does one ... ja, but how does one get to the stage of knowing what to do?"

Colin : "Do it once before."

Yaneck : "Learning."

Byron : "Looking."

Colin : "You keep on doing."

Me : "Byron watching?"

Byron : "Watching."

Me : "Watching what?"

Yaneck : "You learn and you ask questions and you are going to get your answers."

Byron : "Observe."

Me : "I hear words like you've to ask questions and observe. Who do ... who do you ... you observe and who do you ask questions of?"

Yaneck : "To you or to the other bodies."

Simon : "Look, hear and talk ... look, hear, read, talk ... that's the only way you can learn it. Look, read, hear and talk ... and do."

Me : "I am starting to hear words like communicate, question ..."

Yaneck : "Observe."

No-one in the class pinpointed the problem of reading the instructions. Even in the final lesson there were queries that could have been resolved had the instructions been read correctly or carefully.

Paul : "Sir ... so ... er ... for ... for a very rough track they say rough in surface or .. or bends?"

Me : "No, it'll be the surface. You find that in the front of the circuit plan. On the front of the circuit plan, if you have a look, Paul ... er ... circuit plan and it says country England longitude ... surface smooth. Right, now that dictates what kind of tyre you drive ... you're driving with, together with the weather."

While the boys were filling in the detail of their race planners, Rhoald asked where the circuit was. The information was in the beginning of the instructions that had been handed out. Julian replied -

Julian: "Put it in America." (From another group.)

Throughout the series of twenty lessons it seemed that, although the information had been handed out to all the groups, it had either not been properly read or not read at all. The boys were quite prepared to express their views and opinions, though these did not have the exactness required by the programme to respond.

2.3 RESEARCH FINDINGS

In the normal run of any day, we tend to follow procedures without really thinking about them. These procedures are made up of a series of well-defined steps that lead to the solving of the problem. This type of procedural thinking - of step-by-step instructions on how to do a specific task - can be likened to the use of the computer where exact instructions are needed to operate and perform specific and often complex tasks.

- (1) It tends to be accomplished by following a logical series of actions or steps.
- (2) It involves repetitive use of these steps.
- (3) At certain points it involves making decisions.
- (4) Different procedures could be equally successful at solving the problem (Clements, 1985).

Clements (1985) further maintains that children need to be exposed to a specific sequence of instructions. Their attempts to follow the directions precisely will help the children lose their egocentric point of view and help them correct or debug any errors that they uncover. The software I chose was to assist in the attempt to do this. The information for running the software was at their disposal, both in the programmes used and put up on the chalkboard. The class could then analyse, synthesise and evaluate through their acting on it and coming to know it. When children think about, organise and reflect on the procedures required, they are cognitively acting on it. Successful procedures and information concerning computers are retained as knowledge of them.

"Turning information into knowledge is the creative skill of the age, for it involves discovering ways in which to burrow into the abundance rather than augment it, to illuminate rather than search."

(Smith, 1980)

The children should be placed in the position where this can be allowed to happen.

To solve the problem of gaining access to the software and to play the games, the boys firstly needed to remember the information concerning the procedures involved. There is evidence that young children do not spontaneously use memory strategies such as rehearsal (Cleary et al, 1976). The result is many procedural mistakes are made because of the guessing that occurs. Clements (1985) states that children may benefit from understanding their own limitations and that psychologists note that young children do not have well developed "metacognitive processes". The result is that they do not seem to realise when they do not understand. Children do not think of

rehearsing a list of things they are to remember. In fact, they do not have an accurate picture of the frailty of their own memories. Therefore, there is a need to ask the child what he has done and have him explain as

"Errors are seldom capricious or random ... Children's faulty rules have sensible origins. Usually they are a distortion or misinterpretation of sound procedures."

(Ginsburg, 1977)

Apparently children are not incapable of learning complex procedures and executing them consistently. In fact, Brown and Burton (1978) conclude that even when making errors, primary school children are generally consistent and systematic. Frequently their errors are the result of methodically following the wrong procedure, rather than making random mistakes. These conclusions support those expressed by Ginsburg (1977).

What seems to be missing from the reactions of the boys to the procedures required of them, was making use of the information available to them as a validating or correcting system. They seemed unable to make sense of the procedures or symbols required of them, and appeared to have no way of knowing why the processes they were using were incorrect. While they may be convinced that the procedures they are applying are the right ones, this confidence often comes from the belief that they have mastered the rules and tricks of the game, rather than a feeling that the procedures they use reflect the reality situation (Erlwanger, 1975). It is only when the pupils feel confident in what they are doing that they frequently feel less threatened and begin examining alternatives. In addition, they have a strong perspective from which to view the alternatives (Brown,

1974). This can be seen in the boys playing the game of SNOOKER and the later sessions of CARS - MATHS IN MOTION.

Brown and Van Lehn (1982) have produced a theory as to why such 'bugs' occur in the development of the child's procedures.

"... When a student has unsuccessfully applied a procedure to a given problem, he or she will attempt a repair. Suppose he or she is missing a fragment (sub-procedure) of some correct procedural skill, either because he or she never learned the sub-procedure or maybe forgot it. Because the missing fragment must have had a purpose, attempting to follow the improvised procedure rigorously will often lead to an impasse. That is a situation in which some current step of the procedure dictates a primitive action that cannot be carried out, usually because one of its preconditions or input/output constraints has been violated ... When a constraint gets violated the student, unlike a typical computer program is not apt to just quit. Instead he or she will often be inventive, invoking problem-solving skills in an attempt to repair the impasse and continuing to execute the procedure, albeit in a potentially erroneous way. We believe that many bugs can best be explained as patches derived from repairing a procedure that has encountered an impasse while solving a particular problem."

The 'repair rule' invented by the child clearly depends on the extent and manner in which he understands the instructions. The erroneous 'repair rules' that the boys tried to use were generally at odds with the structured and programmed required responses of the software.

Ginsburg (1977a) states that children experience great difficulty in translating their informal, experience-rich system into the formal, symbols-and-rules system of school work. Gaps begin to develop when the children are unable to establish meaningful links between what they know intuitively and what they are asked to do in schoolwork, which is formalise this knowledge using symbols. When the pupils cannot assess their intuitive understandings of mathematics when asked

to handle mathematical situations, they begin developing their own unique systems of symbol manipulation, some of which are filled with misconceptions and faulty procedures.

When Carpenter and Moser (1979) investigated the ability of children to evolve strategies prior to formal instruction, they reported the following -

"The tremendous variability between and within children in the solution process used suggests that before receiving formal instruction, young children do not transform problems into a single type and apply a single strategy. The results indicate that children have available a rich repertoire of strategies and that they make use of many of these to solve various problem types. It is still not clear what triggers the use of a particular strategy; but it seems plausible that children solve each problem type directly, rather than collapsing them and applying a single strategy consistently".

Some children's strategies or procedures, though, are likely to be less sophisticated than those which are available to children who have greater understanding, and their grasp of what is required as a result is more tenuous (Romberg and Collis, 1980). This also tends to contradict and work against the computer's need for a set sequence of instructions in the procedures required for playing games and even in the use of simulations.

CHAPTER THREE

"Class computer interaction forfeits the individualization so often claimed, as the programs cannot meet the educational needs of individual pupils."

(Hopkins, 1985)

3.1 INTRODUCTION

Another of the issues that presented itself was the way in which the boys grouped themselves in the class. They presented a variety of ethnic and socio-economic variation, as well as a range of achievement and ability levels in mathematics. When the boys entered the computer room, the only directions given were that they must work in groups of two at a computer. They were allowed to choose their own partners, although Paul later elected to work on his own on occasion. Except for the selection of the initial software, the activities were to be entirely child-initiated and any teacher-direction was to be kept to the absolute minimum. There was a freedom of association and if any of the individuals wished to change their groupings, they were free to do so.

During the course of the twenty lessons, the group number initially varied from the two or three of the first ten lessons to the four and five of the latter nine. One-man groups also happened, though less frequently. The video recordings were closely studied and notes made on how the boys engaged in interaction with each other.

3.2 THE SMALL GROUPS

The first half of the lessons, ie.ten, were taken up by boys operating in small groups of two and three. Lesson eleven was a review of one of the boys on his own.

3.2.1 The first four lessons

The selection of videoing Byron's group (Byron and Paul) was entirely random as the video camera had been set up prior to the boys entering the room. This group elected to sit where it did without prompting. The groups were soon involved in trying to gain access to the games included in the software. The groups, and particularly Byron and Paul, seemed initially to be based on friendship selection rather than on similar abilities.

During the first lessons Paul established himself in a dominant role. He often remarked, "That's quite easy to do" and "I now understand", without providing an explanation to Byron, and ignored his pleas of "Explain to me please...". Byron was obliged to read the instructions and then ask the group next door, "What have you got to do here? ". Later the boys began conversing, co-operating and collaborating. Byron also talked about Colin - "He is good at guessing" - and that he should join their group. They discussed this and agreed to have him join their group the following week.

As early as this first session, Paul established himself as the dominant partner in their group. He took on the role of keyboard operator and Byron did not appear to be offended. When Colin joined the group, he did not appear to mind either.

Though the boys were in their separate groups, some of the groups did tend to share their knowledge of how to play the games. While Paul and Byron were playing the game GUESS, they had a problem finding the number selected by the computer.

Byron: "It's one to ten ... this should be interesting ... it doesn't have any signs ... this I'm going to do in two moves. Okay, what's it? ... what's the bet ... two."

Paul : "Three ... too small."

Byron: "Two. Oh, no, two's wrong ... four ... it's got to be four."

Paul : "Four's too big!?"

Byron: "... and three too small?"

Simon remarks: "It's so clever, boy ... jeeoh."

Byron: "Hey look here ... if this is too big...."

Beukes interferences: "Try ..."

Byron: "No, don't ... don't, please don't".

Paul : "Wait! wait! wait!."

While Paul was contemplating what was unfolding on the screen, Byron was distracted by what was happening on the monitor next door. He soon returned his attention to considering what was happening on his own screen.

Byron: "But how can it be?"

Both boys are now attempting to fathom the problem.

Byron: "If five's too big ... is too big ..."

Paul : "Four too big ... three too big ... five ... six is ..."

Byron: "Four is too big, three is too small" ... (a pause, then) ... "Aah! Three and a half."

Paul : "You can't ... you can't do a half."

Byron: "Oh. Look at this, sir ... look at this. If five is too big and three is too small and ..."

Paul : "Okay, look here now ..."

Byron: "... and then four is too big."

Paul : "Three and a half."

Byron: "Three and a half."

Simon nudges them at this stage: "Try three point nine."

Byron: "Three point five ... three point two ... three point four ... three point four ... four ... four ... it's three ... three point three."

Paul says as he types: "Three point three."

Simon again nudges: "Three point four you haven't tried."

Byron: "Three point four ... it's got to be three point four."

There is general relief when at last they have succeeded in finding the number.

Byron: "Correct. You took twelve tries. I told you it was a half or something."

Paul : "No, we don't want to try that again."

This statement was made in response to the computer inquiry as to whether they wanted another chance at guessing the number. Byron showed the initial insight in suggesting that the answer was a fraction, though Paul initially rejected it. It was only after some reflection that he attempted to use it. Paul, as the dominant partner, exercised a control and authority in the group. An example of his control was when the menu was displayed for the final time before the end of the lesson.

Paul remarked, "But we've done all of these and hardly like any of them". This was rather unfair on Byron, as he hardly participated at all in the selection of the games to be played.

In the second lesson the group was enlarged by the inclusion of Colin. At this stage Paul began showing his want to do something different.

Paul : "These games are not that interesting, sir."

Me : "Sorry?"

Paul : "These games aren't very interesting."

Me : "Why? Why are they not all that interesting?"

Paul : "I don't know."

Me : "There must be ... there must be a reason why you... um ... you say that they are not all that interesting?"

Byron: "They're guessing games, that's why. He doesn't like guessing, sir. He wants ... I don't know ... he wants games that you've got to work..."

Me : "Okay. Now have you tried every game?"

Paul : "Ja. Every game last week."

Me : "Right ... and which one do you ... and which one do you find the most interesting?"

Paul : "BOXES."

Me : "BOXES?"

Byron: "Because it's not guessing."

Me : "Well, then why don't you get into BOXES?"

Byron: "Okay, just after we have finished this game."

Me : "See how you feel then."

The group did play BOXES and, instead of playing to the rules, Paul decided, "Let's see how many rejects we can get ... let's see how many rejects we can get." And later -

Paul : "I'm just rejecting all of them to see how many we can get to fit in one box. I doubt if you can fit ten in ... probably say end of game."

Colin: "What happens when you come to five?"

Byron: "It can line up on the second tier."

Paul : "Ja."

Colin: "Uh-uh, it'll start piling on top of the others."

Paul : "This is an experiment. (Into the microphone.) This is an experiment. We aren't as bad as this."

Byron: "I want to see what it says when we get there."

Paul : "Very badly done ... Try it again ... It'll probably say, well done."

The screen responds with the line, "Hard luck, you boxed nought", which is greeted with general laughter by the group. Paul suggested they try to box all ten numbers. Paul made reference to the game being like one armed bandit gambling machines. Again the word lucky was used.

It is worth noting that during this lesson Paul and Byron discussed the problem of there being three in the group. They decided that perhaps it was Colin's turn to control the keyboard and the selection of a game to be played. This offer to Colin was not for long, as, soon after, Paul had assumed control again. At one stage Simon from the next group joined them. He seemed to join their group out of general interest.

There was no animosity or rejection for his joining their group. After watching them trying to find the co-ordinates in ELEPHANT for a short while he became involved in their attempts.

Simon: "I think I've got an idea."

Colin: "If you've got an idea, don't tell us, Simon."

The boys showed a high degree of collaboration and sharing when they discussed and tried both the methods suggested by Simon and Byron. There was a sharing and not the denial of one system of working it out at the expense of the other. They attempted both systems of finding the elephant and Byron's system uncovered it.

Byron: "Ah! My method works the best. No, I'm only joking - it might actually work your way."

Here there was an acceptance of another individual's methods as well as his own. There was also an acceptance of more than one way of solving the problem.

During the third lesson, friction seemed to be growing because of Paul's impatience to get on with things. In spite of Paul being considered the 'computer expert', he was not considered as the boss. Byron tried to regulate the turns taken in answering or providing responses to the games. He was not entirely successful. When playing the game PILOT -

Colin: "Aw, that's easy. They think we don't know that."

Despite Colin's insistence that the game was easy, he found difficulty with it. When the game had ended, he stated that he did not want another chance at the same game. Paul and Byron continued to play the game. Byron, sitting at the keyboard, attempted to regulate the turns taken in giving the direction required as an answer. Colin showed his lack of understanding.

Colin: "Oh, you've got to make the buoy."

Byron: "No. You've got to move the boat to the buoy."

Colin: "Then what's the boat? I don't understand what."

Byron: (pointing) "This is the boat here. That's the buoy."

Colin: "Oh. I thought you had to move that. Sorry!"

There was a growing disagreement between these three now, seemingly based on their differing abilities. When Colin was allowed to select a game he chose MAZE.

Paul : "MAZE is junk. Okay, let's try MAZE. MAZE is junk ... but anyway ... J..U..N..K."

The three discussed the graphics as they unfolded. Paul used his finger to trace the path they should take through the maze. Byron was keen to get going and began using the controls before Paul was ready. This led to an argument about Paul not being the boss; though Colin said -

Colin: "Okay, Paul, you control it."

Later Colin remarked -

Colin: "Can I control it?"

Byron: "No. I want to. You can press a few. I'll go halfway. (To Paul) You just find the maze."

Despite Byron sitting at the keyboard, and his suggestions concerning co-operation and sharing, Paul took over the typing of directions. While he did so, the following conversation took place -

Byron: "It only takes us till you reach a decision. It's so simple."

Colin: "Oh, no, this is easy."

Byron: "This is babyish."

Paul completed one maze and began another. The group discussed which lines would be taken away to create the maze.

Byron: "Us playing babies' games!"

Byron disagreed with Paul's method of tracing out the maze before playing the game.

Byron: "No, don't work it out first, man. Let's just take the man there, man."

Paul : "You have to."

Byron: "That's junk, because you are then working it out on your fingers."

Paul : "So?"

Byron: "That's junk, because you must work it out while you are doing it."

Paul : "Nonsense."

Paul then typed the directions in while Byron and Colin watched. Paul's insistence on having his own way, and the resultant arguments, led to him leaving this group during the fourth lesson. He left the group to do what he wanted - to involve himself in doing BASIC. Because of Paul's withdrawal, I decided to find out why he was doing so -

Me : "Why ... why aren't you joining in?"

Paul: "I'm sick of games and I want to do some basic."

Me : "You're sick of games and you want to do some basic."

Paul : "Ja."

It was now left to Colin and Byron to continue. They did, and seemed much more settled as they worked through the software. There seemed to be a lot more communication and sharing of ideas. While playing the game PILOT and discussing the way to remember the different compass directions -

Byron: "I know it's west. Naughty elephants squirt water."

It was repeated by Colin, who then said -

Colin: "Is that how you remember it?"

They talked about other ways of doing it.

Byron: "News ... N..E..W..S."

3.2.2 The next five

During the next five sessions it appeared that Byron and Colin had become more content with each other's company and seemed more suited. These two seemed to be at the same level of understanding. Without the domination of Paul, there appeared to be a great deal more interaction. Byron was quite prepared to share what he knew with the others and to offer comment. He talked to Simon in another group and stated, "That's speed one, that's junk", and later, "RHINO ... that's just like ELEPHANT". This sharing was restricted to certain of the groups only.

During the playing of the game SNOOKER, Byron tried a 180 degrees angle just to see what happened. When Colin argued with him, he was quite prepared to do it again to show him what

happened. Simon, on the keyboard next door, leaned across to confirm Byron's statement. No-one took exception to this sharing. The sharing can again be seen in their conversation while playing SNOOKER -

Colin: "One nine five."

Byron: "One nine five. This is your guess."

Colin: "No, you can't ...it's not ..."

Byron: "No ... no, you said."

Colin: "No, you can't."

Byron: "You said ... you said it ... you said it, Colin, and half the game is yours and half the game is mine."

Colin: "Don't blame me."

Byron: "I never said anything."

When it was eventually sunk -

Byron: "Thank you, that's my shot ... with your shot as help."

Both boys collaborated in trying to get the right angle, and took it in turns to use the drawing of a compass they had done to help them estimate the angles. The word 'guessing' still appeared to be prominent.

Colin: "I'm just guessing ... I think I'll just take a guess."

There also tended to be an uncertainty about making a commitment to an answer, in case it was wrong. Even though they voiced that their answer was wrong, they were hopeful to be proved the opposite. This could well be the result of an insistence of right answers only in mathematics. The insecurity was shown in -

Byron: "It's between these three. Which one do you think?"

and again

Byron: "This isn't going to go in, I know."

There were times when the typing was shared. In fact, there was not an argument between these two as to who should control the keyboard. Turns were taken, even though Byron sat in front with Colin to the side.

Byron: "No, I am going to let you work this out."

Colin: "I'm just going to guess."

Yet Colin used the drawing they had made to help them very carefully to get the answer. Guessing here could almost be seen as a protection, in case of being wrong. Later, while still playing the same game -

Colin: "One twenty."

Byron: "No, I would say 100 or 99 ...no, 199."

Colin: "Look, there it is."

Byron: "I would say ... um ... I would say 200."

Colin: "Listen, I'm aiming for that hole."

Byron: "I would say 110."

Colin: "Look, there's 125 which bounces off over there."

Byron: "I would say ... ja, 110."

Colin: "I would say about 120."

Byron: "No, I wouldn't - I would say about ..."

Colin: "You are the colonel now - I am the major."

Byron: "A 100 ... a 100 ... a 199, I would say."

Colin: "And if it misses?"

Byron: "It's up to you. It's your game."

Byron was by now very much the dominant participant at the keyboard, though he shared his views and opportunities with Colin. Information was also shared with and by other groups. An example is when Byron and Colin had trouble understanding the game DARTS. They resorted to asking Richard in the group next door for information. There was little initial understanding of the rules of the game despite the sharing. Through the continued interaction with Richard, Byron slowly mastered the game and played it largely by himself. At times Colin was included.

This shows an uncertainty and a tendency to refer to an 'expert' outside the group when stuck or when not understanding the requirements of the programme. The situation was aggravated by the software's assumption that the pupils had an understanding of certain games such as Darts and their associated vocabularies.

The group shared much of the mathematics required by the programmes.

Byron: "Take away 89 from 501 is ..."

Colin: "Take away what? 89 take away what?"

Byron: "501."

Colin: "You can't take 91 ... you can't take 501 away from 91. (Byron ignores him.) You can't ... you can't ... (Byron continues talking about Alwyn and the others who are playing against each other.) You can't take away 501 from ..."

Byron ignored him and continued adding up his score.

Colin: "Don't forget, I want my turn just now to ..."

Byron: "109 take away 501."

Colin: "You can't take 500 away from 109 because 500 is too big. You can only take 500 ... a 9 ... 109 away from 500."

Byron: "That's what I said."

Colin: "Oh, you said 9 ... 109 take away 500."

Byron: "No, man ... just work it out, man."

The group often shared ideas and humour. Discussions were open and varied. When faced with the challenge of trying to beat the computer, they collaborated and discussed their strategies. The prospect of winning seemed to motivate them to play the game. The game JUMPING was played several times. Byron did become frustrated when he perceived the computer do a jump 'similar' to the one he had done previously and which had been rejected. While both still felt that they had a chance of winning, they took care in planning their moves. Toward the end both conceded that the computer was going to win.

Fernandes: "He's gonna kill you."

Byron : "What do you mean? I know. But, anyway, it's just for the fun of it."

Colin : "Just for the death of it."

The computer did win and Colin got up and pretended to chop the computer. They then changed their strategy.

Byron: "Let's do it and see what happens if he goes first."

Colin: "Ja."

Byron was apparently happy because of the chance of now probably winning.

Colin: "I bet he has a clever plan hidden up his sleeve. I bet you he is saying now, I move to 7 or something like that."

During the interview after the seventh lesson, I asked Rhoald, who was one of the non-sharers according to the class, what he felt about the need of keeping the information he discovered a secret.

Rhoald: "They've got to find out for themselves."

His partner, although agreeing with him, seemed distinctly uncomfortable. The class started making typical schoolboy remarks -

"Ah, they're Jewish, hey."

When the class was asked if they agreed with the remarks of Rhoald, the chorus was "No".

In the next interview, I came back to the matter of secrecy of information and sharing. One boy responded that Fernandes had typed it in for him. He couldn't share it because he didn't know the instructions.

Byron : "But Fernandes didn't want to type it in for me."

Rhoald: "It was actually first the secret of mine and Solomon's when we worked on the computer, but then today everybody else had it."

Me : "So, in other words, they discovered your secret?"

Rhoald: "But now ..."

Me : "Did that upset you?"

Rhoald: "Ye.e.es, because Nix here couldn't do anything without looking."

Me : "In other words, he wanted your information?"

Rhoald: "Humm."

Me : "And you didn't want to share that with him?"

Byron : "Spy versus spy." (Laughter.)

This non-sharing was contradicted when Byron went off to look for information while the group was doing LOGO. He returned with additional information he had gained from the other groups. Colin, while on his own, had continued in a limited way, sometimes uninvolved and swinging on the swivel chair. Byron returned and talked to Colin about the 'red buttons'.

Byron: "They are all different colours, okay."

Colin: "Ja, I know that."

Byron: "Now you press like say this and you go like this ... and there's yellow and say nought ... you can get a flashing thing like that's ... let's try ... it's not flashing ... there's the flashing. Eight's the number for flashing and you can write your name or anything ... write anything."

Colin tried, then pretended to type. Finally he decided that he had to get rid of what was on the screen. When he could not, he responded in frustration, "But it must do something."

Also, while playing CAPITAL MEDIA in the subsequent session, Fernando joined Byron's group and shared his skill and information with the group. This enabled them to do things they would not normally have been able to do.

3.2.3 A group of one

Lesson eleven saw one of the boys, Nigel, working on the console on his own. He was none-the-less still under the watchful eye of the group of Simon and Rhoald next door. Even though working on his own, he frequently called on one of the others to help him when stuck. There was very little verbalising. Nigel was constantly moving from one piece of software to the next without completing them and at times without actually participating in them. Nigel showed a constant need to refer to someone else when he became confused, or failed to understand what was needed to continue playing the game.

Nigel's reactions could be compared to those of Colin when he was left on his own for periods of time. He, too, when alone, spent large tracts of time in inactivity, at times resorting to 'flying' the swivel chair he was sitting on. Colin also had little success in handling the computer and the software when on his own.

Paul on the other hand seemed to be happiest on his own and throughout had been very active in striving to get the printer to print; although Paul did team up again with others in a group. This grouping again failed to work for him and he ended in a group of two with Julian.

3.3 THE LARGER GROUPS

The sessions 12 to 20 were taken up by the boys working in groups larger than two. The first lesson was used to make the class

familiar with the software and what was expected of them. Here the boys worked in their original small groups first. The entire class was soon totally involved in looking for the "SLYFOX" on the farm. There was a tremendous amount of sharing and collaboration.

Byron : "Where are the clues ma'am ... Ed said there would be clues.

Colin: "No, it does give clues as you get further. Just look at Adams ... "you are cold."

Both boys were soon involved and gradually mastered the levels of play and followed the clues given by the programme. Then, despite Colin's warning that the computer had said that they were cold, Byron insisted on using his direction of thought. Saying that it didn't really matter. When the computer response was "you are cold", Byron started listening to Colin and they began their search elsewhere. They considered their mistakes and Byron remarked, "Oha, this is difficult."

Byron: "Oh, please ... the fox is laughing his tail off."

This response was shared with all that would listen. Byron later told Karl that he got the same response because he too was so far away. He later said, "I told you so". The warm response, "You are on the right track", provided an incentive and the two showed their excitement in their body language. Byron stood and rubbed his hands and then typed. Mistakes did not seem to concern them. Byron later became impatient with the computer and typed in indiscriminately. He then realised that he had to use the prepositions that were listed in the programme. Both were very involved and became frustrated when the computer kept printing "I don't understand". They eventually lost sight of where they were in the game and could not appreciate the final clues. They

uncovered the fox in 16 attempts and got Donald Duck as the treasure.

After the class had gained experience in the game they were going to design, the boys were told to elect their own groups of four. This was done without prompting by most of the class. Byron's group was expanded by Fernando, who had worked with the group before, and Karl one of the non-sharers.

Byron soon tried to establish his dominance in the group, rather unlike his role in the small group. "I think a house is best" and he did not think that the key as treasure was a good one, "I'm sorry about it" were two early remarks. Byron upset Karl when he called him a morph and then upset the whole group by crumpling up their sketchplan which they had been designing. Byron was unable to settle and constantly offered alternative suggestions. The group were also continually contradicting each other.

Fernando: "This is junk."

Colin : "Not, it's not. It's grand."

Fernando: "Everybody disagrees with everything."

Fernando then decided to organise two of the group on the planner and two on the drawing. Karl again asked who was the best at drawing. The group was beginning to be on task, though Byron had other ideas.

Byron: "Look, let's do a modern day scene where you can have like a fair and you've got to find the circus, or got to find the clown, or got to ... where there's lots of things."

Fernando: "You guys, we shouldn't've just started just like that. We should have just thought about it and then started ... and what are we going to do now?"

Colin insisted that they draw the scene before they write down anything. Byron then joined Karl and they began to write down the

information together without a sceneplan. Colin carried on drawing, oblivious to it all. The final comment of Byron was interesting in that he was upset and said -

Byron: "We are always changing our minds."

A very different situation prevailed in Paul's group where they were unconcerned about the need to complete the exercise, especially as there was no teacher interference in what they were doing. Most of their time was spent in playing with the recording equipment or other 'off the task' activities. Paul eventually remarked -

Paul : "I am sitting here doing this when other people are playing around on other ... on other computers and doing everything and not doing anything. That's weird, totally weird."

When the class was asked in the interview session whether they had enjoyed the morning or not, there were many yesses and some no's. The boys who had said 'yes' felt it was fun and that they had more freedom.

Chew-Wha: "It was more creative sir ..."

When Byron was asked why he had'nt enjoyed it, his response was -

Byron : "I don't know ... maybe it's because I couldn't find a game and our group was all ..."

Fernando: "And we had to re-do it all the time."

Paul : "No ways, sir ... sir, because ... because everybody was like ... like Julian trying to get into SMILE and Richard trying to get into the thing we are supposed to be getting into next week."

Byron: "But that's not the game, actually. That's not the game."

When Paul was asked what he saw as the solution, he responded -

Paul : "I don't know ... co-operation, that's the solution."

And when asked how he would achieve this -

Paul : "I don't know."

And asked whether he would work on it,

Paul : "Ja, I am going to try."

The other three groups appeared to be well-balanced and on task.

Tensions built up as the dominant members of the groups continued in their power struggles or personality differences, resulting in nothing concrete being achieved. Byron's group appeared to be more settled in the second session and tended to collaborate and share their ideas. Ideas were shared with other groups. Because of having nothing specific to do, Colin and Fernando discussed trout fishing until Karl informed them that "We're getting off the point now."

Byron controlled the scene-planner and could reject or accept any suggestion he chose. It was noticeable that the majority of the clues listed were his own. When Karl made a contribution -

Karl : "The audience are laughing their tails off."

Byron rejected this as a cold clue, which led to the two of them having an argument.

Karl : "Where's mine here? Where's mine here?"

Byron: "You haven't got one there."

Karl : "So!"

Byron: "You haven't suggested one. You've got one there."

Karl : "Only one! And you've got all these."

Colin: "You've got to suggest a good one to have one ... to have one."

This tussle continued when the group took their completed scene-planner to the computer to enter in their information. The group gained access with a little assistance from me. Byron and Karl seemed to be having difficulties again. Their personal differences were affecting the efficiency of the whole group.

Byron: "You're so thick, you know."

Karl : "Thanks, hey. It's always me."

Karl later remarked that Byron was weird. Karl was the better typist and thus had the pole position, much to Byron's malcontent. Byron had to content himself with reading out the information, some of which had not been planned beforehand. When stuck, Byron called Chew-Wha and asked him how to continue. All Chew-Wha did was point at the screen where the information required was displayed. A growing urgency developed to finish inputting their information before the end of the session with Karl calling, "Go on, go on". When the group was told they couldn't save the information, their disappointment was extreme.

Byron: "Ah, now we have to do it all over next week."

Karl wants to continue but is persuaded that it is simply too much.

The following week found Byron calling out the information while Karl typed it in. Byron showed a sense of humour when he said, "You're slow!", hitting Karl playfully on the shoulder. Karl typed it in and then Byron remarked, "I didn't mean there!", and, when Karl looked at him, said smilingly that he was only joking. All too soon the group became frustrated and then bored by the constant stoppages.

Byron: "This damn computer."

Yet when Karl told him to press 'return' to continue, Byron tried other keys rather than do what Karl suggested. When Karl was quietly persistent, Byron responded -

Byron: "You think you know everything."

Byron moved off and later returned with information gleaned from the other groups working on their games. He helped Karl by reading for him. Colin said that he did not know what he was doing but continued on the other console. Fernando joined Colin. There were now two groups of two - one to each console. It was evident that the boys needed to learn to work together. Byron resorted to Simon for advice. Simon helped Byron who in turn helped Colin. The frustration bit deep when they found that they had to start all over again a second time. They ignored the editing possibilities built into the software. Colin and Fernando continued working on the machine vacated by Karl. Byron managed to print out what they had typed in. This success spurred them on. The group again began using the map and scene-planner and continued trying.

In the interview that followed -

Chew-Wha: "I think people who don't know should go and ask Simon, sir, because first I didn't understand how ... so I asked Simon and he told me."

Me : "In other words, you say by sharing knowledge you mastered it."

When Simon was asked how he found out, the boys explained that he was a brain. Chew-Wha explains that Simon succeeded because of his game's thinness. Simon thus streamlined the game till it worked and then improved on it.

Paul : "I've seen a lot of people ask Beukes because he's the brain on computers. He always gets into things but he never shares them ... just keeps them to himself. Like people ask him, "Please, how can you do this?", and he just like says, "Find out for yourself", (points to me) like you."

Richard confirms what Paul has said by stating that when he asked Rhoald, he was refused help.

Me : "Now, Beukes, you obviously don't have a problem with this. Do you feel that other people must find out for themselves?"

Rhoald: "Yes, if they found out for themselves, I think it will."

Byron : "We should have a debate one day ... share on one side and not share on the other, and we'd sort it out once and for all."

During the final session of SLYFOX, Byron's group had spread itself between two consoles, with Fernando and Colin together. Colin was determined to finish the game before the end of the session.

Colin: "We've done it Byron, look."

They gradually became bogged down again. The group were confronted by the same problems encountered previously. This led to a temporary break-up of the group. Karl and Byron moved away.

Fernando: "Let's play a game."

Colin : "No, I am determined."

Fernando: "I've given it up. We've only got 40 minutes more."

Colin continued, though at one stage he did say, "I think I agree with you". I interfered and helped these two to continue.

Colin: "We must save it."

The two were now on task and shared the information and tasks without disagreement. This was a team of two. When Karl later wanted to

rejoin, Colin refused because he had earlier opted out. Karl offered his help, but was told by Colin his help was no longer needed and that he was no longer a member of the group. I interfered and asked the boys to let him join.

Me : "This is Solomon's game as well."

Fernando: "But he won't join us."

Me : "The three of you sort it out."

The rapport was soon re-established with Karl leaning across Colin to type, explaining that he knew what to do.

Colin : "Aw, Solomon's, man."

Fernando: "Solomon's can type the fastest."

Because of the internal strife in Paul and Byron's groups, their end results were not successful. Byron's group appeared to have resolved a lot of the differences and became a more cohesive unit - not so Paul's. The last three sessions were spent in doing the software CARS-MATHS IN MOTION. In the beginning the groups were the same. Byron's group were soon on task and interested in what they were doing. They shared the tasks and collaborated in providing the information. There was some friendly rivalry between some of the groups. There was a different atmosphere in existence in Paul's group, which was also aggressive. While Paul's group were talking about the name to give their team, Nigel overheard their conversation and the following happened -

Nigel : (from next group) "Dustbusters."

Julian: (very aggressive) "I never said Ghostbusters, you fool!"

Nigel : "I never said Ghostbusters."

Julian: "What did I say?"

This response was ignored and the group continued to make suggestions.

Paul : "Dirtbusters."

Julian : "Dirtbusters, ja."

Richard: "Noways!"

Yaneck : "Gunston."

Julian : "No, not Gunston."

The name of Camel was rejected as was Turtle, as being too slow.

They then came back to Dustbusters.

Paul : "Who votes for Dustbusters?"

Paul and Julian agreed. Yaneck and Richard disagreed. Richard tried to take control and suggested Cobra, Yaneck - Arnold Swarsinger.

Paul : "A normal name like Albert Einstein or something like that."

They continued going through a variety of names from T.V. shows, and ended up with names like Lassie and Bugs Bunny.

Richard: "Terminator."

Paul : "Aw, please man, Richard!"

Yaneck : "Put down ... we're getting nowhere ... just put down Richard de Wet, and that's final."

A recognition of the futility of their arguing. Julian refused.

Yaneck : "Nigel Mansell, just put it down."

Richard was in control of the writing and asked for the spelling.

While this was going on, Julian became interested in the group next door and Paul and Yaneck showed signs of boredom.

Richard: "Country ... Kyalami."

Julian : "Kyalami, please! R S A, man. Kyalami is a racetrack"
(very aggressive).

The group pressured Richard to hurry and finish. After much discussion, they settled on 'enthusiastic' as the temperament of the driver. Julian though, wanted 'careful', as he was not keen to crash. The conversation changed to a bottle of champagne broken over the driver's head. This group had lost interest. Their reactions fluctuated between boredom and aggression.

Paul : "What are you doing?"

Richard: "Don't worry."

Paul : "What are you doing?"

Richard: "I know what I am doing. Don't worry."

Paul : "What are you doing ... I want to know what you are doing?"

Richard: "Man, I'm doing what it says in the book."

Paul : "I want to know what you are doing, man!" (getting angry).

Richard: "If our team doesn't do this, then I get into trouble."

Paul : "Shame, man! I just ... I just want to know what you are
doing ... Ah, dammit, man!"
(He gets up and stalks off.)

Paul returned later and the arguments began again, with all of the group participating.

Yaneck : "Calm down."

Richard: "I am, man."

Yaneck : "You are getting on my nerves."

The three become involved about talking about the aerodynamics.

Yaneck : "What should we put in, five or six?"

Paul : "Ja, six."

Richard: "Don't listen to Paul, he's playing around too much."

Paul : "Speak about you!"

Yaneck wanted the aerodynamics to have a factor of five, Richard wanted eight and Paul was trying to work it out. They were soon distracted and talked about the recording equipment instead. Paul helped in the estimation of the different speeds needed, but was stymied by the performance percentages.

Paul : "I wish someone would explain this to me."

Richard: "No, you're playing around too much ... you don't have to get it explained to you."

Paul : "Why? I don't play around."

Richard: "You and your funny bird whistle."

Yaneck : "Don't blame it on him."

Paul at this stage had become so angry that he said -

Paul : "I will just sit in the bloody corner and get the sulks."

Later Paul negotiated with Julian to join him in a group of their own.

Richard: "Uh-uh, Julian ... Julian's with us, Paul, sorry get lost."

Julian : "So is Paul."

Richard: "No, he doesn't want ... he's with us, of course, but he doesn't want to help."

Paul : "No, you're the one whose saying no when I'm ..."

Richard: "I'm trying to write down, but you don't want me to."

Paul : "I do want you to help."

Richard: "Uh-uh, you just want to ..."

Yaneck : "Shaddup, man!"

I eventually intruded and separated the group of four into groups of two each. After Paul and Julian had been placed in a group of their own, they proceeded to get on with the simulation and were a lot happier. While the groups were typing in their improved data, there existed a friendly banter between the different groups as they discussed the data. When Byron's group get to 'safety features', Byron was all for not including them. This would have increased the risk of their 'car' crashing. If he had had his way, the group would again have failed in what they were being asked to do.

Byron : "Ed, can you choose what things you want over here?"

Me : "Ja."

Fernando: "We want them all".

Byron : "No, we don't want a fire extinguisher ... because what are you going to do with a fire extinguisher, man?"

Fernando: "Because if the car overturns."

Byron : "Overturns. Ja, what you going to do? You're going to be out of the race, anyway."

Paul : "Put it together."

Byron : "Ag, please, Paul, put it back together again."

Byron argued across the room with Paul that they had engine coolant to keep the car cool and they didn't need an extinguisher. Fernando remained insistent.

Colin: "Put them all down."

Byron: (relents) "Okay."

During the interview I again broached the topic of sharing.

Me : "I am starting to hear words like communicate, question ...

Yaneck: "Observe."

Me : "And observing ... now is it permissible to share ideas?"

There was a general yes from the class.

Yaneck : "What do you mean, permissible?"

Me : "In other words, if you don't have ... uh ... if you don't have something, to ask somebody..to ask somebody for information."

Byron : "Not in this class, sir."

Yaneck : "I think you could."

Me : "Why not, Byron?"

Byron : "All the other people don't want to share it with you."

Richard: "They're all meanies."

Byron : "And you sometimes, Richard."

Me : "But, Beukes, you're sharing with everybody now, aren't you?"

Class : "Noways."

Nigel : "We do, man."

The class commented that too much sharing would lose them the race. When asked, "Is winning the race that important?", there was an overwhelming "Yes".

In the final session, the class were involved in what they were doing and enjoyed the competition of the race. Afterward the groups were allowed to re-adjust their 'cars' to try and improve the performance. Richard had left Yaneck and wandered around attempting to join one of the other groups. He tried Simon's group.

Nigel' : "No, you've got your own group."

Richard: "Ed says I can come and work with one of you guys. I'm first, you see, and I can help you come first."

Rhoald : "Okay, we'll let him work with us."

Richard's stay with this group was short-lived. He soon left this group to play computer games on one of the consoles, together with members of other groups who had completed their tasks.

Paul was on task. Julian played a non-active role. Richard even spent some time on the fringes wanting to join Paul, without success. Paul seemed unaffected by the recording equipment. Julian, on the other hand, played with the camera and image. At one stage Julian became involved when he wondered why there were so many pitstops.

Julian: "We mustn't make so many pitstops somewhere."

Paul : "We have to. Because, look here, you've got heavy rain, then you've got nought-a rain and then we're going to get ..."

They talked about the engine adjustments and the need to change these because of the changes in the circuit. Paul had to attract Julian's attention to the task on hand and to keep him involved.

Paul : "Cummon, cummon."

Later, Julian left Paul and went off to play the computer games. He was called back by Paul.

Paul : "Come diff."

Julian paid no attention and continued at the computer. When Paul was asked if he had finished adjusting his 'car', he responded -

Nigel: "Paul, have you finished?"

Paul : "No, because Julian, the little idiot, doesn't want to ..."

Much later Paul finished on his own and left to have the information typed in. When Julian was asked why he had not stayed with Paul, he did not have an answer.

During the final interview we talked about sharing and the class generally agreed that it was good to share. Comments were still made about Rhoads, who had developed the dubious reputation of being the 'non-sharer'.

Karl : "I agree, some people are stingy and keep things a secret."

Paul : "I think it's quite nasty not to share, because you are probably ... experiment, experiment, experiment, while others are doing programmes you haven't even dreamed of."

I talked about sharing of information and sharing in tests.

Yaneck: "You can't share in tests, yet you can share information."

Paul : "Why learn if you, like, can ask for answers ... sit back and ask the answers and get nowhere in life."

Byron : "Computers is a bit different ... millions upon millions of programmes ... we should learn more about computers."

It appears that the larger the groups are, the less harmonious they become because of individual personality differences. Except for Chew-Wha's and Simon's groups, the other large groups tended to spend more time arguing amongst themselves than doing the task required of them. Byron's group, in particular, failed to complete task because of that group's inability to co-operate. However, during the last few lessons the task did become important to them.

The groups of two, on the other hand, seemed far more harmonious and on task. Except for Paul, who enjoyed working on his own, the boys seemed to prefer working in small groups and with peer equals.

3.4 PAUL AS EXPERT

I noticed soon after the class had arrived that the boys considered Paul to be the 'expert' on the computer in the class. Despite the problems that he experienced on occasion in gaining access to the software, the boys continued to use him as a reference.

Nigel : "Paul, how do you use Chain Smile?"

Rhoald: "How do you get out of this game?"

These were two of the early requests directed at Paul. Later, while Paul and Byron were playing the game FACTOR, the following conversation took place -

Paul : "I now understand."

Byron: "Explain to me, please, what's factors ... what's factors, Paul ... just explain to me first."

Both discussed it. Paul seemed to understand factors, Byron didn't.

Byron: "Okay, let's get out of this."

The games soon lost their appeal to Paul. He began to lose interest and expressed his boredom.

Paul : "I don't know why you find this so interesting."

Byron: "It's grand."

Despite Byron's competitive nature, he did not object to Paul keeping the role of keyboard operator. Paul often interfered with Byron's typing and showed his impatience and, at times, withdrew out of boredom and frustration. When Colin elected to play the game ELEPHANT, Paul showed his disgust by withdrawing, and Byron said -

Byron: "Ag, man, just leave him alone."

Despite Paul being considered an expert, it is interesting that he was not considered to be the leader of the group. When he took exception to what Byron was doing -

Byron: "It doesn't matter, you're not the boss around here."

And a little later

Byron: "Don't take it so serious."

Paul, though, was constantly approached by both members of the group for information when they did not understand. While playing PILOT, and after having spent some time tussling with it, Paul was the first to have mastered what was required.

Paul : "Oh yes ... now I understand."

Byron: "I don't catch this."

Colin: "I think its boring."

These two allowed Paul to complete the game - another confirmation of his status of 'expert'. When playing the game RACEGAME, which involved the use of vectors, Paul too became confused. Without understanding the rules, the game became difficult and frustrating to play.

Byron: "What you gotta do?"

Colin: "We don't even know how to play it."

Byron: "Ja, you said you would give us the information."
(This said to Paul.)

Later -

Byron: "Ja, I know ... I know ... How did you get the plus, Paul?"

Paul did not respond to this question. He later left this group and worked on his own, using BASIC and LOGO, and tried to get the printer to work. He succeeded in the end through the use of the manual. This action probably enhanced and sustained his status of 'expert'. The boys showed an interest in what he had printed. Paul did not seem to tire of what he was doing.

While Byron and Colin were doing CAPITAL MEDIA, Paul was called to set up the printer for them. Byron asked how one typed in a -10. Paul showed them how. He later offered them 'something nice to play' like the printer. He also tried to print out what Byron thought he had saved. When Paul was in a group doing the scene planner for SLYFOX, the group tended to rely on Paul to do the work.

Richard: "C'mon, Paul, work."

Paul : "Why don't you?"

Richard: "You're the computer boffin here."

Another example of the view the class had of Paul as the 'expert' was heard in the penultimate interview.

Byron: "I don't know, I just ... I don't know how to make like a little man walk across the screen and do those things ... like Paul can do it."

Paul : "That is because ... I well ... I look in a book to find all the basics and here from a book ... so there you go. I wouldn't know how to make a little man walk across the screen without the help of a book."

3.5 RESULTS OF A QUESTIONNAIRE

Because of what appeared to be unfolding in the class, while the boys were handling the microcomputers and the mathematical software,

I prepared a series of questions and asked the boys to fill in the answers. It was done at the end of the 20 sessions. Each boy was asked to complete it without consulting each other. (See annexure one for Questionnaire.)

3.5.1 Analysis of the results

The video recordings were analysed to consider the task-related interactions the boys had within their groupings. It seemed that they would tend to collaborate with persons they perceived as being on a par with themselves. It also seemed that they had perceptions of certain members of their peer group as resources for help in the tasks on the computer. It is possible that microcomputers in the classroom may provide new opportunities for interaction, collaboration and sharing and that the microcomputer may also contribute to the emergence of 'computer experts' in a classroom who are not necessarily the same as the 'math expert'. The boys were asked to choose a partner, as well as name the boys in the class they considered to be the 'math expert' and the 'computer expert'.

Twelve of the nineteen boys chose a peer who had a similar mathematics ability rating. This rating was taken from their global year mark, according to examination and test marks, and the teacher's rating of their mathematical ability. All of the four boys who had a poor teacher rating and mark rating, considered themselves to be good at mathematics and three chose Chew-Wiha Shih as their partner. Paul Kalil was chosen only once and, except for Chew-Wiha, there was very little duplication of partners, and no other boy was chosen more than

twice. The selection of partners in helping on a computer task in a large group tended to show a greater spread of ability. This tends to militate against larger groups being fixed when doing a computer task such as a simulation. Also, these groups need to be chosen with a great deal more care and pupil participation. The group composition cannot remain static, either.

In response to the question, "Who is the best at mathematics in the class?", seventeen of the nineteen responded 'Chew-Wha Shih', with the other two suggesting Alwyn Hendricks. Fifteen of the nineteen responded that they would call on Chew-Wha to help them solve a difficult math problem. The boys rated Paul (10) and Chew-Wha (9) as the best on the computer in class, while sixteen chose Paul as the person they would consult in solving a computer problem. These results point to the 'computer expert' not being the same as the 'math expert', and that microcomputers could provide new opportunities for the emergence of 'computer experts' who have peer recognition. These experts can be seen as different from those having an expertise in mathematics. The two boys chosen by their peers as experts were also identified by the class teacher as the most sophisticated users of the computer, and Chew-Wha was the top boy in mathematics in that class.

3.5.2 The Research

Clements (1985) maintains that competition between groups in a simulated exercise and between pupils and the computer can encourage inter- action and co-operation among them.

According to Pontiel and Petersen (1984), the stereotype of each child being effective on their own computer is an inaccurate one, as working at the keyboard and answering questions are not solitary tasks. Contrary to what might be expected, practical experience suggests that optimum pupil-computer ratio is not one to one, but two to one, as the pupils must not only react with the machine but with each other to serve as a check-and-balance system to their learning.

As a result of her study, Allen (1984), came to several conclusions. A great deal of social interaction among the teacher and the pupils surrounded the use of microcomputers, the most prevalent interaction being collaboration (34,88 per cent), in which pupils worked together asking and answering questions to solve problems. In this study the microcomputers were not shared equally. This inequality of machine utilisation did not seem to negatively affect the pupils. The study also revealed that, given preference, the majority of pupils would prefer to work with a partner on computer assignments. When two children work on a given assignment, they are able to share their thought processes. Answers can be talked about before entry and incorrect answers can be challenged (Pontiel and Petersen, 1984). It allows for positive social interaction and places the pupils in a position to rely on one another for problem-solving, rather than calling on the teacher every time they have a concern. It encompasses a reciprocity, which means working with others towards the accomplishment of an objective. Sheingold et al (1981) report from case studies that in those schools where pupils were

permitted to work together on computers, teachers often commented on the amount and quality of the social interaction which took place round the computers. Levin and Kareev (1980) view the computer usage by pupils as a revealing environment for studying the pupils' social interaction when problem-solving. According to Goodyear (1984) the computer certainly encourages more interaction between pupil and pupil. They tend to talk freely about their discoveries and experience

"the interaction and flow of knowledge become more informal and more widespread and there is more task-related interaction than during any other non-teacher directed classroom activity."

Also, timid children seem to adopt a more aggressive approach and show more enthusiasm with shouts of excitement on discovering something. The children also seem to concentrate for longer periods of time; though Jones (1984) warns that we as teachers spend too much time encouraging pupils to be competitive rather than co-operative, and acquisitive rather than inquisitive.

Pontiel and Petersen (1984) state that as additional pupils are asked to share one computer, the effectiveness of the learning decreases, regardless of the attraction of the software, with dominant members taking over and the introverted and less motivated ceasing to participate. On the other hand, only one pupil on a computer tends to lead to frustration. Ultimately peer matching will foster a greater sense of independence. This pairing must be done with care, and each group should consist of children of similar ability. They then list some do's and donts.

- * DO pair children with similar ability levels.
- * DON'T use things such as friendship or the alphabet as pairing criteria.
- * DO put children who handle concepts well together. They'll urge each other on.
- * DON'T match high- and low-level pupils unless peer tutoring is your goal; otherwise the more capable child may end up doing all the work. (Pontiel and Petersen, 1984, p67)

Jones (1984) cautions that teachers need to use their professional judgment when sorting out groups. They then need to observe the workings of those groups to ensure that certain pupils are not isolated from the collective activity. It is quite possible for one or two of the more forceful members of a group to dominate the activities and monopolise the decision-making process.

Hawkins et al (1982) did two studies of primary pupils on computers while using LOGO. The first study showed that there was more task-related interaction during computer activity than during other non-teacher-directed activity. Most dramatically, there was more task-related talk around the computer than during other class activities. Also, there was more connected talk among children. In the second study the results tend to support Sheingold et al (1981) in that children, as a result of their expertise, become valued by their peers as resources for help. Approximately half the pupils involved in the study made similar choices of peers as computer helpers. Thus the computer task appeared to be different from other classroom tasks with respect to perceived expertise. The pupils nominated as 'computer experts' by

their peers were not necessarily perceived to be experts in other activities. When the pupils were asked to designate both a computer 'helper' and a computer 'partner', few of the pupils selected the same person to fill both roles. Many of the pupils selected partners who were of the same level of expertise as themselves. The research of Hawkins et al (1982) suggests that microcomputers may be an important aspect of classroom organisation that affects pupils' tendency to work together. Their findings indicate that more task-related interaction occurred among children when they were working with computers, than during other non-teacher-directed classroom tasks. In addition, the results of their second study suggest that computers may provide a context in classrooms where pupils recognise each other as helping resources, thus affecting their tendency to work together. It also takes the first step of identifying a classroom context which appears to invite task-related interaction among children. It also supports the fact that pupils tend to choose partners who have a similar ability.

The children's responses indicate that the presence of microcomputers may provide new opportunities for peers to serve as resources for each other and for pupils to perceive each others' competence. This could change the roles of teachers of mathematics, as the increasing availability and impact of computer technology will affect the social life within the mathematics lessons, and the interactions of the three actors ... the pupils, the teacher and the content to be taught.

CHAPTER FOUR

"... in order to help the teacher who must implement research findings in her own situation, the educational researcher may well learn from the novelist, the artist and the actor in reporting research ... Educational research is confronted with a complex problem of communication-reaching teachers. There is a need for a new approach to the communication of educational research to the teacher; an approach which will allow the reader to identify with the researcher's subjective experience. The impact of educational research will be enhanced if some studies report not only the observation made ... but also what is being experienced by the researcher."

(Shumsky, 1958, pp59-60)

4.1 INTRODUCTION

During the course of video recording the activities of the class, there were several other situations that came to light which, on reflection, needed airing and even highlighting. These were the themes I chose to call the use of pencil and paper and sexism in the use of the microcomputer. Military usage, names given to software, what I ended calling 'personalitying the computer' (giving the computer a personality), and artificial intelligence are included under sexism. These 'themes' are important, I feel, and need to be kept in mind when considering how children are thinking and communicating while using the microcomputer in the classroom. Educationists need to be aware of these areas when selecting the type of mathematical software to be used by the pupils.

4.2 THE USE OF PENCIL AND PAPER

While watching the boys handling the mathematics software, there were several instances when I felt the boy or group would have been better

off had they resorted to using pencil and paper to clarify their ideas. In many instances the boys resorted to the use of this medium themselves. It appeared that, without the presence of the answer being written down, the groups resorted to what they called guessing, and answered almost without thinking. Their guesses were not permanent, as they were erased almost immediately, if wrong, by subsequent guesses.

Byron showed a high degree of competitiveness throughout playing the software. He resorted to a form of chance that did not include calculated guessing. The strategy he used embodied possibly the highest degree of chance, and even luck, rather than guessing. There is very little mathematising when one denies the locus of control of an answer, and resorts to chance and luck. Byron resorted to the russian roulette of 'eeni, meeni, mini, moh'. Colin responded -

Colin: "That's a great help."

And later -

Colin: "Ah, let's not do that."

When playing ELEPHANT, both boys began trying strategies to find the correct co-ordinates that would uncover it. They did not seem able to decipher the requirements of the games and kept resorting to what they called guessing as a strategy.

Colin: "Guessing where the elephant is."

When considering the clues Colin retorted -

Colin: "Byron, this is useless, it doesn't go anywhere."

They had both retrogressed to the stage where Byron began choosing numbers by closing his eyes and typing in numbers. The difficulty was that he did achieve afterwards, getting the elephant in a further two tries. This led him to make the statement -

Byron: "I'm an expert in this."

Colin followed suit and chose the first co-ordinates with his eyes closed. I feel that this is not the estimation and determination of the results and reasonableness of their answers, proposed in the 'guess and test' method suggested by Clements (1985), although by lesson four the group had found the need to use pencil and paper. Paul resorted to writing down what he felt should be remembered. After reading the instructions of the game MASTER, Paul said that he wanted to write down the rules and asked for a pen. Both Byron and Paul used the word guess while typing in their solutions. Both boys also referred to the rules they had written down. They spent a great deal of time playing with the sequence of the numbers, and trying different combinations and options, sometimes repeating ones already done before. Colin was heard to respond -

Colin: "Guessing doesn't get you anywhere."

It also seemed that neither would take the responsibility for the other's answer.

Colin: "I'm just guessing.
Not my fault - I'm just taking a chance.
Don't blame me."

Byron: "I'm not blaming you."

And in a later lesson, Colin said -

Colin: "I don't know. You can't blame me. I'm just guessing."

I had the feeling the boys would have fared a lot better had they used pencil and paper to assist them, as their initial responses were soon lost, leading to a needless repetition. It was only once Byron had himself resorted to the use of pencil and paper to assist them in the playing of SNOOKER, that the group achieved a greater accuracy in their answers. I asked Byron and Colin why they used the drawing they had made while playing Snooker.

Me : "Um ... you find that doing that plan of directions has helped you?"

Colin: "Ja."

Byron: "Ja."

Colin: "Because you can ... you put it on the ball, and you can work out the positions."

Byron: "But you know what they can do ... they should make a target ... a target on the ball, and it shows you all the compass directions and then ... and then you like shoot from those."

Me : "Isn't that going to make the game too easy for you?"

Byron: "Ja, but then they should put objects in. That will make it easier. I'm just saying it will make it easier for us. This game is quite easy ... but they should put in objects like you know in SNOOKER ... the red balls... those are like ..."

Me : "What made you decide on using that?" (pointing to the drawing.)

Colin: "Well, we used it last time as well."

Byron: "Because last time ..."

Colin: "To remember the bearing."

Byron: "We always forget the instructions, so we got that ... so we got that, and we have come up with this."

On each and every subsequent time the boys played SNOOKER, they used the drawing of the compass bearings. They used the paper with the compass drawn on it, or they resorted to using a pencil or ruler to work out the angle on the screen.

The group used pencil and paper again while playing the game DARTS. Byron discovered that he needed a pencil and some paper to write down the scores and instructions required to play the game. Byron wrote down the scores given to him by Richard from the group next door.

Byron: "Okay, I've got it now."

Pencil and paper was used extensively while the group was playing DARTS. Byron was unwilling to share the console while playing the game, which resulted in Colin becoming bored and frustrated. Byron continued playing and used mental arithmetic to subtract. He then proceeded to put in his answer. When it was rejected, he asked for pen and paper to check that his answer was accurate. He said, "I want to subtract", worked out the correct answer and then continued. Colin was only involved occasionally and expressed his frustration and boredom. At this stage there was very little sharing.

While the boys were using LOGO in lesson nine, the group did not use a diagram or really consider the commands they were entering into the computer. They were none-the-less a little upset by what their instructions had drawn.

Byron: "Aw c'mon! ... Just look what it did."

They tried to use the copy key and discussed the smallness of the numbers they had used. They ended up by increasing all the numbers, as Colin put it, "to be like spaghetti ... going all over the screen".

There was also a very strong want from the boys to see the results of their labours in print, and to see what they had managed to save.

When Nigel was left on his own during the eleventh lesson, he continued to struggle, even ignoring the instructions displayed on the viewer. He continued to appeal for help from the group next door, until he too began writing down the instruction words as a source of reference and used pencil and paper.

When doing SLYFOX and CARS-MATH IN MOTION, all the groups were required to do the initial planning and recording on their planners before they could enter the details into the programme. Byron's group failed with SLYFOX, because he influenced the group against doing the design fully and sequentially, as well as writing down all the the required responses. This resulted in the group guessing the final information needed to complete their game.

In the programme CARS a great deal of mathematics and calculating using the calculator is done, and recorded on the worksheet. Thus the groups found it easier to refer back and correct, or make more accurate their responses. The microcomputer was used to test their results first, before these were pitted against the results of all the other groups who had been doing the same thing. After the 'race', the groups were able to go back and use the data they had on their worksheet to try and improve their results. It was competitive, yet required a constant use of recorded mathematics and little or no guesswork. The computer was being used as a tool.

Paul, in the last interview, admitted using information gained from books to achieve the results he did on the computer. When the class was asked if, while working on the computer, they felt it was necessary that the groups have pencil and paper to help them with their working out, the responses were -

Paul : "It depends if you have to write something down or work something out, so like ... I mean, I don't think a journal is a very good idea."

Yaneck : "I think that whenever you come here, you should always bring pencil and paper for the computers, because there are times when you need it."

Chew-Wha: "Use a light pen."

Most of the others in the class agreed that it would be a good idea if there was pencil and paper handy.

4.3 RESEARCH FINDINGS

Clements (1985) maintains that at times information has to be organised so that patterns can be found. It is helpful to write it down, in pictures or words and numbers. Like talking it out, writing it down forces pupils to become more explicitly aware of their thinking and serves as a record of problem-solving efforts, so that unproductive paths are not retraced. This can be seen in the attempts of Byron's group to solve the game of MASTER, a game of logic, where the group repeated numbers used before. Fusen and Brinko (1985), in their research study, produced results that call into question the use of microcomputers in the classroom for drill that involves only the retrieval of facts. Gebert (1986) states that learning mathematics on a small computer screen "contracts space, sucking students' attention and consciousness into the small terminal screen". Wolpert (1986) claims that the child with a pencil in his hand and paper at his disposal, is directly doing something and is also conscious of the whole process of which he is in control. There also seems to be no experience of the commensurateness of action and result in using the microcomputer when not using pencil and paper as

support. He also maintains that the child is stimulated into a high state of visual, mental, emotional and some physical activity, and these activities are based on the illusion of communication. There is no computer consideration of the pupil's individuality in the artificial encounter.

Price (1985) warns against the element of control when a pupil is passive in front of the microcomputer, especially when dealing with numbers they have dealt with successfully several times before. The important work goes on off the keyboards, where pupils plan and hypothesise their moves before checking them on the computer. This demonstrates the value of constructive error: the pupils' mistakes become an integral part of the solution. Without the use of pencil and paper there is the danger of developing the over-simplified view of the nature of mathematics, together with the belief that there are straightforward, technological solutions to the teaching and learning of mathematics (Ridgway, 1985).

Groen and Resnick (1977) and Resnick (1980) propose that instruction should be designed to put learners in the best position to invent or discover appropriate strategies for themselves. It is essential that they are provided with the appropriate aids. It appears, then, that pupils may benefit from instructional methods that provide the opportunities for them to develop and apply a variety of solution strategies, and these strategies are more likely to have meaning for the pupils. These strategies need to remain on permanent record for pupils' referral, in order to reflect on and react to their thoughts, actions and possible errors (Fuson, 1979). Case et al (1979) have shown that pupils need ways to aid their external memories when encoding and decoding. One way is to have things written on paper.

Papert (1980) tends to consider pencil and paper technology as simplistic and primitive when compared to the computer.

"In brief, I maintain that construction of school math is strongly influenced by what seemed to be teachable when math was taught as a 'dead' subject, using the primitive, passive technologies of sticks and sand, chalk and blackboard, pencil and paper."

(Papert, 1980, p 52-53).

According to Jahnke (1983), it is difficult to understand how, when pencil and paper is compared to computers, Papert considers the former to be cognitively simplistic and passive. This view only opens up the gulf between humanistic/literary and realistic/technological education, which Papert has the intention of breaching. It also disregards the substantially higher cognitively variability and flexibility of working with paper and pencil, as compared to working with the computer. It does seem impossible to treat the relationship between the structural aspects of mathematical knowledge on the one hand, and its procedural aspects on the other, without recurring to paper and pencil activities. There should be a systematic co-ordination of the computer and paper and pencil activities. Both pencil and paper and the computer together, give the full range of metaphor and operational meaning and prevent the so-called 'aphasic defect' according to Otte (1985). From these observations it also follows that Papert's dream of the "child as an epistemologist", as somebody thinking about thinking, cannot come true with the computer as the only means of thinking. Paper and print will not automatically lead to realism of thought, of course, as one sees when considering the exhibition of expressive symbolism by so great a part of pure mathematics, but realism in mathematics is not conceivable

without visual metaphor. Otte maintains that Papert is trapped by his one-sidedness. One does not just want to print out polarities existing within human thinking, but to stress the fact that this complementarity must be represented by different means of human activity, ie. paper and pencil visualisation versus machines (computers).

4.4 SEXISM

The comment made by Paul when Sue, the researcher, won the first run of CARS-MATHS IN MOTION, brought to a head the developing male chauvinism that seems to come out of handling microcomputers in schools, particularly in the subject of mathematics.

Paul : "Girls don't count, you see."

The boys felt justified in ignoring her being placed first by the computer and proceeded to place the group that came second, first and so on. There is almost a taken-for-granted notion of a superiority, and an acceptance that the electronics and working of microcomputers are for the male domain only.

4.4.1 The names of software

I became aware, toward the end of the series of lessons, that the names of virtually all the mathematical games used during the course of the videoing tended to be 'male' or have male implications. The games of SMILE included the names of BOAT, FACTOR, LOCATE, NIM, PILOT and SNOOKER, to mention only a few. The simulations favoured the interests of the boys as well,

being called CARS and SLYFOX. Though not consciously done, the choosing could well have been the result of my tendency to favour my own interests, although the software was chosen in attempting to answer the requirements of Nicolson (1984). Also, there seems to be a dearth of mathematical software that could be called non-sexist, making it very difficult to apply such software. The class was also totally male and thus a biased sample.

4.4.2 The appearance of militarism

The software seems to have encouraged a military vocabulary to be used in a far more open manner than would be the case had this software not been used. As early as the second lesson military statements were being made.

Paul : "Colin doesn't find this interesting. He likes ELEPHANTS ... radar screens and everything."

The use of military words and expressions became more evident after Colin joined the group. The use of the words 'turbo', 'turbo boost' and 'radar scanner' became common. Also, 'over and out'. Instructions such as 'There please, Colonel' were also used. Another usage was -

Colin: "Lieutenant-Commander, is your keyboard ready?"

Byron changed the colour of the screen to monochromatic and remarked to Colin that "It's more army like this". When asked whether the change of the screen colour was because it was too bright his response was -

Byron: "No, no, it's just more military like."

Again, talking to others in the class, Colin remarked -

Colin: "We're trying to find a Russian gunship on our radar screen."

And later -

Colin: "I bet you Rommel or Hitler couldn't do better than us, and Ronald Regan couldn't do better in his thing."

When Colin was on his own, he became very involved in what he was doing. He sang the song 'Hitler, Rommel and Hess'. Paul responded by coming back to the keyboard and singing 'You ain't nothing but a hound dog', an interesting piece of nostalgia to counter what Colin had been singing, particularly as Paul had been at the video console listening to what Colin had been saying and watching what he was doing.

While playing the game LOCATE, Colin uttered the following to Byron -

Colin: "We're just trying to pinpoint Airwolf, but we can't blow it up ... our missiles are just going wild."

Throughout the playing of SMILE, the conversation of these two boys was peppered with military jargon. The beginning talk, when playing SNOOKER, was about the bombing of Hiroshima. When they failed to sink the cursor, they remarked that they had just failed their mission.

Byron: "Okay, Colonel, you can have the honour."

Byron: "You were intending to go into that hole."

Colin: "Yes, but I still destroyed the town."

The two talked about the ranks continuously while destroying this town or that town, and even being expelled from the army 'if you miss', in a heavy German accent. They closed their ears and made explosive sounds.

Colin: "This is Cape Town and you are blowing the golf course up."

Colin: "We are heading for Russia on a secret mission. Our job is to blow up Stalingrad ... Stalingrad shall not stand when the lights ..."

Byron: "Our job is to blow up Hiroshima, and we will succeed."

Colin: "Hiroshima's already blown up. Hiroshima's had enough."

Byron: "I know."

Colin: "Let's give it a break."

Byron: "Our aim is to destroy Russia, and we will succeed or die."

There were further remarks made about Adolf Hitler and the fall of Poland. Perhaps these historical data were being handled in the school at that stage, and it had a natural overflow into their other subjects. These games lent themselves to a military flavour.

Later, when the group was enlarged to begin the simulations, Colin suggested making a game that concerned the search for terrorists. Byron responded, "Ag, no ... you would, Colin!" Throughout these latter sessions, the boys were constantly shooting at each other, or shooting the camera and the computer screen, making explosive noises as accompaniment.

When the class was asked why they found most of the software boring, the following responses were made -

Colin : "Because there's not enough action."

Byron : "It's the same route all the time."

Brendon: "Once you have mastered all the games, it then gets boring."

It seemed the more 'action' and variation there was, the more the class responded positively to it. This could also be a result of playing the freely available commercial 'action games'.

4.4.3 Personality - giving human traits

All the boys in this class tended to give the microcomputer almost human qualities and attributes. The microcomputer was called shrewd and clever, and at times was spoken to as if it could hear what was being said to it. "If you insist, mister", and "Congratulations" were two examples where the boys addressed the computer. Early on in the series of lessons, the microcomputer was given a gender.

Colin: "Byron, he just needs one over there and he's got a whole line."

Later -

Colin: "Well, let's get him."

Byron: "He says that's a line."

During a later lesson the following conversation was recorded.
When addressing the software, the 'he' became a 'they'.

Colin: "See what they do when I type in directions."

Nowhere did the boys refer to the computer as being female.
To the boys its gender was male. Colin at one stage said,
"Now he's going to go ahead of us, I bet", and Byron responded,
"Oh, he jumps to 60."

The computer seemed to have a form of life for the boys.
Colin said, "Oh, you dumb computer!", and later threatened the
machine with his fist, calling it a 'cheat'. At one stage
Byron pointed at the viewer and shouted in anger "You can't!"

Colin: "Then if he can jump to that, then we can."

Byron: "He'll move."

Colin: "No, he'll go to 12. He goes to 12 and one ahead of
us."

Colin: "Ah, he always does that to us, the cheat."

Throughout, their discussions were peppered with pronouns and
other references relating to the computer. "He will kill you"
and "He has got a clever plan hidden up his sleeve" and "I bet
you he is saying" and "Get it into your big bek" seemed to give
the computer a personality.

Rhoald: "I'm going to klap this thing."

Paul : "How do you explain to this stupid computer what on top
is?"

Rhoald: "I'm going to bash this computer if it doesn't wake
up."

And later -

Rhoald: "See, it put everything together, it's clever, hey?"

There was an interesting comment made in frustration by Colin, while playing CAPITAL MEDIA.

Colin : "Stupid piece of junk ... electronic junk."

The constant use of the male pronouns in 'sexing' the computers could be to enhance the notion that microcomputers are a male domain. Also, it was possible that the boys gave the computer a personality, so the locus of control for their mistakes could be removed from them and, instead, the computer blamed. The machine is not really able to respond and defend its position.

Colin : "Aw, this stupid thing won't save. I'm telling you, you're stupid."

Julian: "Please, I beg you, come on ... or you've had it ... I'm warning you, you've had it."

Paul : "C'mon, you old juvenile delinquent."

These threats were really empty and unlikely ever to be carried out. It was also interesting to note that, when the boys wanted to end the programme, they talked about 'killing it'.

4.4.4 Artificial intelligence

Because of the tendency to give the microcomputer human traits, I felt I needed to investigate the class' attitudes and opinions about computers being able to think or not. There was a mixture of yesses and no's, with some of the boys venturing more elaborate answers.

Chew-Wha: "No, they can't think, unless you programme them to think."

Me : "Unless you programme them to think?"

Chew-Wha: "Like often they ... like, you know, like ... like games, like some games, like 5 times 5, and the computer says it's wrong or right ... should have been programmed on the floppy disk ... or shows the strength of the computer, then it knows whether it's right or wrong ..."

Paul : "Sir, er ... actually what all ... all a computer knows is off and on. Like when I should ... when I should ... should like switch on and when I should switch off. Like you ... you like programme into it, er ... LOGO, and it will switch on LOGO and then switch on forward nine, and it'll switch on forward nine and then switch off again."

Me : "In other words, it can only obey an instruction?"

Paul : "Ja."

Byron : "No, it can't. We have to programme this computer to switch on and then forward nine." (A reference to the complicated access instructions.)

Colin : "Well, you couldn't even programme a computer to think on its own. To think of to what you want. A computer can't think ... think it's own thoughts. It can only do what it's being programmed to do. That's all it has in it."

Yaneck : "I think computers could think, but I mean they could think in a way that we wouldn't be able to understand because on our ... you know ... it ... it always pauses for a while and says, "I don't understand and ... and ..."

Me : "Yaneck, why does the computer pause?"

Yaneck : "Well, because ..." (Shrugs.)

Byron : "Looking through its database."

Chew-Wha: "I think that computers can think a bit, that, but ... um ... um ... programming is programmable. The Americans will invent a computer, because sometimes if you like type in the wrong type of programme, then syntax error ... tell you that you're doing something wrong or numeral error or something is wrong with your programme. So it can think, but before it can think it ... somebody else could have invented that computer and programmed it to basically think right."

Paul : "Sir, I think a computer is just like a maze of switches coming from programmes. You know what I mean like ... like, say you type in something wrong and it says ... and it like switches on the switch to the microchip or something and the microchip tells it to print out on the screen ... something error or something like that."

Clifford: "I think that computers can talk ... I mean, think in a way, because like you say you are like playing a game or something, and you type in something. They will like answer you, er ... like do something in that ... like on the opposite or something. So they must also like ... also in a way also think."

Paul : "Objection."

Me : "Oh, you are going to object?"

Paul : "That is because once ... once the ... the computer's made... all the ... the information gets like typed into the computer, like when something wrong is typed in ... please say wrong or please say whatever."

Me : "Do you think that computers will ever get to the stage where they can think like human beings?"

Chew-Wha: "I don't think so, sir, unless the person programmes a robot. Like nowadays they use robots to build cars by themselves. You have to programme before they can build the car ... ROM chips and everything. Same as the computer now, you do maths and you say like 5 plus 5 print out 10. Without your programme that's BASIC from a ROM card and all those things inside sir ... the chips, sir."

Yaneck : "Well, maybe they'll think like a human. Maybe in the future, but not now."

Byron : "Sir, people say that they ... robots will take over the world and all that, but they like need instructions. They can't like ... they do like if they want to build a car ... move left, do that, do that."

Later -

Byron : "Man can't make a brain just like God has made the human being."

Chew-Wha: "If you programme everything into a robot, sir. Like if you programme everything into a robot, a human being knows that robot is going to think in the same way as a human ... like I know about maths and everything ... you can programme everything into the computer ... it's going to act like a normal human."

4.5 RESEARCH FINDINGS

Clements (1985) expresses the view that educators must not allow microcomputers to become a male activity only. Many teachers tend to believe, often unconsciously, that boys will excel at computer activities. They, thus, inadvertently reinforce more strongly the boys for their computer work, than they would girls. It should also not become solely a mathematical activity. Pontiel et al (1984) claim that there is mounting evidence that computing is part of a 'man's world', with the type of programme in use leading to this form of stereotyping. According to Perez and White (1985), rating comparisons and anecdotal observation reveal gender differences in perception of motivational characteristics. Boys tended to rate higher an action game and simulation experience than problem-solving or strategy exercises which lacked the element of competition. More specifically, boys identified aspects which related to achievement such as scores (see my score!) and challenge or speed of response more frequently than girls. Thus, if we are to develop meaningful mathematical software for an appropriate curriculum, it seems worthwhile to gain an understanding of just how the particular groups and, indeed, individuals feel about and react to microcomputers and software. The significance of these findings must be viewed in the light of the emerging technological age. The new tools and media capabilities available to educators and psychologists demand that we

take a fresh look at traditional theories of learning processes (Perez and White, 1985). The pupil reports identified a broader range of motivational characteristics in the computer lessons than in classroom activities. This research begins to identify motivational factors that contribute to learning with the aid of technology, as well as suggesting a means of measuring future microcomputer mathematical software. The success of doing things keeps the pupils excited and curious. According to Palmer et al (1984), all the educational axioms about experiencing success in learning reinforcing the desire to continue are tied up in the reactions of the pupils, although Enochs (1984) confirms an earlier report (Enochs and Murray, 1983) that there is no significant difference in general attitudes of boys or girls toward computers. This is countered by Hawkins et al (1982) where, in their study, girls were seldom identified as computer experts. Girls were chosen by other girls as partners, rather than by boys, while girls tended to choose boys as being experts. Further, Burns and Bozeman (1981) revealed that intermediate grade boys profited more from drill and practice supplements than girls; though Carrier et al (1985) found that the only sex difference when using C.A.I. as supplements was that the girls tended to make greater gains in the retention of division facts. Price (1985) states that, when watching mixed pairs, it was his impression that either the boy took control, or the girl expected him to do so.

Hudson (1985) expresses concern about the 'macho' male image that playing war games undoubtedly has, to the detriment of female interest in microcomputers. This lack of interest can have serious implications for mathematics as a subject. Stanley (1985) states

that to most children computers mean games of zapping aliens, sinking ships or climbing ladders in pursuit of gorillas. Pontiel et al (1984) write that most games seem to involve battling, bombing or exploding your way to victory.

Hudson (1985) also expresses the concern about the quality of the content of the software used in the mathematics lessons, where games like BATTLES and VECTORS are played, and the participants are either shooting or being shot at and blown up. These games seem to be pandering to the interests of boys and affecting the attitudes of many girls negatively. Aggression is seen as a male virtue in our society, and playing war games may assist in the development of such behaviour. In fact, we seem to live in an age where war is seen by the majority to be a normal way of resolving international and internal conflicts. At least, let us not reinforce this in the mathematics lesson (Hudson, 1985). Kelly (1984), too, points to the danger that certain types of microcomputer use in our schools may instil habits of solitary, almost anti-social, learning and behaviour. In terms of the computer-presented text, the layout all too often appears to be designed by the computer specialists, with consideration primarily for the technology, rather than for the user (Henny, 1983), and the content influenced by the inevitable profits over losses.

Against this mentioned background, the belief that computers are incapable of error and what it 'says' is not open to question or challenge, raises several issues. Today computers are making it possible to construct systems which go a long way toward mimicking the whole human being. Children do not view computers as cold,

impersonal machines. They often demonstrate a very personal style of computing (Humphrey, 1982). They tend to interact with it, rather than simply respond. They do expect it to be useful and highly flexible in meeting the needs of the individual user, and that it ought to become more personal and user-friendly. Many of the comments made by the pupils suggest that they often expect the machines to comprehend or evaluate stored information, and children tend to see microcomputers as 'knowing' rather than merely storing information.

According to Clements (1985), for children to understand computers, they must come to understand the unique capabilities and limitations of the computer, and, in so doing, help themselves to understand their own capabilities and limitations in more depth. Pupils will need to have numerous experiences with computers before they engage in any discussion. Intelligence is not all we humans possess - feelings and values are of crucial import. Marvin Minsky (1970) and Christopher Evans (1979) believe truly intelligent machines can be developed. Weizenbaum (1976) argues that it is the responsibility of humanity to limit the power of any tool, and that man faces what computers could not possibly face. Gerbert (1986) talks of 'carbon-chauvinism', a term used by MIT artificial intelligence laboratory for those who think that there is something special distinguishing the human being from its silicon counterpart. We need to move away from this chauvinism, where educators particularly consider inhuman and threatening, even having a sense of loathing for, creatures made of silicon and germanium rather than proteins and skin and bone. Jahnke (1983) states that opponents of artificial intelligence deny its

significance because, according to their opinion, there is, beyond formal operations, no connection between the procedures of machines and of human thinking processes, which would be worth investigating.

In order to ensure the best is done for the young children, while learning mathematics using microcomputer software, careful cognition will have to be paid to many of the issues raised here. Rather than avoid or ignore them, educationists need to tackle these directly and be in a position to provide advice in the development of future mathematical software and computer usage.

CHAPTER FIVE

"We are happy, gain a sense of creativity and a sense of movement in the direction of self-fulfilment when, as a result of small innovations introduced by us, we observe slight improvements - change ... unless it grows out of oneself, no knowledge is really of value to the individual. A borrowed plumage never grows."
(Shumsky, 1958).

5.1 REVIEW

It is only at the end that I can look back and reflect on what has happened during the twenty lessons I recorded. There are several problem areas that need to be considered. Firstly, the parameters I set for this research project were far too broad. I only came to realise this when considering the amount of recorded interaction I possessed (some fifteen two-hour video tapes). There was also the uncertainty of what counts as children thinking, as there were no clean data or carefully prepared hypotheses. It led to the problem of finding a focus and then justifying the data gathered. On occasions the machinery failed me, and on other occasions I failed the machinery. My inability at times to master the workings of the ECONET made me feel hopelessly inadequate. The tremendous uncertainty of this type of research has had a sobering effect on me; though, if given the chance, I would not hesitate to do it again.

When selecting the software I did try to keep the school mathematics syllabus in mind. I later felt that not all of the software was appropriate. Much of the software assumed that the pupils had

mastered certain mathematical prerequisites and made no attempt to fulfil this function. It was left to the accompanying notes or the teacher. The type of software was also restrictive in that I did the choosing. Perhaps it would have been more successful had the boys done this themselves as well and I had provided a greater variety for them to choose from. These aspects need to be considered before one can have the total picture of how the boys reacted to the types and usage of the software.

The use of the computer laboratory, where the boys were brought up to the university by their class teacher once a week, rather than when it fitted the mathematics being done, was also problematical. In fact, there was no direct link to the school curriculum at all. This was not helped by the class teacher who withdrew every week, refusing to involve herself in computers. The problems of gaining access to the network were also very frustrating. It was unfortunate that the class was one of boys only, as many of the issues raised needed boys and girls co-operating together in order to consider the full effects.

5.2 I AS ACTOR

The role I had elected to play throughout was one of being a non-expert and it proved a very difficult one indeed. I had to keep telling the boys that "I have not the faintest idea" when they asked me for information. Many of the boys expressed initial concern when I refused to help and referred them to each other. A fair degree of frustration was expressed at my constantly shrugging my shoulders and saying "I don't know" and "Find out for yourself". One was even

heard to remark, "Ah! you know nothing". These remarks later changed to the type -

Byron: "You could tell us, but you don't want to tell us, hey?"

Colin: "Don't look at Ed, he never says anything."

Once the boys accepted that I was not there to provide the answers, I restricted my interference to the nudges that I felt were necessary. I was trying to enact the subjection of teaching to learning and not impose strategies on the pupils. I found that after my refusals to provide the boys with help, many did take control and got on with it. They either did it themselves or asked one of their peers - the 'experts'.

5.3 APPROPRIATENESS OF THE SOFTWARE

Software should be concerned with the active involvement and development of the pupils' intellectual abilities. The games I chose did very little, unless constantly prodded by the pupils. The style of interaction of much of the software was authoritative, repetitive and lacking in humour. Many of the games reflected an inadequate view of what is meant by pupils' active responses. This allowed the games to degenerate into blind button pressing or guessing until success was achieved. Positive, directive feedback was also lacking in much of the software. The pupils needed this direction. Kulhavy (1977) suggested evidence that feedback which provoked an active reconsideration by the pupil of what he had just done or had said, becomes far more effective.

On consideration, I felt that much of the software content was ineffectual and educationally questionable. Games based on violence and activities that emphasise the view of a world that is always competitive and ethnic and is sex-typed or stereotyped, must be questioned. In order to use software effectively one needs to consider whether the contents are educationally significant, suitable, and whether it has an identifiable purpose. I feel the software should involve the pupils in co-operation as well as competition and have applications which involve all facets of mathematics. It includes off-computer activities such as pencil-and-paper work to freeze and give permanence to pupils' thoughts and make these thoughts more explicit and organised.

This makes the development of higher level skills, such as knowing how to reason about knowledge and how to acquire and adapt it, more important than the content of the software and crucial to the focus on the activity of learning (Self, 1985). It becomes dehumanising when one automates any part of thinking and learning and puts the results into the 'desolate language' of the computer.

Sixteen of the pupils responded in the questionnaire that the software CARS-MATHS IN MOTION was excellent, because it was more exciting than the rest and was competitive. Also, it was like a real race which you had to plan and it was not you and the computer competing but you and everybody. All the others were seen as boring with SLYFOX being seen as 'like a wild goose chase'. LOGO, also, seemed to evoke a negative response both in the interviews and on the questionnaires. Although SMILE was preferred to LOGO, it was seen as guessing games which became boring.

According to Zajonc (1984), appropriate computer use in primary schools is consistent with the world of childhood, environment and teacher ... "filled with movements, patterns, emotions, images and actions". It does mean that the interaction of young people with computers can be encouraged, if thought is given to the appropriate selection of the software. In fact, appropriate computer use can liberate and empower the individual to think. Turtle (1984) supports my view that the computer is not intervention; it can be used to liberate and elaborate. Using computers in our classroom will mean a change in teacher approach, as well as a reconsideration and adaptation of the methodology and, perhaps, even the content presently being used in school curriculums. When using new programmes, teachers reveal themselves as learners and the pupils gain an opportunity to learn with a learning adult. The teacher who often is new to computer use risks been seen as a learner and not just the possessor of knowledge. This model provides a richness of possibilities in the teacher-technology-pupil relationship. Any teacher embarking on using computers has unique opportunities waiting to be explored. If software is to act as an effective auxiliary to these opportunities, it must be able to be used in a way that is consistent with the approach to learning found in the classroom. Education needs 'appropriate' technologies that are a tool and not simply a toy or a technological means of control. We need a pragmatic approach where the old can be integrated in the new without losing its capacity to be evoked by itself (Gattegno, 1985).

5.4 CONSIDERATIONS

In order to ensure that the software used is appropriate, computer work must be an integral part of the curriculum and not tacked on as an afterthought. Software needs to be tied into the mathematics syllabus and its use guided by educational considerations rather than simply because the programmes are available. "Essentially the task is to explore and exploit opportunities provided by the microcomputer without sacrificing that which is educationally worthwhile and valued". (Garland, 1982). Using software should place the pupils in control of their own learning, allowing them to make self-selecting decisions and to manipulate the informational substance of the programmes. The developments to be discouraged are those where the teacher uses the computer to constrain or to pace the pupil or his learning, or to manipulate the knowledge base. This denies the pupil the opportunity to experience personal control.

When mathematical software is selected, due consideration must be given to the content and its system of instructions. There is also the need to consider the collaborative working in groups, the use of peers as resources and experts and the fact that not all the pupils cope with equal facility. I have no doubt that computers will affect the social organisation and, as a result, determine educational outcomes to a greater extent than the content of the software.

I feel the use of the computer can also be said to humanise rather than mechanise education. While using mathematical software the boys did tend to have positive social-emotional exchanges. Swigger et al (1983) supports this view and noted that children preferred social use of computers to their isolated use and they did tend to share more.

Once the barriers of keeping their knowledge private had been broken down, I did find that the boys shared and collaborated more regularly. Hawkins' (1983) findings support that the pupils are more talkative and collaborative when using computers than when not. The co-operation and sharing makes appropriate usage of computers as strongly humanistic. It also freed me as an information-bound giver. I had time to move around and discuss non-computer matters with the boys.

What 'Artificial Intelligence' is needs to be understood, and what computers can and cannot do clearly explained so that pupils can come to understand their own abilities and limitations. The social and ethical consequences and implications of being computer literate should be openly discussed. The real danger of a widening of the gap between the 'haves' and 'have nots' could lead to a new breed of social outcasts, the computer illiterate. Pupils should be made aware of this potential problem.

Me : "You are all very fortunate. What of the children who don't have access to these computers ... all those needy children?"

Chew-Wha: "They just have to suffer, sir."

Byron : "I am fortunate, sir."

5.5 RECOMMENDATIONS

I agree with Self (1985) that the wave of the micro is riding on a small band of enthusiastic, self-elected teacher-cum-programmers (tcp) who are unrepresentative of teachers as a whole. Their enthusiasm does not derive entirely from a cool analysis of the needs of pupils

but in part from their own position as computer 'experts'. Their commitment does not seem to be based on a sound educational philosophy. Neither is it based on a deep understanding of the capabilities of the computer technology, nor on an understanding of the pupils; much to the detriment of computers and the potential educational value.

The computer can never replace the warmth and understanding, skill and training of a human teacher - a logical, technological extension of your teaching but never a replacement (Pantiel et al, 1984). The emphasis must be on learning 'with' computers rather than 'about' them. This does mean that the mathematical software must be developmentally appropriate and educationally relevant.

It is ultimately the unparalleled interactive capacity of computers that educators point to as the principal ingredient that makes the technology worth all the fuss (Karoff, 1983). I found that pupils interacting with computers do become more co-operative, more autonomous, more patient, and their self-esteem is increased. Burg (1984) and Chin (1984) confirm these findings. Mathematical software needs to be used as a tool to extend and enrich the lives of pupils, in addition to, rather than as a replacement of, other experiences. The computer can be a time-saver and allows pupils to do things they could not do before. This does require a set of directions or clear principles. Not all software helps pupils achieve important educational objectives, though carefully selected software that matches curricular goals could raise the levels of achievement.

I feel that teachers will have to interact with computers, and the software, to establish themselves in the forefront as change agents and play a crucial role in the move to use computers to enhance and accomplish educational objectives. I agree with Gattegno (1985) that by acquiring the ability to dialogue with the computer, we can increase enormously our human mental powers, as well as note how we made the computer share some of our resources and thus become still more useful in education.

The real change, though, needs to be in our views about how children learn mathematics and how classrooms need to change in order that learning can take place. This involves realising that children own, rather than rent, their mathematical awareness. Warwick (1985) supports this view. The teacher using the computer as facilitator must help the pupil take a more active role in its learning, reflecting and organising and creating mathematics for themselves and then communicating their understanding to others. These implications will have to be fully researched.

The real challenge for teachers in using the software is not how to interest the pupils in computers but rather how to preserve and continue to stimulate a pupil's initial interest and, at the same time, have the computer become a tool for learning, where the pupil actively responds as the controller of his own learning.

Unfortunately, it is largely being effected at present as one that controls pupil behaviour.

Using computers appropriately in mathematics also requires that a balanced understanding be given of micro-electronics and

computer-related activities. Pupils need to grow up understanding the range of applications of computers in the today-world and the difference between theoretical and existing possibilities. They also need to be aware of the moral and social implications. This could best be achieved by teachers selecting suitable computer activities in which the pupil can engage. It does mean that teachers develop a properly critical attitude to avoid the danger of developing the over-simplified view of the nature of mathematics and the belief that there are straightforward technological solutions to the teaching and learning of mathematics.

5.6 CONCLUSION

I have come to understand that computers are not a 'once only' event but the beginning of a continuous commitment in terms of belief, changes in method and approach to content matter. There is currently a serious debate about the relevance of the mathematics we are teaching in the schools. The advent of the computer has raised the question of its relevance to the teaching of mathematics as well. Are pupils learning mathematics more successfully as a result of using the computers? Do computers provide the environment for mathematising? I think they do. Educationists should not be dismissive of the research being done at present. They ought to keep considering it and, when evaluating software, ask key questions such as, "Has it been researched, written up, and evaluated by other teachers?" And, more importantly, "What effect will the pupils have on it?"

The two current conceptions are -

- (1) computer aided instruction with the computer as tutor, and
- (2) the view of the child tutoring the computer.

(Papert, 1980)

Both have merit and need to be considered when teaching mathematics, particularly when designing a structure. Despite the boys showing a dislike and lack of keenness to do LOGO, I would include it in (2) even if it appears not to fit into the current mathematics syllabus. Papert (1980) maintains that LOGO can 'concretize' thinking processes. A carefully thought out mathematics syllabus, including the use of computers and software, can encourage pupils to think about their thinking. Is this not what all mathematics teaching should be doing?

1. NAME : _____ AGE : _____

2. WHAT IS YOUR FAVOURITE COMPUTER PROGRAMME? _____

3. WHAT IS YOUR VIEW OF THE FOLLOWING PROGRAMMES?

(i) LOGO

Very poor	Poor	Fair	Good	Very good	Excellent
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Why?

(ii) SMILE

Very poor	Poor	Fair	Good	Very good	Excellent
-----------	------	------	------	-----------	-----------

Why?

(iii) SLYFOX

Very poor	Poor	Fair	Good	Very good	Excellent
-----------	------	------	------	-----------	-----------

Why?

(iv) CARS

Very poor	Poor	Fair	Good	Very good	Excellent
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Why?

4. Whom from the members of your class would you ask -

(i) to help you to solve a difficult Math problem? _____

(ii) to help you solve a computer problem? _____

(iii) to be your partner on a computer? _____

5. Whom do you think is -

(i) the best on the computer in your class? _____

(ii) the best at Mathematics in your class? _____

6. If you could choose any three in your class to help you in a computer task, whom would they be?

(i) _____

(ii) _____

(iii) _____

7. Where do you rate yourself in terms of your competence in computer games?

No ability	Very Poor	Poor	Fair	Good	Very good	Excellent
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8. Where do you rate yourself in terms of your competence in doing Mathematics?

No ability	Very poor	Poor	Fair	Good	Very good	Excellent
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9. Do you think working on computers has helped your Mathematics?

YES	NO
-----	----

Give reasons:

TEACHER RATING

Actual Math ability :

No ability	Very poor	Poor	Fair	Good	Very good	Excellent
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RATING _____

19

according to examinations and tests this year.

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PRESENTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF EDUCATION

by

EDWARD WILMOT JAMES CHANTLER

AUGUST 1986

NON-EUCLIDIAN GEOMETRY - THE REVELATIONS

"Every man who raises above the common level has received two educations: the first from his teachers, the second more personal and important, from himself."

(Edward Gibbon)

INTRODUCTION

Throughout the formal years of my schooling and the four years spent at a Teachers' College, geometry teaching was confined to the presentation of standard Euclidian examples from a traditional textbook text. I was never expected to conceptualise anything beyond the figure drawn. Occasionally I would be taken slightly beyond them, through unusual examples, but always within the limits of a symmetric and ordered arrangement of words and rules concerning the figures which were always near and small and very clinical.

This staple diet of Euclidian geometry, much of which remained Greek to me, served to evoke beliefs within me of the exclusive reality and impeccable consistency of this body of knowledge. My intelligence had no real grasp and comfortably accepted and assumed that the rules Euclid had laid down for geometric relations in space were inviolate and confined to the comprehensible present. Space obeyed Euclid and Euclid obeyed space (Newman, 1956 : p.541). Euclidian geometry was the necessary geometry of any space. In the words of Plato, "If God ever geometrized, He surely looked to Euclid for the rules."

For the Greeks geometry had a dual aspect. It is claimed that it is an accurate description of the space in which we live and also an intellectual discipline, a deductive structure. These beliefs I had tended to subscribe to myself. Within deductive geometry the axiom

functions as a cornerstone on which further conclusions are based. The Euclidian postulates to me were self-evident.

In my teaching of geometry I held the popular belief that this component of mathematics consisted of a well-defined body of knowledge mainly concerned with the development of skills and techniques to solve certain well-defined problems. Thus for many years I had accepted that Euclidian geometry provided the historically first example of the axiomatic presentation of a mathematical discipline. Over recent years, though, several things have been said to me which, on reflection, left me with vague feelings of disquiet. Statements such as, "Euclid's own set of postulates are inadequate as reference is made to feelings of self-evidence rather than exclusively logical deduction, particularly his Parallel Postulate", worried me. As did one concerning triangles, where it was stated that they (the triangles) could have angles equal to more, or even less than two right angles of 180° . The Euclidian geometry which I had seen as an irreproachable, competent and accurate measuring tool - and so easy to teach and full of common sense - was being threatened to its roots. This issue I could no longer avoid. I had to find a solution to the issue and once and for all still the feelings of disquiet - that perhaps these last ten years I had been teaching geometry that was not only inaccurate, but a falsehood. My reading of the statement made by Eric Temple Bell galvanised me into 'research' action. It read: "The cowboys have a way of trussing up a steer or a pugnacious bronco which fixes the brute so that it can neither move nor think. This is the hog-tie and it is what Euclid did to geometry."

Could what I had been teaching all these years be considered as a hog-tie to children's thinking as well?

THE BEGINNING

It has been many years since I last investigated what I considered a new mathematical concept. I felt I had to research non-Euclidian geometry for insights that were meaningful to me, yet not so easy as to appear trivial. The academic content of my topic, I felt, had to be non-trivial to give substance to my individual investigation, and not be seen as the usual working exercises taken from a textbook. My insights and discoveries had to show my involvement and withstand a close scrutiny. I also wanted a content that was able to excite and lead me through an engaging and rewarding period of intellectual extension. In short, I had to set my sights realistically and also answer what was required of me. When others began talking of calculus and numerical analysis the concern for an academic merit for my insight deepened. The consideration that the subject matter and style of the actual mathematics investigations would vary, did nothing to console me.

The fact is, where does one start? I began reading in Courant and Robins (1973) and Coxeter (1961). The enthusiasm I initially felt was soon dampened. The reading was extremely difficult for me. I felt that something was missing. I was not achieving what I had set out to do at all. After some deliberation I decided to move away from this area and into another where I felt safer. I began looking into the domain of left and right cerebral hemispheres and how the left thinks in words and the right in images. I was now much more comfortable. It seemed from reading the book of Linda Dickson (Dickson et al, 1984) that spatial thinking and spatial processing were integral parts of the more comprehensive whole needed for the

investigation of geometry. Our physical environment is spatial, therefore a spatial facility is an essential component of mathematical functioning - intuitive awareness of spatial properties seems to me to be at the heart of most mathematical thinking. Spatial representations involve pictures, and diagrams that we draw in mathematics are representations of the real world, which is the physical environment around us.

How did my view of Euclidian geometry fit into this framework. As I see it, the Euclidian properties relate to size, distance and direction, which leads to the measurement of lengths, angles, areas, etc., and that shapes differ based on these measurements. The rules of this geometry are taught and simply applied, which seems a characteristic of left hemisphere processing. Also, society seems to emphasise and reward these types of activities. A premium is placed on being able to put ideas into words, to state them explicitly and to operate with rules. And the quickest and easiest way to do this is for the teacher to state the rules and demonstrate how they are applied. The feeling that something was missing grew all the more strongly within me.

The need for an academic component to my investigation led me to consider the 'nine-point circle'. The initial excitement felt on seeing something new soon paled. After I had drawn the figure several times, and considered the orthocenter and drawn the circles, I tried to find a consistent ratio between the area of the circle in relation to the area of the rectangles. My frustration grew as I became progressively bogged down in a dead end. My numerous drawings and calculations had led to nothing. Or so I thought. I stopped and took time to reflect on my position and the way I was avoiding issues.

THE CONFRONTATION

Thus began a sequence of understanding and insights into myself and mathematics. The major obstacle in my investigation was the tussle I was having within myself in admitting that my own mathematics was sorely limited. What kept resonating through my mind was that the view I had of myself as a mathematician was fast becoming an illusion. It was disconcerting to admit that I could no longer fool myself in a dressed-up notion of what I thought I was. I was testing the depth of my mathematical understanding, and, after removing the camouflage built up over years, I was exposed and feeling decidedly uneasy. I had also a growing realisation that I had to confront this issue, rather than resort to considering conciliatory strategies.

I had to face up to the fact that I really was a Primary School teacher with a limited academic mathematics background. My qualifications were more a study of the theory of education, which concentrated on the practical skills of teaching, rather than a specialisation in subjects such as mathematics. I thus had little guarantee of an adequate conceptual base in what I intended investigating. Equally disquietening was the consideration that subconsciously the reason for embarking on a course of this nature was perhaps to certificate and legitimate what I stood for and my future intended action.

I now found this investigation becoming more that one of looking at a new topic in mathematics to gain insights. It was also a growing awareness and admission of what mathematics I did understand and the

way in which I understood it. The search for rules and regularities as a basis for deep understanding was wrong. I had to give cognisance to my common sense in my investigation and risk the exposure of what I consider as meaningful and new to me, being seen as trivial by others.

THE INVESTIGATION

Despite the uneasiness I felt, I now had a sense of purpose and was no longer drifting along too frightened to become involved. I needed to go back to where I was originally - the two statements that disquieted me every time I thought of them. I began reading mathematics textbooks about non-Euclidian geometry. I considered the parallel postulate of Euclid first, as it seemed unproven. Soon I was again bogged down in a morass of non-understanding. It would appear that historically attempts had been made to improve this fifth postulate. Greeks to Arabians tried, but each of these attempted proofs carried a lurking fallacy (Newman, 1956 : p.102). It appeared that a proof of the parallel principle on the basis of the postulates of Euclidian geometry is impossible (Newman, 1956 : p.164). At this stage the reasons were lost on me. Was I about to enter another dead end?

I decided to go backwards into history to see how the postulate was disproved and by whom. By considering how the non-Euclidian geometries came about, and how they have stood up to scrutiny over time in terms of their truth and consistency, I hoped I would gain an insight into understanding them. It seems that early investigations of Euclid's fifth tried to assuage the doubts of its validity by attempting to derive it logically from other axioms, which seemed to

be self-evident. It would then become a theorem and have its status assured. It was when I came across the work of the Jesuit priest, Girolamo Saccheri (1667-1733) that I felt at last I was on to something.

Saccheri developed the consequences of denying Euclid's parallel axiom while retaining the others. He expected to develop a geometry which was self-contradictory. He worked with a quadrilateral ABCD, which has right angles at A and B and in which $AD=BC$. Within Euclidian geometry AD will be parallel to BC and this makes the angles at D and C both right angles. Saccheri, by not accepting the fifth postulate, concluded that he had three options:

1. The angles at C and D are both right angles.
2. C and D are both obtuse angles.
3. C and D are both acute angles.

If one considered the (2) and (3) options then the conclusions are startling. Saccheri stopped at this point and failed in contradicting himself, and, according to Newman (1980, p.2020), laid the foundations of the first non-Euclidian geometry. I began toying with the idea of C and D being either more than or less than right angles and whether AD and BC could remain parallel. I was not convinced - or did not understand.

It was when I began reading of the work of Gauss, Boylai, Lobachevski and Riemann that I felt I was at last getting to the heart of non-Euclidian geometry. What these men had found and decided after analysing its foundations, was that while Euclid's geometry was

unimpeachable as a system of ideal space and a good exercise in logic, its validity as regards actual space should be tested, not by mathematics, but by observation. Other geometries deduced from postulates differing from those framed by Euclid - especially his parallel postulate - were not only logically possible, but might turn out better suited to describe regions of space not normally accessible to our senses. (Newman, 1956 : p.456). I found this fact disturbing until I began thinking about the solar system and the universe. An understanding of non-Euclidian geometry would enormously extend the horizons of my own understanding.

Gauss, Lobachevski and Boylai had shown that a perfectly self-consistent geometrical theory is obtained if the postulate of the parallels is replaced. Out of this grew a branch of geometry called hyperbolic geometry. This geometry was not simply a novelty; it was a revolution then and a growing revelation to me now. In a very practical way it runs counter to Euclidian geometry.

On closer consideration of their alternative postulate, I became aware of the following :

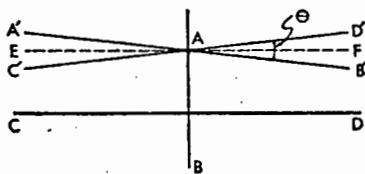


Fig. 1 (From Kasner et al, Aug. 1959)

In Fig.1 line AB is perpendicular to CD. If we allow the line to rotate about A counter-clockwise it will intersect CD at various points to the right of B until it reaches a limiting position EF when it becomes parallel to CD. Continuing the rotation it will start to

intersect CD to the left of B. Euclid assumed there was only one position, EF, parallel to CD. Lobachevski assumed there were two positions represented by A'B' and C'D' as well as all lines falling within the angle θ while not parallel to CD, would never meet, no matter how far extended. (Kasner et al, 1959 : p.139).

It was while reading further that I came across the fact that Riemann proposed still another substitute for Euclid's fifth postulate, differing from that of Lobachevski, Boylai and Gauss. "Through a point in the plane no line can be drawn parallel to a given line." The insight I thought I had gained in considering the hyperbolic geometry was once again in disarray. I had thought hyperbolic geometry was the only non-Euclidian geometry. According to Riemann's substitute, every pair of lines in the plane must intersect. To him space may be finite but unbounded. His hypothesis would also affect those theorems of Euclid dependent on the fifth postulate. Both Euclid and Lobachevski geometries state that only one perpendicular can be drawn to a straight line from a given point. In Riemann's any number of perpendiculars can be drawn from an appropriate point to a given straight line. What does this mean and how does it affect Euclidian geometry?

Euclid declared that the sum of the three angles of a triangle is equal to two right angles. He also declared that the sum of two adjacent angles, made by crossed lines, is equal to two right angles. Both properties were implied in his fundamental axioms and postulates. According to hyperbolic geometry the declaration about the crossed lines is true, the one about the triangle is not. In fact, a triangle can be drawn where the sum of the interior angles is less than two right angles. In Euclidian geometry two triangles can have

the same angles but different areas. In hyperbolic geometry as a triangle increases in area, the sum of its interior angles decreases. Thus only a triangle of equal area can have the same size angles. While I was considering these statements I discovered that Riemann indicated that a triangle can have the sum of its interior angles equal to more than two right angles. This was called elliptic geometry. I felt I was now at the heart of it. Less, equal and greater - three contradictory statements which give rise to the three geometries of elliptic, parabolic and hyperbolic, the parabolic being that of Euclid. All three are still part of the understanding of a whole Geometry. The problem I was having at this stage was that I was considering these three geometries as flat surfaces. I had not considered lines and surfaces in three dimensions or as very large or very small spaces. What if one does consider three-dimensional shapes?

Indebted to the postulates of Euclid are the two non-Euclidian geometries of Lobachevski and Riemann. The question is - are their postulates consistent and without contradictions?

If one generates a surface by revolving the curve known as the tractrix about a horizontal line one creates what Beltrami named a pseudosphere. The geometry applicable to a pseudosphere is that of Lobachevski. I became fascinated by this shape.

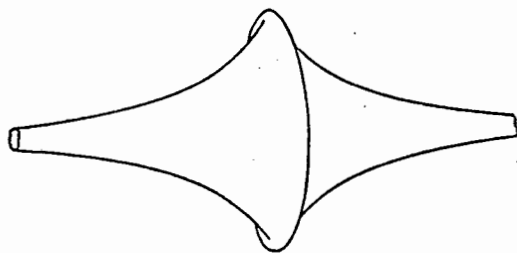


Fig.2. The Pseudosphere (From Kasner et al, 1954)

Through a given point two lines may be drawn parallel to a third one, which will approach them asymptotically without ever intersecting. Thus Lobachevski's geometry is satisfied by an entity from Euclid's geometry complying with the criterion of consistency. (Kasner et al, 1959 : p.143).

I now realised that the belief I had that geometry considered flat surfaces only no longer had any value. Also, that if one draws triangles on a pseudosphere, the larger the triangle that is drawn, the smaller the sum of the interior angles. It was all beginning to make sense to me.

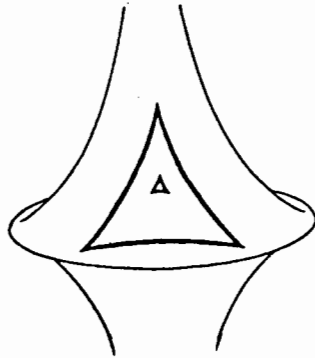


Fig.3. Triangles drawn on a pseudosphere (Kasner et al, 1959)

I found the geometry of Riemann is applicable to the sphere. It became easier for me when I considered the sphere as the earth with planes passing through the centre cutting the surface in a great circle.

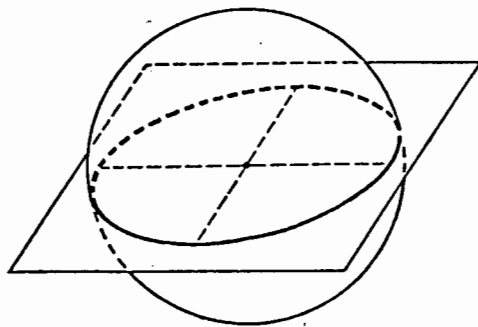


Fig.4. (Kasner et al, 1959)

Every circle passing through the north and south poles on the earth's surface is a great circle (longitude), but with the exception of the equator, the circles of latitude are not. Yet the lines of longitude which are straight lines and always perpendicular to lines of latitude (which, in Euclidian geometry, would imply they are parallel) always intersect at the poles. The elements which satisfy the surface of the sphere (earth) are identical with those of Riemann's geometry. In fact, two straight lines drawn on the sphere's surface, if sufficiently extended, will always enclose an area. This means the axiom of betweenness has to be abandoned.

I was further taken by a triangle drawn on the surface of a large sphere having interior angles totalling more than 180 degrees and the fact that the larger the triangle, the greater the sum of those angles. I could even visualise it on a tennis ball.

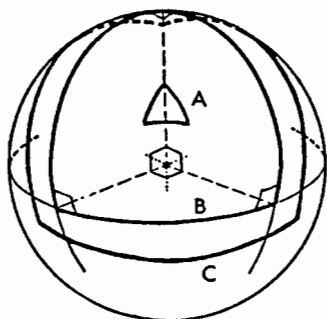


Fig.5. (Kasner et al, 1959)

In Figure 5, triangle A is small compared with the sphere and the interior angles are close to a total of 180 degrees. When we consider triangle B, the sides which lie on three perpendicular great circles, the interior angles can be $90^\circ + 90^\circ + 90^\circ = 270$ degrees. In the still larger triangle C, the obtuse angles will have a total far greater than 270 degrees.

I did pose myself the question of whether these straight lines are not really curved. In fact, the great circle on the sphere corresponds to the straight line on the plane - it is the shortest distance between two points. Generalising this notion, a curve which is the shortest distance between two points (analogue of the straight line in the plane) on any kind of surface is called a geodesic of that surface. (Kasner et al, 1959 : p.146).

Thus in the plane, if we adopt Euclid's postulate, then a pair of geodesics meet only at one point, unless parallel when they do not meet at all. While on a sphere a pair of geodesics, even if parallel, will always meet in two points. The sphere obeys elliptic geometry of Riemann. On the pseudosphere parallel geodesics may approach one another asymptotically, but they will never intersect or cross, thus obeying Lobachevskiiian or hyperbolic geometry.

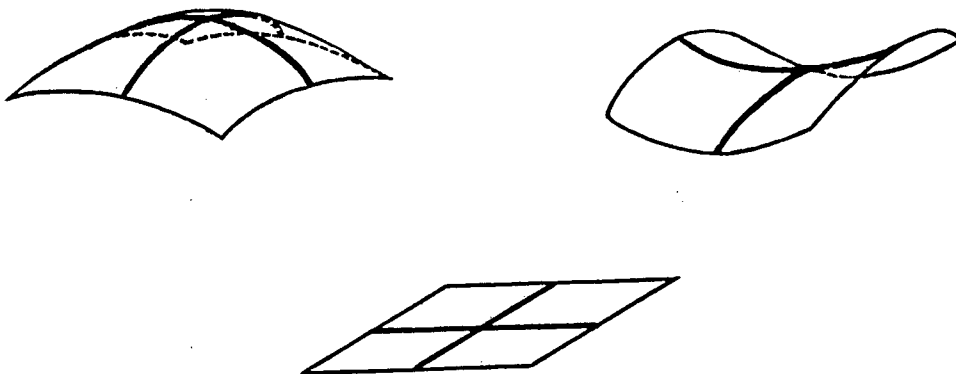


Fig. 6. Curvature (Kasner et al, 1959)

In considering Figure 6, it can be seen that the geodesics of a surface are determined by its degree of curvature. The flat plane of parabolic or Euclidian geometry with its zero curvature. The elliptic geometry which plane is that of a sphere or ellipsoid and is one of positive curvature. The saddle-shaped surface of the

pseudosphere is said to be of a negative curvature. These parts of a whole in the figure made the question of 'straight lines' make so much sense.

THE REVELATIONS

It was only when I was asked to explain what is meant by non-Euclidian to my young nephew, that I began realising what understanding I had developed. The rapture I experienced in being able to explain with confidence this aspect of geometry I once avoided, will never be forgotten. I ended up drawing lines all over a tennis ball. No longer will I ever reason in straight lines drawn in a plane of zero curvature, or in a world that is flat, near and small.

On reflection, I consider the insights I have gained through my investigation comprising two broad categories - one being mathematical, the second personal.

Some of the important insights that I have gained from this brief study of non-Euclidian geometry are :

- (i) We cannot prove everything - but must take something for granted.
- (ii) Some statements may be true in one environment but not true in another.
- (iii) Some statements may be true from one point of view, but not from another, ie. my statements can be questioned.
- (iv) There is no need to despair, on the contrary, many fertile ideas can lead to more discovery.
- (v) A major constraint is the limitations of the human mind and its prejudice.

I have come to know that space is finite, but unbounded. For every surface, however complex its curvature, there is a peculiarly suited

geometry which can be just as 'true' as the geometry of Euclid. The convenience of Euclidian geometry must not preclude using the others. The world is in a state of flux, ever changing. Even the absolutes of space and time contract and expand incessantly. Everywhere the pattern moves. Our mathematics needs to include this dynamism. I can no longer believe that the customary geometry taught in our school is logically inevitable or spodictically certain. I have also become far more aware of the need to be critical of the material we teach and the way we teach it. I now know that the poor teaching of mathematics, so plainly evident in our schools, is because of the restricted quality of the mathematics of persons such as myself.

It is in the personal insights where perhaps the greatest revelations have taken place. I have suffered an anguish in confronting the insights into myself and my shortcomings. The insights into myself have caused me to ponder on my position as a mathematics teacher and realistic educator. I feel I am at last becoming reconciled to how little I do know. The investigation has changed my attitude to researching mathematics topics and given me an added confidence in myself in tackling unknown aspects, despite the uncertainty, risk and intellectual turmoil it creates. I feel I can now set about repairing the shortcomings in my own deep understanding of mathematics through experiential involvement. I feel I can now conquer my resistance, and work toward higher levels of mathematical abstraction, no matter how ordinary and concrete the beginnings. I have also become aware of how inflexible I am at times and the need to be more open and see my limitations as potential opportunities and possibilities for growth, rather than something to be avoided.

CONCLUSION

Though constraints of time have obliged me to write up the investigation and insights I have gained, I have not stopped my reading into the topic. At present I am tussling with the isosceles birectangular quadrilateral and the results of the figure being drawn on the three surfaces. The insights I am striving for are somewhat tempered by the partially resolved thoughts I still have about legitimating myself as a mathematics teacher. Yet, somehow the uncertainties of my future as a mathematics teacher no longer seem so threatening.

I have resolved to keep putting questions to myself and leave options free and open, thus allowing for decisions, changes and choices in interpretation. I will continue to develop my awakened mathematical awareness and uneasy understanding which have lain dormant for so many years. Mathematics teaching has again become a challenge. A challenge to develop a mathematical awareness and insight in the young children I yet hope to teach.

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SPATIAL THINKING AND THE RELEVANCY OF GEOMETRIC TRANSFORMATIONS
IN TEACHING PRIMARY SCHOOL GEOMETRY : A REVIEW OF RECENT
RESEARCH FINDINGS

"Space only has meaning when it contains objects which we can see in relation to each other, or can observe in motion, as they change their position relative to ourselves or to one another." (Williams et al, 1980)

INTRODUCTION

The interpretation of the current Primary School Geometry Syllabus has long been felt by many teachers to be less than satisfactory.

Geometry in general is not considered important in its own right, probably as a result of the rather useless topics that have been included in the school syllabi. It is seen as teaching for 'fun' or preparation for High School. Little consideration has been given to developing a different kind of 'space experience' geometry for pupils.

There is a growing need and emphasis for freedom in an alternative and more appropriate interpretation of this syllabus, providing for a more integrated approach. This approach contradicts the more 'traditional' approach of separating the different aspects, be they geometry, arithmetic, etc. Such a 'new' structure in Primary School mathematics is not intended to impose a new set of jargon words on young pupils, as this would simply serve to perpetuate the fear and isolation already felt by pupils in the current approach, but to provide a more acceptable way of mathematical reasoning in Geometry.

My intention in this essay is to consider a child's spatial thinking and to review recent research in the learning and teaching of

transformational geometry in children aged approximately 5 to 12 years. It is hoped that this information and insight gained by the researchers will help in the teaching of Primary School Geometry.'

SPATIAL THINKING AND ITS DEVELOPMENT

In the past spatial work has been neglected in favour of a mechanical 'sums and problems' approach (skill oriented) which has all but extinguished any possible love pupils may have had for mathematics. Many of the problems are artificial to the point of absurdity, concentrating on a child's reading ability and aptitude in handling symbols. Geometry was concerned with the area of strange shaped rooms or of garden paths that surrounded a boring rectangular lawn. (Wain, 1978). Opportunities to develop their spatial awareness suffered.

In fact, children show an early interest in shapes and their properties as well as the movement they undergo in changing their position or altering their structure. Some of the earliest characteristics that a child discerns are the topological properties of open and closed, solid or hollow and flat or curved, and whether shapes have curved edges, straight edges or no edges. Edges become sides and corners points in the move from three-dimensional to two-dimensional shapes.

These new concepts which are acquired by children in mathematics must be expressed in some way so that the concepts are clear in their own minds as well as being available for use in new thinking. We do know that children of school-going age have a wide range of spoken language through which they can express their actions, observations and ideas.

This spoken language is often insufficient for the young pupil to register and record what is being acquired mathematically.

According to Williams et al (1980), there are three main types of mathematical language. The first is words of common speech with special mathematics words added denoting relationships and operations. This special vocabulary is learnt by the children. The second form of mathematical language is the use of diagrams as a convincing way of expressing relationships which children perceive. The third language is the abstract use of symbols which normally develops after the first two. The spatial activities and development of spatial thinking in the young child leads to all three forms of mathematical expression, stressing the need for a comprehensive teaching in any math syllabus of a Geometry.

Piaget and Beth (1966) claim that logical, arithmetic and geometric concepts arise from a common source in children's interaction with concrete materials which in turn is dominated by the child's spatial experiences (thinking).

In the teaching of Geometry it is essential that the visual and perceptual aspects of figures become known while children are encouraged to use appropriate language. Many young children who enter school are unable to express mathematical ideas because of language inadequacies which restrict their learning.

There is increasing physiological evidence that these two aspects (spatial representation and language usage in the learning of mathematics) may be linked to the activities of the different halves of the brain with spatial processing done by the right and language functions performed by the left hemisphere. Wheatley and Wheatley

(1979) suggest that individual pupils are not necessarily equally proficient in both areas. Thus a spatial approach may lead to the introduction of appropriate language in a meaningful way, especially spontaneous oral communication, in the learning of mathematics (DO, DISCUSS then RECORD).

Sharma (1979) has given a comprehensive account of much of the literature in this area and research indicates that for most right-handed people the left hemisphere 'thinks' in words and the right hemisphere 'thinks' in images and is concerned with spatial and visual aspects. Sharma identifies two types of mathematical learning personalities :

1. the left hemispheric orientation one who is good in language and solves problems bit by bit and works sequentially;
2. the right hemispheric orientation one who sees problems holistically and explores global approaches to solutions in a non-directed metaphoric way and is spatially and symbolically more creative.

Much of this hemispheric theory is as yet speculative and many learners do not favour either of these strategies, but operate in a versatile way depending on the context of the problem. Wheatley (1977), however, feels that the spatial development (right hemisphere) of children at school has been under-emphasised at the expense of putting ideas into words, to state them explicitly, and to operate with rules. Regardless, the two aspects of mathematics - language and symbols on the one hand and spatial representations on the other - are entirely complementary in nature and should receive a reasonable share of attention in any mathematics curriculum.

How important is spatial thinking? People tend to be more frequently confronted with spatial problems than with numerical ones in their

everyday activities, because our physical environment is itself spatial. Thus a spatial facility is an essential component of mathematical functioning ... "Intuitive awareness of spatial properties seems to be at the heart of most mathematical thinking". (Hemmings et al, 1978).

Plunkett (1979) points to two basic types of spatial matters in the teaching of mathematics :

1. Those to do with the real world.
2. Those concerning representations of the real world.

Representations of the real world involve pictures and diagrams with varying degrees of distortion. Much of mathematics teaching has its foundation in this medium and thus spatial difficulties can lead to problems in other areas. Lesh (1978) states that

"Most of the models and diagrams teachers use to introduce arithmetic and number concepts presuppose an understanding of certain spatial/geometric concepts. Consequently misunderstandings about number concepts are often linked to misunderstandings about the models that are used to illustrate them."

Thus a certain type of spatial interpretation can hinder the communication of a mathematical idea.

A CONSIDERATION OF PIAGETIAN THEORY

The young child's first interactions are concerned with his immediate environment and is based almost totally on spatial experiences using the senses of sight, hearing and touch. Language comes only later. Thus physical actions become internalised and generalised into concepts and relations (Dickson, 1984). Psychologists such as Piaget, Bruner and Dienes (1959) believe that the manipulation of

'concrete' objects forms the basis of knowledge concerning mathematics. Most pupils in primary schools have not moved beyond the 'concrete operational' stage and are dependent on spatial concepts for their understanding in all areas of mathematics. The research of Prigge (1978) tends to support this view.

Piaget et al (1960) proposed a theory of the child's development of spatial concepts distinguishing between perception, which is defined as 'the knowledge of objects resulting from direct contact with them', and representation (mental imagery), which 'involves the evocation of objects in their absence'. There is a time-lag involved between perception and representation and quoted on by Lesh et al (1978).

Piaget further distinguishes a progressive and sequential differentiation of geometrical properties going from

- (i) topological - global properties independent of size or shape;
- (ii) projective - prediction of how an object appears from different angles;
- (iii) Euclidian - relating to size, distance, direction and measurement.

Despite Piaget's significant contribution to the study of spatial thinking in children, much of his theory is open to criticism. Lesh et al (1978) state that the present tendency is to blur the distinction between perception and representation which Piaget considered so important. As an example, they quote how a two-year-old, in order to correctly name shapes, must have some mental representation of these figures to match his perception. Also, different results can be achieved when the methodology of Piaget's experiments is changed. Fuson et al (1978) showed that children identify shapes by touch much more easily if shapes are smaller.

Thus the difficulty may not be the matching of tactile to visual information, but the using of a more systematic approach in exploring larger shapes.

Piaget tried to explain the development of spatial ideas by hypothesising a topological, projective Euclidian sequence. Weinzweig (1978) maintains that Piaget does not use mathematically acceptable definitions of these properties or test the full implication of his theory. Coxford (1978) notes that it is more probable that some topological concepts develop early, while others, like topological equivalence, develop later after some Euclidian and projective ideas have been grasped. Thus Piaget's theory of spatial development does not seem to stand up to recent evidence. See also Martin (1976) and his study to test the Piagetian hypothesis.

It seems a developmental theory relating dimensions of psychological complexity to the child's ability to process information will eventually provide a more successful explanation (Dickson et al, 1984). Geeslin et al (1979) considered testing procedures and the very careful use of mathematical terms in their 'alternative model' of perception and suggest that a hierarchy of cognitive skills is necessary to understand different geometric properties.

VAN HIELE LEVELS - AN ALTERNATIVE

Coxford (1978) outlines Van Hiele's theory of five levels of spatial development with specific reference to school geometry curricula.

Level I

Here figures are distinguished in terms of individual shape as a whole and relationships are not seen between shapes or their parts.

Activities should concentrate on individual figure recognition, production and naming, ie. visual geometry. Each shape should be of a size that fits comfortably in a child's hand. Construction is preferred to drawing, using sticks, as it allows for trial and error and adjustment placements.

Level II

A development of an awareness of parts of the figures as well as relationships through observation, experimentation and practical work (model-making). Egsgard (1970) emphasises the use of three-dimensional solids before two-dimensional surfaces. There should be plenty of discussion as these two- and three-dimensional shapes lay the groundwork for understanding area, volume, their measurement, as well as providing the foundation for geometric transformations.

Level III

Relationships and definitions clarified under guidance, practical experimentation and reasoning. Pupils establish relations among the properties of a figure and among figures themselves. There is a logical ordering of properties. The pupil does not yet understand how to modify this order. Deductive methods and reasoning are used to discover properties.

Level IV

Development of deductive reasoning and theory construction. There is an understanding of the role of axioms, definitions and theorems. The logical structure of a proof is accepted. Pupils can now see the various possibilities for developing a theory proceeding from various premises.

Level V

Complete abstraction devoid of concrete interpretation and corresponding to the modern (Hilbertian) standard of rigor. Geometry acquires a general character and broader application.

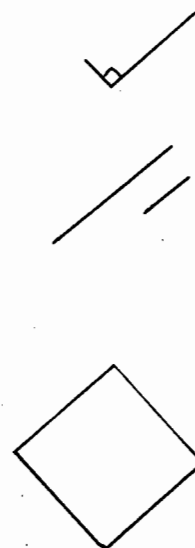
Wirszup (1976) maintains that a child's efforts in geometry are doomed if it is introduced to geometry via measurement, relationships and definitions before it has had a solid grounding in the visual geometry of Level I. Many of the misconceptions children have about space seem to be derived from focusing on wrong criteria through rather inadequate teaching. Often when a geometric form changes position, children believe that its character has changed as well.

Kerslake (1979) agrees that there is a usual manner for presenting various geometric figures. Children find it difficult to generalise concepts when these figures are represented using non-standard illustrations.

Standard



Non-Standard



Fisher (1978) discovered that children showed a preference for handling 'upright' figures rather than tilted ones, particularly when right angles were present, demonstrating the importance of orientation.

Kerslake has also pointed to the problems associated with differentiating rectangles and squares. There is an insistence that rectangles 'lie down' or are 'flat, long and not very wide', again pointing to the importance of orientation. The square was almost universally excluded from the class of rectangles.

Zykova (1969) provides a wide variety of misconceptions which 12-year-old Russian children have formed due to the nature of their geometry teaching where it has been confined to the presentation of standard examples. Many pupils do not conceptualise beyond the limits of the figures shown or go only slightly beyond, but remain within the limits of an ordered and systematic disposition of the figures. He concluded :

"It was experimentally confirmed that variation of the form and position of geometric figures alone without the organisational strength of the teacher's explanations, does not foster correct mastery of concepts. Only when the teacher's explanations play a leading role in instruction, do variations in geometric illustrations help the pupils to abstract essential features and to master the true geometrical relationships."

Another serious obstacle facing pupils is the perception of two-dimensional representations of three-dimensional space or shape and the building up of clear images. As Lappan and Winter (1979) state :

"In spite of the fact that we live in a 3-dimensional world, most of the mathematical experiences that we give our children are 2-dimensional. We use 2-dimensional books, containing 2-dimensional pictures of 3-dimensional objects

to present mathematics to our children. Surely this use of 'pictures' of objects introduces (for the child) another difficulty in the process of understanding. Yet it is necessary that children learn to cope with 2-dimensional representations of their world. In our modern world information will continue to be disseminated through books and pictures, possibly through moving pictures as on television, but still 2-dimensional representations of the real world."

This statement supports the use of nets and concrete apparatus and the need of children to talk about their discoveries in order to establish the language before recording a two-dimensional representation. The use of a concrete block and a later association with a square on the grid paper of the same size leads towards abstractness. Pupils need to explore and experiment through constructing, representing and re-constructing before recording. Two-dimensional representation appears to be a matter of convention and does not develop 'innately' but has to be learned.

THE USE OF REFERENCE SYSTEMS

Movement in space involves using reference points that are a stationary and unchanging aspect of space as a means of locating position and direction. These reference points provide a framework for the study of motion (Dickson et al, 1984). Piaget et al (1960) state that there can be no measurement, just as there can be no true representation of change of position, unless the space in which it takes place is structured by a system of references. An important factor of the reference system is an awareness of direction. Grieves (1979) maintains that normally spatial relationships are initially explored along the vertical axis and the language of looking up or down, high/low, above/below, take on a distinct meaning. Thereafter horizontal relationships develop, such as in front and behind, and

left and right; this last distinction being the most difficult, as both domains exist simultaneously in our visual field.

From a very early age children organise their world based on its unchanging aspects using their five senses. Their perceptions of the spatial world around them rely particularly on sight, touch and, to a lesser degree, hearing, in an appreciation of what remains unchanged. Despite alterations in time and space.

It is only once the child has come to grips and appreciates the unchanging aspects of such situations, that a deep understanding of space and geometry can occur and that time, space and movement can be seen differentially.

TRANSFORMATIONAL GEOMETRY IN THE PRIMARY SCHOOL

School geometry has in recent years become increasingly concerned with the movement of geometrical figures from one position to another or movement involving a change of size or shape. This transformation of shapes is beginning to play an important part in the teaching of geometry at the expense of the more formal approach involving theorems and proofs and the deductive method. Many teachers believe that geometric transformations help to provide a more unified whole of mathematics. Kuchemann (1980) maintains that this form of geometry is as inaccessible to pupils as Euclidian, but that transformations can be used to generate discoveries and check children's predictions and inferences. Thomas (1978) states that the main value of transformational (motion) geometry is in achieving an objective of an

informal intuitive appreciation of geometry. It also helps highlight congruence and similarity.

The basic transformations used in the Primary School can be considered to be:

- (i) Reflection (flips)
eg. folding,
mirror images

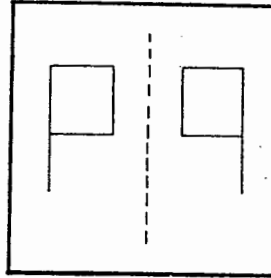


Image and object
are the same size
and shape

- (ii) Rotation (turns)
eg. orientation
of figure
changes

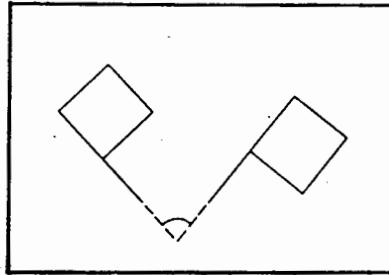


Image and object
are the same size
and shape

- (iii) Translation (slides)
eg. without turning,
to a point a certain
distance away in a
given direction,
ie. the orientation
of the figure is
unaltered.

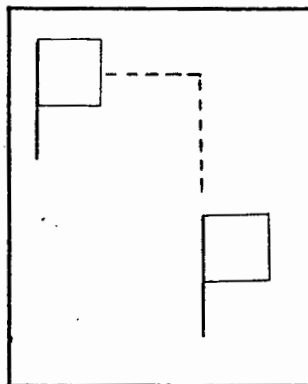


Image and object
are the same size
and shape,
ie. congruent.

(Based on Dickson et al, 1984)

RECENT RESEARCH FINDING IN TRANSFORMATIONAL GEOMETRY

Thomas (1978) ran a series of tasks involving the rotation reflections and translations of a triangle among 6-, 9- and 12-year-olds. The children had to compare the length of a specified side before and after each motion. The children were already familiar with the language 'larger than', 'shorter than' and 'the same length as before' before the tasks began. She found a crucial concept was the ability to conserve length in the classical Piagetian sense. Most pupils considered length to remain invariant for rotations and reflections, but for translations the non-conservers saw the length of the sides of a geometric figure as having changed. In fact, when a congruent copy of the triangle was close by for non-conservers to make visual comparisons they were more apt to believe that transformations changed the lengths of the sides of the triangle.

Thomas also studied children's (9 to 17 years old) understanding of the effects of reflections and rotations on the orientation of a plane figure. Letters of the alphabet were used and the children had to imagine what it would look like after a specified motion (a half turn clockwise, reflect vertically, etc.). Her main findings were rotating figures which already had rotational symmetry were very difficult for children of all ages to imagine. Also the youngest children attained the lowest scores. There was no striking difference between direction of turning on the rotational tasks nor between the horizontal and vertical on the reflection tasks.

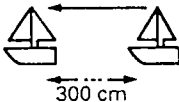
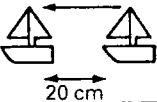

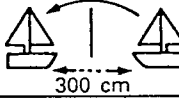



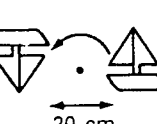

Kidder (1978) gave 9-, 11- and 13-year-olds seven sticks from which they had to select three to map out the image. She found 67% of the errors made were due to a failure to conserve length. Thus she concludes that conservation in the classical sense is probably a

pre-requisite for the conservation of length in more complex situations. Kidder suggests that a child should be at the Piagetian level of formal operations before it can differentiate between the tasks involved in the construction of such an image. Before this stage the child is concerned in finding a 'like' image rather than a 'congruent' one. (See also Kidder, 1976.)

Pernham (1978) used 6-year-olds in her studies of translations, reflections and rotations. The first two were investigated in terms of horizontal, vertical and diagonal orientation of movement while rotations of 45° , 90° and 180° were studied. Also, she compared the performance on those tasks before and after specific instruction with one group and with no specific instruction in another group. Her results bear out Piaget's conclusions that children learn the transformations in the order of translations, reflections and, lastly, rotations. Also, the ability to select a correct image from a series of alternatives does precede the ability to construct one's own. She points out that the results suggest that it would be better to orient the transformations, ie. horizontal or vertical, than to teach the different types of transformation. Pernham advocates including horizontal and vertical translations and reflections as alternatives in a series and as constructions for 6-year-olds.

Schultz (1978) considered the nature and size of the object as well as the complexity of the nature of the transformation.

Transformation	Horizontal	Oblique
Translation		
Reflection		
Rotation		

Transformation	Long	Short	Overlapping
Translation			
Reflection			
Rotation			

(From Schultz, 1978)

It was discovered that :

- (i) the tasks involving translations were performed more successfully than reflection and then rotation tasks;
- (ii) short translations were easier than long overlapping ones;
- (iii) horizontal translations were easier than diagonal ones. With diagonal translation the object tended to take on the direction of the displacement;
- (iv) images which required an overlap onto the original proved difficult;
- (v) 6-year-old children frequently changed a 'non-meaningful' task into a 'meaningful' one;
- (vi) the children preferred larger 'meaningful' objects which they found easier to translate than smaller ones;
- (vii) the most significant error with diagonal reflections was the fixation for either vertical or horizontal displacements rather than co-ordinating the two;
- (viii) overlapping reflections were more difficult than long or short reflections;
- (ix) the most striking errors made with reflections and rotations were to do with spatial orientation. (From Dickson et al, 1984.)

Children tended to turn an image so that it faced the direction of the reflection or turn.

It would also appear that young children had difficulty in reflecting when the mirror line was in a diagonal position rather than vertical. Kuchemann (1980), in studying children's difficulties with reflections, considered this aspect. He also varied the complexity

of the object under reflection. He found that :

- (i) a common error was ignoring the slope of the mirror line and simply reflecting horizontally or vertically;
- (ii) as objects become more complex, (i) becomes more apparent, particularly when the object was horizontal or vertical to begin with;
- (iii) two approaches to reflection problems were identified :
 - (a) A sequence of two steps involving the centre of the direction the object is moved in, and then the distance. Here performance in the task is assisted when using a grid.
 - (b) When a complex object is used both end points of the object must be located before the image can be drawn. The object must also be broken down into parts in order to control direction and distance. Using a grid seemed to assist most of the children.

In the same investigation, Kuchemann found that major difficulties were experienced by children when, in rotation, the centre of rotation was not on the object. Grids did not appear to be useful as an aid and horizontal and vertical starting positions were easier than diagonal starting. These results show that children as old as 14 years can find difficulty visualising even the simplest transformations. It may be the case that this type of geometry has a greater real life application than our traditional syllabus content.

Austin et al (1983) felt that transformations are considered only in terms of slide, flip and turn. They felt that the transformation's direction, as well as the configuration's size and meaningfulness, may affect children's understanding of transformations. The purpose of their study was to investigate the effect of direction of motion on the difficulty of slides, flips and turns for first, third and fifth graders (Sub A, Std I and Std III).

The results suggested that :

- (a) transformation-type-by-direction interaction suggests that the

direction of a transformation affects a pupil's understanding of transformations, particularly diagonals;

- (b) slides (translations) seems to be the easiest transformation for these pupils to visualise. However, the direction of the transformation influences the relative difficulty of turns or flips;
- (c) no clear sex differences on the tasks were found.

CAN THIS RESEARCH HELP THE CLASS TEACHER IN TEACHING GEOMETRY?

The research seems to provide the teacher with a systematic approach and an educational soundness for using transformations in teaching geometry. In any geometrical syllabus the children's exploration of space and the development of spatial thinking depends to a great extent on a consideration of their own physical movement and their observations. Shapes are recognised most easily in the position in which they are most frequently seen - balanced in shape, on a level and with a vertical axis. Finding shapes that look balanced leads to the discrimination of a symmetrical configuration and a practical appreciation of one of the most important concepts of mathematics - the idea of symmetry.

Children explore space spontaneously through the natural movements of jabbing or pointing, movement to and fro or up and down, and in moving round and round with their heads, hands or whole bodies. Williams et al (1980) transformational geometry seems to be the logical extension of these natural movements.

Another movement which is fundamental in mathematics is the motion in a straight line without any change of direction. Children see this every day on roads to school. One can develop this idea through the making of patterns. The child has seen how to make a good pattern by

reflection or folding, how by repeating a shape along a line produces an interesting pattern as well. Two shapes can be used and translated horizontally instead of vertically and even diagonally. A further variation is to reflect a shape and then translate the new shape. Rotation round a central point can also be used to make more complex patterns by superimposing one on another or by translating the shapes side by side in a pattern. The child can see that the shape itself is not changed by the turning movement or rotation. The inherent shape is invariant despite its orientation change.

By using these transformations a greater range of spatial experiences are given and the children develop a wide familiarity with mathematical ideas which cannot be obtained from number and operations alone. Translation along a line illustrates the basic operations of addition and subtraction in either direction needing both positive and negative numbers. The movement in rotation gives rise to a finite number system as on a clock face. Reflection shows that an irregular figure cannot be made to fit the original by a movement in the plane such as rotation or translation or a combination of the two. The symmetry created by a reflection is a valuable tool for discovering properties of shape. Later on children can use translation to rename a point when it changes its co-ordinates on a graph $(x,y) \rightarrow (x+a, y+b)$. Rotation can lead to the expression as a fraction the amount a line has moved or turned in comparison to a revolution. The children come to understand that under rotation there is a point of the plane which remains unchanged.

Using transformations as a heuristic means of investigating open-ended geometrical situations or problems to be solved, can lead to potentially unique discoveries where a pupil can experience a sense of exhilaration and freedom in which they are in control of the material.

All that is required of the teacher is a carefully worded initial statement or activity that initiates the investigation for each child at his own level.

A piece of apparatus which could be very useful in developing an understanding of the properties of different figures is the geoboard. It can be used for constructing open and closed figures as well as investigating symmetry, turning and matching, and sliding. Another way of investigating rotational symmetry as well as reflections and translations is using tessellations of regular and non-regular shape to design interesting patterns. Three-dimensional pantomimes can also be used in various ways to fill space and develop good groundwork for developing conceptions of volume, capacity and their measurement.

In fact, through the above usage pupils come to know the importance of being able to think spatially in both work and leisure time.

This recent research leads more and more to the realisation that ideally individuals need to be considered as the teaching units for which syllabi are planned. The whole idea of concept development and the significant variation in the developmental rate in individuals needs to be catered for and the implication is that syllabi need to be more diverse and flexible, rather than less. Teachers need to make full use of their freedom to consider educational objectives and maintain a continuing critical awareness in re-thinking the Geometry syllabus without simply accepting a 'new' orthodoxy. (Wain, 1978).

Children, developing at their own individual rates, learn through their active response to the experiences that come to them. Through constructive play, experiment and discussion, children become aware of relationships and develop mental structures (and language) which are mathematical in form and are, in fact, the only sound basis of mathematical techniques (from Mathematics Association, 1969).

Transformations strongly suggest this 'action based on learning by doing' characteristic. Through transformations school geometry can become an intellectual activity aimed at developing abilities such as abstractions, generalisations, symbolisations and proofs where pupils work individually and in collaboration, respecting the views of others instead of competing. The mathematical content of the learning process becomes subservient to this development. Mathematics can then finally become an activity to be experienced through investigation rather than a body of knowledge to be acquired.

"Certainly let us learn proving," wrote George Polya, "but also let us learn guessing. For the process of doing mathematics involves the interplay of experiment, of conjecture, of testing, of generalising and, only in quite small part, of proving."

CONCLUSION

If information about children's cognitive structures is ever to be useful in organising instructional activities for children, it is likely that known mathematical systems will have to be used as a guide. Transformational geometry seems to furnish an excellent guide and context in which to investigate

- (a) the extent to which known mathematical systems can be used to model the sequential development of children's mathematical concepts;
- (b) the psychological viability of analysing, ordering and equating tasks on the basis of their underlying operational structure; and
- (c) relationships between figurative and operative aspects of thinking. (Lesh, 1976).

As Piaget et al (1971) state :

"Spatial geometric intuition is the only field in which imaginal form and content are homogeneous."

The question of how the results of this research is passed on to the everyday teacher is unresolved. In fact, very little of this research is accessible. This problem has to be addressed if the benefits of the research is to lead to any improvement in the mathematics teaching and the understanding of mathematics by children.

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THE REALITY OF MY CLASSROOM PRACTICE

THE TASK

The period of research into my own practice, and reported on in this essay, came about as the result of an opportunity presenting itself while I was engaged in lecturing Primary School Mathematics Methodology to final year students. I had for some time been considering how I could fulfil the requirements of the 'Classroom Project'. I was required to video-record my classroom practice and then analyse the effectiveness of my teaching against the way David Wheeler (1970) outlines as the 'role of a teacher'. I had a choice of either researching my present practice in the lecture room, or the teaching I could do in one of the local schools.

I was blissfully unaware of the situation I had been constructing in the lecture room which was making it difficult, even impossible, for the students to have a choice in ways to react. They were struggling to preserve their freedom, autonomy and self-reliance and reacted through absenteeism and rejection of what I had to say. I simply put these reactions down to student fickleness.

SETTING THE SCENE

I do not know how long the rumblings of discontent had been aired in the lecture room and beyond, but I suddenly became aware of them being vocalised when, at the end of a lecture, I asked the students to pay attention to a piece of theory. The rebellious, bellicose mutterings

caused me to pause and reflect on the need, even desirability, of writing Bloom's taxonomy on the chalkboard for these students. Something deep inside me told me, let it be - it can wait. A brief discussion with my supervisor about this little episode left me only partly mollified. The students had sent a representative to discuss the matter as well. This student had been in before I had. During the next few days a plan began developing. Little did I know that in the ensuing weeks I would be reflecting on my classroom practice with highly critical students, video camera and observer in the lecture room.

My supervisor had asked me to see the disruption or problem as a potential form of enactive negotiation and that the discourse about the classroom process out of earshot of each of the involved parties leads to the building of different experiences and beliefs based on the same shared events. The different parties have the feeling that each one is justified and right in his beliefs. There is a need to share these experiences and beliefs using a recorded reality - the video camera. Also, the one who brought the complaints were in the frontline of disaffection and disruptiveness and could, in fact, turn out to be the most penetratingly analytical members of a collaborative group. I agreed reluctantly to become part of the collaborative exercise.

During the very next lecture period the entire group was approached about the problems they were experiencing with my style of presentation. We were asked to give our impressions - our memories of what had happened the previous week. The students were asked to comment first on the things they found difficult, didn't like and

where they felt things could be improved upon. After some hesitancy the first comment was made, based on what some of the students had been saying.

S: "As we began working through the two worksheets that ... we weren't given sort of enough time to work or decide on our own ... what to do with them or how one presents. The idea was that Ed sort of gave us the worksheets as the sort of type of way one wouldn't teach the worksheets or the type of worksheet one wouldn't use and then the idea was we tried to throw in ideas of yes or no, right away."

This was soon followed by the following comment :

"It was a very good idea ... because we all saw two worksheets which any of us could have made up ourselves but weren't ... obviously weren't teachable and we saw they weren't teachable and I went away from the lesson feeling that I know they aren't teachable but I didn't know why. I'd know why, say, because Wendy had said they weren't suitable or Cynthia had said they weren't suitable, but I didn't. I just felt that I wanted someone who ... who had used them before and who knew why they weren't suitable to tell me why they actually weren't suitable. You know, I wanted something more tangible and there wasn't anything ... the second one I mean I might have used myself, but I don't know why not to use this one."

"... the idea was good that we could see we were going to do worksheets that weren't any use, but then that's as far as we went and we had an hour and a half. We could have done that in the first twenty minutes and then gone on to something else which was more productive and perhaps more practical, where we could have had to sit down and grafted on it and work ourselves to a standstill - but then have have done something more practical ..."

"Well, I saw the point as well of the first worksheet and what was wrong, but then by the time we got to the second one, basically the same things are wrong ... different worksheets but kind of making the same kind of mistakes. I didn't see the point of doing it again."

My impressions had been that the lecture had been going fairly well until I had insisted that students write the pros and cons of the worksheets onto the chalkboard. I also felt that not enough time had been spent on working through the exercise. I also felt that if the

group felt they were wasting their time, it was up to them to raise it and ask if they could get on with something else. On reflection, this perspective of mine was perhaps defensive and perhaps to hide my uneasiness. How to resolve the conflict?

It seemed that this was a valuable opportunity of exploring the dimensions of the conflict so that everyone could learn from it and improve their own classroom practice. Patently the scene was being set for a group of students and myself to take responsibility for their learning. It meant that a group of students would have to become involved in the planning and in the criticism of what happens in the lectures. The lesson would be recorded on video so that personal biases could be excluded. Everyone would have to reflect on what actually happened and explain it. The video would keep an accurate record of an otherwise very vague and diffuse classroom reality. Through collaborative and consultative assessment of when teacher behaviour got in the way and when student behaviour got in the way, it was hoped classroom practice would be improved. Our beliefs could be challenged and improved on for the next time in front of a class. With that, the cameras rolled and the recording began and I started teaching.

THE FIRST SESSION

The first collaborative group session found the six students plus Chris, Tom (who had now been included as an observer) and myself nervously confronting a video recorder and about to embark on something both disconcerting and yet challenging. The anticipation of what was about to happen was slowly gnawing away the last vestiges

of my confidence. What concerned me as well was that there appeared to be no fixed agenda beyond looking at the video and remarking on it. It all seemed so unplanned.

It began rather slowly and quietly with our viewing the video and our attention being drawn to the direction I talked in (left or right side of the class) when giving instructions. The students felt I favoured the one side of the class. Perhaps it was the side I needed co-operation from or it could be a control method I used to quieten the noisy students who occupied that area of the room. An alternative reason given was that I appeared camera shy as I always seemed to be looking away from it. A safe reason which I readily accepted. A student suggested we rearrange desks to confirm whether most of the students sat there or whether something else was causing the favouring. The early tensions that had existed in the group were slowly dissipating. My tenuous complacency was about to be shattered.

"... what was the aim of doing those worksheets on the overhead?..."

This question was slightly more problematic and closer to the classroom reality. My response of "If you go back to the beginning ..." was an effective teacher silencing technique using teacher control and teacher authority to put the student down and avoid answering the questions she had posed. Her further suggestions of

"... maybe had them up longer ..."
"... encouraged a class discussion ..."
"... maybe it would be better if we heard everyone's point of view."

all pointed to a need for a careful study of my approach and planning of the lecture. Something we could amicably work out together.

The speed that I had changed the overheads seemed also to be creating a problem.

S: "I think you will see later ... you went through very quickly through some. And others really you got, you know, delayed.

Ja, but it was very frustrating because we lost you with all ... okay, where are we going today? Are we getting more than two today on purpose? Or is it a reaction to the previous week? I say we - we couldn't work it out. They were suddenly coming on and disappearing quickly. So I think that was where they could have been very useful."

We were rudely brought back to reality by Chris pointing to the language I had used in quietening the questions of Viva and I was placed in the invidious position of being obliged to answer the questions honestly. The aim of my lecture was being questioned by the very students it was being aimed at. As the discussion followed it became obvious that the instructions I had given were vague and led to confusion. This meant that the students were confused as well as disagreeing with what was being done and the way it was being done.

S: "... also, some of the work lent itself to more discussion. A lot of people wanted to say something and .. and we were just suppressed because a lot of people, do you know what I mean, were sort of ... let's go on to the next one and not say anything."

I did attempt to explain what I had in mind in terms of my lecture plan (see Annexure I). Chris stated that if I had that sort of goal in mind in my plan then it needed to be communicated clearly to

everybody to avoid confusion and if the students didn't like it, then they could challenge it. The video of my handling the overheads was then viewed in its entirety to see whether I had achieved my aim of having students use the information gained the previous week to evaluate the worksheets I screened. The first responses seemed promising.

S: "... I think that Ed handled the second one fantastically because he saw that we were enjoying it. He saw we were talking about it and he, I think, changed his mind about going through quickly and said, 'Alright, if you would like to discuss it, discuss it'. I think Ed was fantastic because he used an opportunity which I think was sitting waiting ..."

Alas, the period of rising optimism was all too brief. I agreed I had changed my mind to allow for discussion. The periods of discussion had been all too brief as well. It was pointed out by a student who said she had hardly had time to read the instructions. The shortage of time was confirmed by Chris who had timed them. The fantastic "second one" was only fifty-five seconds long, which is no time at all really. Because the mind frame was on quick stemming from my initial instructions, this period seemed like a long time. This lack of time for discussion seems a contradiction of the complaints that had happened when only two worksheets were used.

The manner of randomly selecting worksheets from a packet for the students to view without considering or identifying why I was using them was also criticised, as many of them were not worksheets and thus highly inappropriate. The habit of putting overheads up and then reading them to the class was questioned. It was me simply reading the obvious, though there was a group of students who saw nothing

wrong with this method.

A personality trait or mannerism of mine - making comments or ad-libbing as I go through the lecture - became very obvious on the video.

"... Based on what you picked up last week - if you picked up anything at all..."

"... Now to ensure you do some work this morning ..."

"... Ladies and gentlemen ..."

"I know, but I am not going to tell you."

"Unfortunately for you, but it's Geometry."

"I don't know about you, but I like it."

These 'off the shoulder' remarks I felt I used with the intention of closing the gap between myself and the students. This type of familiarity, in fact, increased the distance, as was shown by the students :

S: "I think that that worksheet could have been quite useful and would have been worth it all and ... um ... but coming to the end by saying 'Okay, let's get on with some work now'. You know that's just useless information, you know ... just a quick introduction ... a fun sort of exercise ..."

and

"... You wanted to sort of get that feeling of that you are teaching us and we are students away, and when you referred to us, you said, well, you know, 'Alright ladies and gentlemen, let's get on with this'. Now I know that maybe I felt you were trying to get us to work with you, yet when you said 'Ladies and gentlemen' you were sort of giving that formal, you know ... that we've all grown up now. Let's work properly. I give you stuff and you work with that stuff. That's how I felt."

These remarks made by the students made me more than ever aware of the care that needs to be taken in the selection of language one uses as part of one's teaching. Also, how easily one becomes a slave to idiosyncratic mannerisms and how they can negatively affect the effectiveness of one's teaching.

The discussion moved to drawing comparisons between the two sets of worksheets I had chosen for viewing. It seemed more time was required to consider them. Also, it was only once the students were actually involved in working on improving the worksheets that the lecture seemed to go and the students began to 'see more into the worksheet'.

S: "I think that one of my first reactions was that it was actually a joke ... that the first one on shapes was actually a joke ... that you were having us on ... and then we got the second one and I thought, something funny going on here. I think some of us got that feeling."

Chris: "Why?"

S: "... Because they seemed so appalling. I mean particularly when Ed suggested we then go and write up on the board. I must admit I balked at that because it was almost sort of, oh dear, okay, let's go and write it on the board ... which was a pity ...

... I think that set the negativity."

The reasons for doing what I had done seemed to pale under the legitimate criticism that was levelled. I had chosen the worst two of a series of worksheets for the students to consider and see where they could improve them. It was, to me, pointless providing what I considered a perfect example. I hoped from these two worksheets that the students would be able to establish generalised pros and cons

which could be used as a frame of reference to be used in evaluating the next set of worksheets in the following lecture. (See Lesson notes, Annexures 1 and 2). Yet what I hadn't considered, and which was extremely important to the eventual lack of success of the lecture, was the first worksheets had specific things wrong with them which were unlikely to be generalised.

S: "I don't think there were enough problems to work with to draw up a list of pros and cons ... because we were stuck ... really stuck. And then you said - um, I know ... you must find out."

It is at this stage of the lesson that I had originally felt I had 'blown it'. Far from it. It had happened long before then in my planning stages of two weeks prior, when I had chosen two worksheets that were not really problematic, but trivial. What I should have done was selected more and done the selection more carefully and allowed for more time to be spent on each worksheet. Unless the worksheets were highly problematic it is extremely unlikely that the pros and cons I hoped for would emerge. The students felt that there would have been more co-operation if I had asked them to re-design the worksheets rather than writing up pros and cons on the blackboard. They wished to avoid anything which approximated theory.

S: "In the course we have done so much theory that all we get is theory, theory and we actually want to sit down and do something which is more practical."

Me: "Yes, I picked that up when I started talking about Bloom's Taxonomy ... I heard a strangled voice and I cried 'cut!... cut!'"

The students were aware of the closeness of going out to teach as

their chosen occupation and wanted something practical and tangible which they could use later in their teaching. I personally had feelings of unease about this aspect as the students appeared to want a vehicle they could use in their classroom, rather than ideas that they could implement.

The careful usage and giving of instructions was also brought home to me. Looking and listening to the video I became aware of the importance of carefully going through one's instructions with the group, paying close attention and afterwards confirming that everyone understood. The video showed the way I used my incessant talking to 'fill in space' and sometimes providing essential information while few, if any, of the students were listening. This happened particularly while I was handing out materials. Something that should never be done in a Primary classroom or any class, for that matter. I was also concerned about becoming teacher-centred and maintaining a locus of control by insisting on students listening quietly to my instructions. It appears from my idle prattle that I had never relinquished it. I kept interfering by giving instructions as the lecture went along. This is a crucial aspect I would have to pay close attention to. And I thought I understood David Wheeler! The instruction stage is the crucial stage. By dropping my voice and moving while talking I made my instructions seem as asides and incidental.

When I queried why the students hadn't asked me when they didn't understand, a response was :

S: "As teacher you say if you don't understand it, its your fault. You should have asked."

and

S: "But the way the class ... well, I know it has gone in the last year, I am not at all suspicious or ... or confused when you don't get the instructions (laughter). I often consider you do this. I mean I automatically assume then its up to me to devise a plan...

... This is the reason why many of them didn't ask because its not an unusual situation...

... You sort of bumble around ... and waste ten minutes..."

Worse was to come (for me).

S: "You know the lesson I referred to before that you gave to us about two weeks ago. At first I thought you were having us on. (Laughter). I promise you. I thought you were ... you were showing them what a teacher-directed lesson was. I actually commented to someone about it. He's really just doing this to have us on - to show us a completely different approach. It was so unlike you - you directed so much."

Any claims I had tenuously held about teaching in the Wheeler style were finally destroyed by this statement. I had been blissfully unaware of how old habits re-surface unless ruthlessly got rid of and one's teaching practice vigilantly monitored.

The way students were coping with chaos, with their confusion becoming self-directed out of frustration shows the gulf between the way the students wanted to be treated and the way they are being treated by my lecturing. Their complaints are valid and need consideration.

Though neither the course nor content was mine to change, the material given to me lends itself to no teacher involvement. The students have changed position as well over the last 16 months. From being teacher-directed they are now student-centred. Once involved in the course I felt a need to direct, talk and control rather than

distancing myself and working for greater student involvement - I was out of step. I need to become a learner in a dynamic learning situation with the students being critical of my practice. The problem had become ours and was being investigated in an open, honest and collaborative fashion. I had come out of the experience changed and humbled by being made re-aware of how much one has still to learn. Despite the anxiety the forthrightness was quietly reassuring.

THE SECOND SESSION (PLANNING THE NEXT LECTURE)

That Wednesday morning found me prepared to take responsibility for the negotiation of change in my practice, that I was sure would be recommended. The lesson began rather gently with a discussion on whether other interested students should be included in the triangulation exercise or not. The consensus was not to, because these students had the disadvantage of having no previous history of the discussions and the perspectives gained from them and would thus affect the rapport that had been built up. Also, the present group had volunteered irrespective of the risk. Now that it appeared a very good idea and valuable experience, others had suddenly wished to join. Perhaps they should have been permitted as this fact had not been clearly spelt out in the initial negotiations.

I began to set the scene for Monday's lecture. A video would be shown concerning subtraction and how it is done, or not done, by young children. Out of this would hopefully come discussion and new perspectives. It led to the following dialogue :

S: "So how are you going to do your lesson, I mean, otherwise we don't quite know what we are going to do today."

Me: "I haven't the faintest idea how I am going to do the lesson."

S.1: "Then what's the point in us being here then?"

S.2: "That makes it exciting because then we can ..."

Me: "You see what is ... what is going to happen is you people are now based on what - the way I see it - is what you saw last week and the week before. There are various suggestions you people are going to make which I am going to implement."

S.1: "I see."

Me: "Right. You see the content of lesson is beyond my control because Chris gives it to me ... um, but the way we use it is up to you people to ... uh ... to suggest ... suggest alternatives like, uh ... like 'Good morning, ladies and gentlemen'."

Throughout I became vaguely concerned by the group's persistence in returning to what the content of the lesson was to be and how it would be implemented rather than considering my own classroom practice. The students wanted the method to be investigations which they could later use themselves in their practice. I explained to the group that I saw the video as an initiator for the creation of visual images that could be used for students to create ideas of their own. Then came the first real response.

S.1: "Why don't we ... why don't we try this week for you to do no talking. I mean ... I mean the bare minimum ... sort of have everything self-explanatory."

Me: "Do you realise the kind of torture you're placing me under?" (Laughter).

S.1 : "I know. I am sure its difficult for anybody, you know, but I ..."

Me: "If that's the feeling of the group, I am willing to try it."

Thereafter discussion developed about teaching a lesson without any talking at all. The lesson on subtraction would not lend itself to this method at all. One of the students rejected this and said :

S: "... I am suggesting a structure or something ... a structured lesson but..."

Me: "With no talking?"

S: "No, the minimum sort of ... um, you know, one for each group or..."

Me: "In other words, are you saying at the beginning of a very tightly controlled ... um, instruction time where people are put on task. This is what I would like you to do today ... is to look at the video. When the video's finished I'll be turning it off. I'd like you to turn yourself to the worksheets and use the concrete apparatus to invent a ... um, an investigation or create an investigation which you could implement in a classroom. Fullstop. That's it."

S: "Could be..."

The group kept coming back to discussing and amending investigations created after viewing the video to provide resource material for the teacher. The following statement put it in a nutshell :

S: "You see we've got so few resources. We don't do method or hardly ever. So we have so little to go into the schools with."

These students were obviously concerned about teaching next year and the role they wanted me to play was to criticise the practical application of their worksheets. I voiced my extreme reluctance and was helped by Tom, who stated the following when it appeared the discussion was becoming a minefield of student personal needs :

Tom: "... I can see Ed's reluctance ... shouldn't he be more of a facilitator here and let you people present your worksheets and the rest of the class react to it?"

This was agreed to and the discussion moved on to the physical features governing the learning situation. The constraint of time and the need to involve others in the class was agreed on. This meant a changing of the groupings, a movement of the furniture and that members of the collaborative group would have to distribute themselves among the other groups rather than become a group on their own. The students talked for some time about their own learning in a group. The discussion on the regrouping of the students was threatening to become trivial. The students offered to handle this aspect. My concern was that all it would serve to do was clearly divide him, them and us. Again, Tom brought us back to the reality of what was needed from the group.

Tom: "From what I got last week that the class' objection was more that Ed was being offhand, casual. You know, he saw the sort of different things that came in and keeping on like that his instructions were a bit casual and he'd make these asides about, you know, 'if you do any work' and so on
...

Are you going to object if he is definite? You see.
Perhaps not. Perhaps you'll feel, aha, this is a new type of Ed. Let's see what he is going to do."

The Supervisor, Chris, then entered and we briefly discussed the content which tended to a different approach to the one we had, as a group, been outlining. The stress was placed on understanding the concept rather than simply an activity repeating it. After he left I attempted to get back to the discussion of my practice by suggesting that my language usage and instructions could be looked into. Instead, my involvement in group work came under scrutiny. I expressed my own wariness of becoming too involved and intruding.

The students stated they did not see my involvement as an intrusion. The involvement can be talking to individuals within the group without necessarily 'having to teach'. A salutary remark made to me was :

S: "You could just listen, you know. If you have nothing to say then, you know, listening is fine."

After much discussion concerning evaluation forms, it was decided simply to leave it to the video recording to monitor the classroom proceedings. The statement following, made by one of the group, sums up the general feeling that prevailed and is wide open to interpretation :

S: "I would like to see just Ed in the classroom. I don't think we have anything to do with the running of the classroom in maths."

After a brief discussion about the subtraction video and that I had to be flexible and ensure that the students did not sit passively accepting what was dished to them, the group adjourned. I was left wondering how do I organise what I do next in terms of improving my own classroom practice.

THE THIRD SESSION - THE NEXT LECTURE

Over the next few days I spent a fair amount of time doing the preparation of the lecture to ensure I had a firm control and understanding of the subject matter. I took care over the planning (See Annexure 2). After briefly introducing Sue as cameraman and Tom as observer, I asked for the groups to re-align themselves, suggesting that a group with a new composition could perhaps be more dynamic.

I then gave an explanation of what I intended doing during that session. I tried to keep the instructions directed and meaningful. Once done, I stopped talking. Throughout I attempted to have the students retain responsibility and control of their learning. I considered my questioning technique and listened to students' responses, taking care not to intrude when they were developing their ideas and sharing insights, or judging them right or wrong (there were occasional lapses). Except for an aside about technology, I managed to keep my language usage under tight control and avoided the 'off the cuff' remarks I am so prone to make.

THE FOURTH SESSION - A CRITICAL REFLECTION

The students began by discussing my use of prepared questions. I explained the intention was to hone in on a particular aspect and start there. Some of the students in the class felt this was restrictive and that only generalised questions should have been posed and the videos watched in their entirety without interruption. Other students had found it very useful.

S.1: "It seems like from what we have done with comprehensions in reading. It's good to pose questions before so that you can ... so you know what you are looking for ... you know."

and

S.2: "I found them quite useful and I used these questions all through the period. You know I hadn't thought that much about language. Just by using ... say, looking at language, I found them quite useful because I looked at ... teacher talk and that sort of thing..."

Some of the group felt the question I had posed should have been placed on an overhead or written down for the students. Others differed. There was also a query of whether the questions posed before the viewing should have been provided by the students rather than myself. A lengthy discussion ensued. This was an area which needed investigation and I will have to consider my questioning technique very carefully.

Tom raised the point of the criticism that had been levelled at my instruction-giving and the casual language in the previous lesson. The opinion now seemed to be the instructions I gave in my last lesson were more concentrated and the students knew what to do. The time taken to set up the lesson resulted in the students knowing where they were going and what to look for.

S: "We felt more comfortable in a structured ... in that structured or semi-structured lesson when they know what they have to look for."

Again, I felt uneasy about making the learning situation too structured and thus safe, unproblematic and free of risk.

It was interesting to note the manner in which I over-reacted to the criticism of favouring the one side of the class. I tended to avoid the side everybody said I kept addressing. The mannerism of rubbing my ear and pulling on my nose also appeared distracting. The group itself offered the following remarks concerning my sense of timing.

S.1: "The group were being given enough time to sort of fully discuss what they wanted to discuss. Ed kept saying ... um, you know, have you fully exhausted what you wanted to discuss. You know, giving us ample opportunity to..."

S.2: "I think your timing was good as well because, well, with our group definitely. Whenever you said 'finish' we had just finished."

I asked the group whether they found Tom's joining their discussion in the class intrusive. They said no, but my behaviour was intrusive because I stood behind groups like a teacher looking over their shoulders without actually joining the group. Some students in the class still felt 'when there's a lecturer around that means you must be working'. They saw nothing wrong with me involving myself in the activities with the group. When I expressed reservations, I was told:

S: "I think Ed should negotiate his position in a group. Stand up in front and say, 'We are having discussions today. Would any group mind if I came ... I sat and joined you?'"

I expressed my concern about familiarity and that perhaps I was seeing it incorrectly and it was I who was too sensitive. Thereafter the discussions moved onto intra-group communication. I was left again to make the decisions concerning the improvement of my practice.

THE FIFTH SESSION - THE LECTURE

The second session of subtraction I planned and designed as carefully as I had the first session (See Annexure 3). As it was the first lecture of the second semester, and after several weeks break, I used the discussion concerning their practicum as an ice-breaker before beginning the lecture proper. On reviewing the video tape of this lecture, I was quite candidly appalled at my practice. Old habits

die hard. I was talking too much, and using the 'off the cuff' asides again, as well as being teacher-centred.

"... Recording done by somebody else, preferably their mother."

"... get children to mark it, so we can go home and surf."

are but two of these asides. Also, I was favouring one side of the room again. The more responsive students tended to be seated there. I also read to the group the information I had written onto overhead sheets. Another most disconcerting factor was that the students involved in the collaboration were the ones who shared insights mostly in the classroom.

THE FINAL COLLABORATIVE EXERCISE

The collaborative exercise seemed to have fared little better. The lapse of several weeks had caused the momentum to be lost. We seemed to gently meander through the twilight zone of safe talk avoiding the issue, which was a critical analysis of my practice. Anything problematic was cushioned by useless reams of verbalism.

S.1: "... did you actually achieve your aim ... what you set out to do? I don't think so. I think most of us left the class knowing as much as when we walked in."

Not every student in the group agreed with this statement. The problem was skirted until the end and other students in the group then seemed to confirm it.

S.2: "... I came away fairly frustrated. The content was there but we hadn't ... I hadn't grasped it. I hadn't actually worked it ... thought it and come up with an idea. I was just scratching over..."

In order to know about deep understanding and surface understanding we have to actually discover it ourselves and we hadn't been allowed to. You just told us."

I felt that my attitude was brusque and aggressive. The students noted my agitation. The questions I asked came too quickly, were vague and almost casual. I did not focus on what I wanted to have discussed and my use of the 'it' left much unspecified. This could well explain why 'much of what I say is not heard'.

Also, I tended to talk to an overhead transparency while the students were trying to read it.

S.1: "... not confusing for me, but I can't do both at the same time and get one whole picture."

The explanation needs to come afterwards and separate from the reading.

The group felt I should consider alternative strategies or approaches to allow for student interruptions when I am moving ahead too quickly, or there is a lack of understanding. The constraint of my planning had not allowed time for free talk and time to investigate. A salutary lesson is to plan for less to teach more successfully. When there are constraints, one needs to share these with the class and ask for their understanding.

CONCLUSION

Was the exercise in collaboration a success? Despite our inexperience, I think it was. Both for myself and the students. The growth is sluggish and reluctant and requires an awareness and acceptance which is not immediate. It is no easy task to be critical of oneself in front of others. Several areas have been raised to the level of consciousness and will have to be considered very carefully by me. The bridge-building dialogue has begun. There can be no room for complacency. I feel I am a little wiser and honest about my own ability, expectations and limitations, warts and all. It has made me take control of my own practice. As for a long term cure - if there is one - it's time, vigilance, constant effort and a want to improve one's practice. At present the feeling I have about this exercise can be summed up in Charles Hull's remark :

"It is in a very real sense, about convincing ourselves that we don't know what we're doing."

ANNEXURE 1

TALK ABOUT ASSIGNMENT

1. Talk briefly about the pros and cons of worksheets handled in previous lecture.
2. Go through briefly the overhead copies of worksheets.
3. Allow students to evaluate each independently according to what they had gained from the pros and cons.
4. Take Teacher Resource books and (1) find a worksheet
(2) work on improving it.
5. Report back and draw together
 - (1) Asking questions posing problems
 - (2) Student questions and problems.

ANNEXURE 2

SUBTRACTION (1986-04-07)

The video programmes you will be watching are not intended to be master classes - they are intended as issue raisers.

The tape we intend viewing consists of five sequences :

1. Subtraction problems	6 minutes	20 minutes
2. Trio tricks	5 minutes	20 minutes
3. Cows and fields	4 minutes	20 minutes
4. Dienes blocks	5 minutes	15 minutes
5. More subtraction problems	2 minutes	15 minutes

I suggest you take down notes.

Concentrate on the language children use to explain how they are thinking.

Observe the quality of their explanations in each sequence.

(1) Subtraction problems

What do you consider to be most interesting about the children's explanations?

What conclusions could you draw about each child's state of understanding?

James 109
70

Mandy 109
70

Charlie 109
70
100

(2) Trio tricks

Neil, Amanda and John.

Game is linking 9, 5, 4 together using sentences involving the idea of subtraction.

What help does Amanda need to make more sentences?

Note the ideas for activities or exercises that occur to you.

What ideas do you have for helping these children use 'less than'?

(3) Cows and fields

A group of children.

Linking of numbers such as 3, 4 and 1 and say 4 is 1 more than 3.

Do children have an understanding underlying this process?

Must they develop a specific language pattern to explain this?

What are the children saying?

What opportunities would you give the children to help them develop this language pattern '4 is 1 more than 3'?

(4) Dienes blocks

Ian, Wayne, Nick, Rita and Shayne have been having difficulty with subtraction.

Dienes blocks are being used to help clarify their understanding of exchange.

Is their explanation of exchanging

(a) loosely tied to the concrete?

(b) closely tied to the concrete?

(c) independent of the equipment?

What other concrete apparatus could you use to facilitate the children talking about exchanging 1 ten for 10 units?

(5) More subtraction problems

Nicola is asked to explain how she gets her answers to subtraction sums.

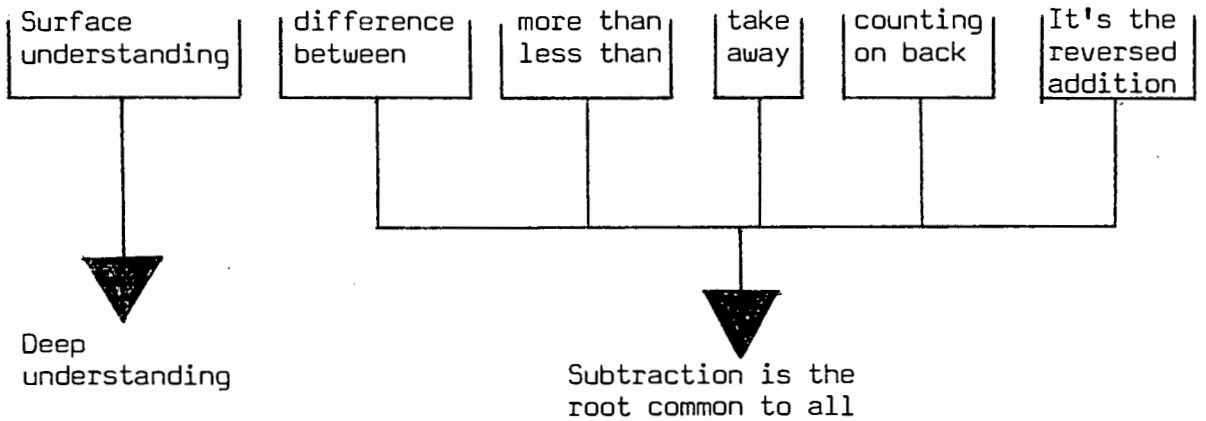
Consider her behaviour - why do you think this is so?

How would you help Nicola?

Do you think that activities such as 'Cows and fields' and 'Trio tricks' have any value in helping children sense when a problem calls for subtraction?

Developing a sense of subtraction.

Developing a deep understanding of subtraction.



Start with difference between take away

developing a sense of subtraction
intuitive or informed numeracy

Develop through emphasis and encouragement of discussion

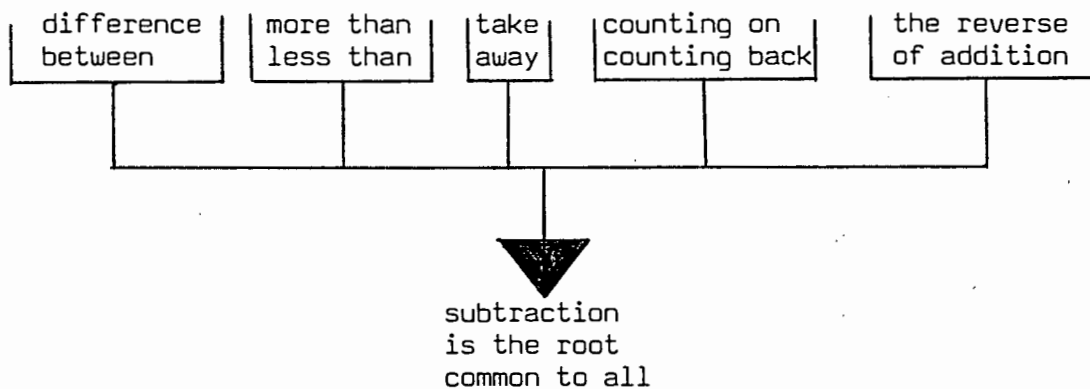
When you understand an idea properly you can explain it.

Games provide the vehicle for developing the language.

ANNEXURE 3

1986-05-19

1. We need to do a recap of where we ended off in our previous session.
2. We were concentrating on three aspects of subtraction.
 - (i) The language a child uses and whether he or she needs it to do the subtraction.
 - (ii) The surface understanding
deep understanding of subtraction



- (iii) the tendency to teach decomposition only rather than develop a sense of subtraction based on the child's intuitive or informed sense of numeracy which is developed through an emphasis and encouragement of the use of the concrete and discussion - DO DISCUSS and DISCOVER.
- (iv) Games can provide the vehicle for developing the language.

Activity 2.2

How would you set out counters to describe $10 - 6 = 4$?

Activity 2.3 (Allow 5 minutes)

Combining 5, 4 and 9

- (1) 9 take 5 is 4
- (2) 9 take away 4 is 5
- (3) the difference between 9 and 5 is 4
- (4) the difference between 9 and 4 is 5
- (5) 9 is 5 more than 4
- (6) 9 is 4 more than 5
- (7) 5 is 4 less than 9
- (8) 4 is 5 less than 9
- (9) If I add 4 to 5 I get 9
- (10) If I add 5 to 4 I get 9

Activity

$$716 - 598 = x$$

- (1) TRY using Dienes blocks
- (2) Describe how a pupil would get the answer.
- (3) If $716 - 598 = 208$

Activity

$$\begin{array}{r} 67 \\ - 49 \\ \hline 18 \end{array}$$

What explanation would show an understanding of decomposition?

I had 67 and have to take away 4 tens and 9 units. There aren't enough units for me to take away. So I get one of the 6 tens and exchange it for 10 units which I put together with the 7 units already in the units position, giving me 17 units. I now have 5 tens and 17 units. I can take 9 units away from 17 units leaving

8 units. I must take 4 tens from the 5 I have. This leaves me with 1 ten and 8 units. That's 18.

This explanation needs an understanding of the language.

Q. At what stage is the child ready to record what he has learnt?

When the explanation is (i) unambiguous.

(ii) can be followed with closed eyes.

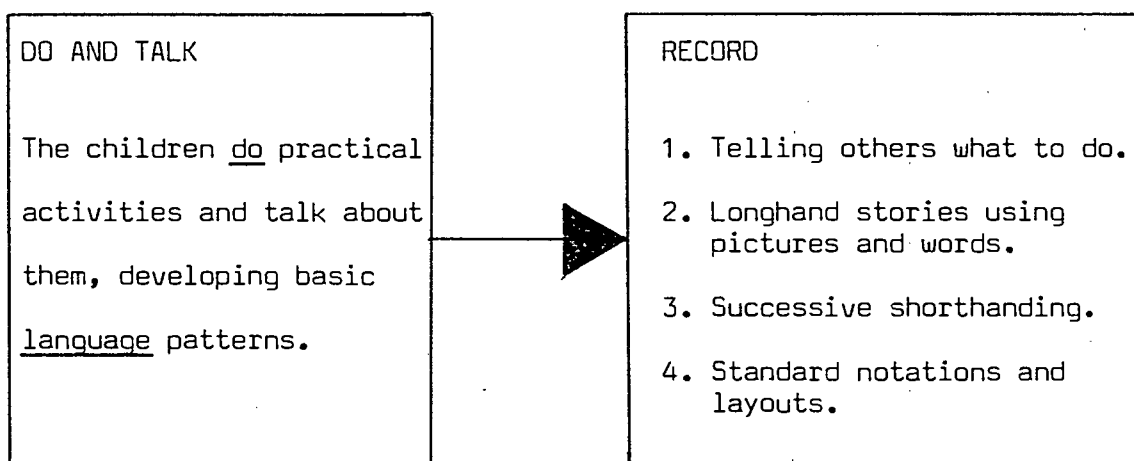
(iii) then the explanation is free from the equipment.

Q. Does one move from the concrete (Dienes) to the abstract written form?

Use mental images

back to manipulative situation

DO, TALK and RECORD Framework for activities and equipment.



Let's look at the deep understanding of subtraction.

Activity 4.1

Carry out the following subtractions noting the methods you use.

83-26

1002-995

3005-2007

750-366

Response:

- 83-26 Take away 10 = 73
 take away 10 = 63
 take away 3 = 60
 take away 3 = 57
- 1002-995 5 more than 995 is 1000
 1002 is 2 more than that
 So answer is $5+2 = 7$
- 3005-2007 If it were 2005 difference is 1000
 I need to take 2 more away
 so difference is 998
- 750-366 366 is 34 less than 400
 750-400 is 350
 So answer is $350+34 = 384$

There are no standard procedures, these are informal methods.

A deep understanding of subtraction involves

- (1) Mastery of five aspects of subtraction.
- (2) Mastery in the use of language to explain procedure used and ability to track back to the concrete.
- (3) Mastery of certain properties of number
 - (i) Use of informal methods - an important aspect of numeracy.
- (4) An awareness of the variety of inter-connections and options available.
- (5) The ability to choose the most appropriate and shortest path that comes naturally to him or her.

An important teaching task is developing a feeling for number.

Develop a myriad of different interpretations and pictures.

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INTRODUCTION

The failure of present systems of government to engage in fundamental educational reform as part of a broader political and economic reform, and persistence in the enforcing of favourable ideological structures as a form of control, could lead to even more tragic consequences emanating from this divisive policy that exists at present, much to the concern and frustration of those oppressed by these structures.

It goes without saying that only radical political change, which includes a Bill of Rights enshrining the equal protection of rights and freedoms regardless of race, political opinion or economic status, can lay the solid foundation for democracy in future constitutions. Any democratic system will have to include the scrapping of unjust inequality in education and have an equal education applied in schools open to all. As Thompson (1981) writes :

"Education being a sub-system of society, necessarily reflects the main features of that society. It would be vain to hope for a rational, humane education in an unjust society. A bureaucratic system, habitually estranged from life, finds it hard to entertain the idea that schools are made for children instead of children being made for schools."

The rigidity developed in educational philosophies over the last forty years and the determination to enforce the futile policy of control, come what may, have constrained the effects of the initiatives of progressive educators. These educationists are all too often seen as being subversive, when battling against the past orientation of

traditional education. (Paulo Freire and his writings are but one example.) While negotiation is said to be immanent, the present status quo seems unprepared to countenance the creation of genuine democratic structures in education, nor face the end of the bureaucratic and elitist domination of education in the foreseeable future. Actions seem aimed at suppressing constructive educational thought, and it is as difficult to comprehend as it is to accept. There is a growing frustration coming from the lack of imagination and lateral thinking, so sorely needed in educational philosophy and design. Particularly as it is wanted to apply persistent pressure for the dismantlement of this oppressive system of 'legalised' control in education. These regimes based on authority from the top and obedience from the bottom cannot develop an education for freedom and personal authenticity.

The mindless radical transformation of these societies could lead simply to the replacement of one form of repression and tyranny with another. The pace of reform will have to be escalated to regain credibility and tacked with a broader community involvement in a spirit of openness. There will have to be a greater dedication, enthusiasm and commitment shown by educators, parents and pupils in moving beyond a blind prejudice and comfortable conformist dogma. Education controllers will have to realise that a democratic educational system cannot arise from a society based on privileges and discrimination.

Every society must assume responsibility for planning the type of education the children need growing up within it. The very

complicated societies we live in make it extremely difficult to initiate such plans and tempts one to see it as someone else's concern. Yet the selection and choice of what children should learn from the broad social context - in short, the curriculum - and how they should learn it, is a shared responsibility. A daunting task. Is education to prepare for life now or the future? Do we preserve tradition or encourage radical change? Do we teach our young to differ and question or to accept and conform? Does one see education as the future practice of freedom?

Despite attempts at suppression, the necessity for a new educational perspective beyond traditional education, and increasingly directed toward development and reality and away from specialisation, is being highlighted. It seems educationists must become involved in a time of transition and transformation in moving from a technicist and elitist education to one education for all and all the challenges and aspirations it entails. Traditional educationists will have to become aware of the mechanistic and manipulative notion of refinement seen as reform, and the naive and narrow outlook which stems from a rigid model of industrial and bureaucratic control. And the questing for ever more efficient and obsolete goals. Also, equal care will have to be taken in considering the application of new principles discovered in a curriculum development based on a radical transformation of society. Particularly when the curriculum has, as the base, a social programme based on a pot pourri of "nineteenth century Marxism and twentieth century Freudianism" (Toffler, 1976). The danger is when these or any new principles are implemented with a passion and conviction and considerable confidence that these

transformations are the right thing and can be swiftly achieved. The difficult task of transforming intention into reality requires that curricular decisions be made (often unwittingly) at various levels by a variety of people, many unable to accept change and some with vested interests. As Hawes (1982) warns :

"The curriculum is neither as appropriate nor as efficient as we had hoped and gaps between plans and realities are very, very great. The process of selection from the culture and of transmission of such a selection to the learners now stand revealed as progressively more complex and complicated and our attempts to prescribe solutions as naive in both method and assumptions."

THE SCHOOL AS A SOCIAL ORGANISATION

The task of transforming intention into reality requires, as a beginning, an intense and objective consideration of the nature and uncertainties of the educational process. One needs to consider the dialectical nature of the dynamics of the socialisation process with its past-orientation and 'clearly' defined sets of values, and the way it shapes a pupil's conscious sense of reality, if one wishes to consider any genuine educational reform (Bowers, 1974). Children go to school and learn skills, behavioural traits and only some information in undergoing the rite of passage into adult middle class society. In fact, schooling is the most systematic attempt at socialising pupils to the dominant view of reality and belief systems espoused by his society.

The child brings to the classroom a personal biography and stocks of knowledge in terms of previous experience. He has a self-concept, a

set of expectations, a sense of anticipation, a feeling of excitement and at least a rudimentary understanding of what school experience will be like. There is no negotiation within the class as the authority of the teacher, the organisation of the school and systematic curriculum already exist.

The school is a social organisation which transmits social messages to pupils who are socialised into standard ways of behaving. This hidden (covert) curriculum, together with the formal curriculum, helps teachers establish control within the classroom. Thus school curricula act as mechanisms of social control and training, presenting only that knowledge and behaviour which is approved by the dominant groups of society and their ideology. Giroux (1983) states that

"... Schooling is distinct from education in that it takes place within institutions that serve the interests of the state."

These interests strongly influence the teaching of an acceptance of authority, the impersonality of a formal organisation, conformity and the creation of artificial and divisive subject barriers. The purpose of schooling is to reproduce an unequal society (Bowles & Gintis, 1976). Dale (1977) sees the hidden curriculum as

"... the central means by which the social relations of schooling reproduce the social relations of reproduction."

To survive in the classroom the pupil must grasp the implicit and explicit assumptions of what teachers and peers count as adequate performance. These assumptions are gleaned from careful observation of verbal and non-verbal interaction in the classroom. Soon the

child begins to internalise behaviour and interpretations congruent with peers and teacher expectations. By internalising what the significant others deem as correct behaviour, the child begins to experience it as the taken-for-granted reality. The social origins are denied. The definitions of myths and assumptions acquired by the teacher through his own socialisation and internalisation are used as a taken-for-granted reality and routinely transmitted to the class as fact. They are considered objectively real and the child encounters them as a fact of an already made external world. The pupil doesn't question or re-think the definitions, or consider he has the right and ability to make his own interpretations and that these interpretations have validity. Thus the education process transmits and legitimates the socially sanctioned definitions of reality through the teacher's unquestioned sense of conscious reality (Bowers, 1974).

There is a fundamental relationship between consciousness and society. Berger and Luckmann (1967) state that "... society only exists as individuals are conscious of it and that the "individual consciousness is socially determined". The dialectical relation between consciousness and society is evident when socialisation is viewed as involving the process of externalisation as a means of communication, internalisation as the acceptance of that communication into our value system or explanatory system as an objective reality, and objectivation, when one loses sight of the human origins of that communication. Reification is the result of extreme objectivation when the human authorship of our social products are forgotten or become dehumanised. Education can be seen as an essential means of breaking out of the sense of powerlessness that comes from man

producing this reality that denies him. They must come to know the social reality they inhabit is a constructed one. (Maxine Greene, 1977).

SCHOOLING - A SYSTEM OF DEPENDENCY

The school, instead of liberating the pupil from the myths and assumptions of his society, in effect subordinates the pupil to the prevailing myths and assumptions so that he becomes controlled and dependent on them. The pupil is presented with a set of typifications that contribute to a false state of consciousness. Pupils are socialised into internalising these objects of the society's belief system that are inherently alienating. Values of individualism, competition, success and role of expert are often reified and pupils incorporate these without question. As the pupil internalises the current social values and perspectives, his self-reliance is progressively eroded. He comes to share a common set of pre-definitions and assumptions with other members of his society at the taken-for-granted level of awareness, which seems to make social interaction more efficient.

The dependency of pupils, as well as the nature of the socialisation, ensures a significant degree of social determinism. The determinism begins to break down when the child encounters differing social explanations which he soon realises are irreconcilable and a choice has to be made. These are times of discrepancy between his own perceptions and what he sees as being socially legitimated. There is a conflict situation in the pupil questioning the validity of his own

position. He begins to mistrust his own judgment. The ability to take himself seriously is eroded leading to an increased dependency. The assumptions and myths which underlie the explanatory system he acquires from his culture and daily routine become part of his consciousness, shaping his perceptions and establishing the parameters of his imagination and behaviour leading to a realistic response. The boundaries of the curriculum become the boundaries of the pupil's imagination. He is conditioned to accept the loss of personal autonomy and as a reward gains social status. The pupil gives up trying to supplant socially defined and legitimated definitions of reality with ones that reflect his own imagination. He then emulates the model of a good student in a competitive atmosphere governed by a school routine. He acquires a good reputation by conforming to the expectations of significant others. These adopted and internalised responses prevent an injury to reputation or damage to the self-image. (Bowers, 1974).

Those individuals that continue to question the discrepancy between what they are told by teachers and their own social experience by using their critical awareness, are labelled 'deviant'. They are increasingly pressured into adapting to the status quo. The formation of a self-identity is dynamic and has a social origin. It is dependent on feelings of how adequate they are judged by significant others. Teachers question the adequacy of this 'deviancy' of performance and, by withholding of sanction, exert a powerful control over the manipulation of the pupil's self-image. Conforming is rewarded, deviance is punished or ignored. This identity manipulation has a powerful effect on making children remain

dependent and conform to the teacher's views and wishes.

The teacher is thus strongly supported in legitimating accepted social values through the possession of the power to give social sanction to certain interpretations and to disapprove of others. The teacher further uses textbooks to designate what constitutes knowledge at the expense of common sense. The teacher is also authorised to evaluate the pupils' ability to internalise socially sanctioned pre-definitions and information and ensure that these pupils see their culture in a socially congruent manner. It is alarming that teachers use their motivational techniques to shape the world view of their pupils without an awareness of the cultured assumption and stereotypes they are perpetuating. (Bowers, 1974).

A NEW FORM OF SCHOOLING - A TREND FOR TEACHERS

Yet the structured control of the educational process does not preclude improvement in making education a more human, relevant and appropriate basis for pupils becoming adults and living a full and purposeful existence. Instead of a bureaucratic handdown of change, the trend for change can be initiated within the classroom organisation and structure and teacher methodology. Teachers must first come to accept the bankruptcy of the present system and then move progressively toward dismantling its divisive and ideological structures.

The common vogue of competency-based and accountability teaching is derived from an ideological position with efficiency, predictability

and accountability considered the most relevant values concerning the question of learning. Measurement is assumed to be the only legitimate means of quantifying whether learning has taken place. What we measure is, in fact, only observed behaviour and our interpretation of it. This measured 'learning' is not the same as the pupil's actual state of being conscious of the world. Competency-based teaching does not lead the pupil to an understanding of how his existence is shaped by his culture. Neither can measurements of the teaching-learning situation make learning more efficient or teachers more accountable.

THE CLASSROOM AS A HAVEN

Teachers should come to accept that the classroom can be a haven for pupils examining their own culture and its underlying assumptions. It can allow them the opportunity to systematically differentiate between myths and factual explanations of reality. The process of examining and becoming aware of the supports of society's basic belief systems can only take place in a protected environment. Here the pupils look at their culture without being prevented from doing so by the power groups, who wish to guard against an unauthorised and questioning investigation of their belief system.

In order to provide this protection in schools, teachers can begin by taking into account the psychological and social needs of the pupils. Erik Erikson's (1959) psychosocial moratorium serves as a useful model for such an undertaking and provides the structure of a safe environment. In such an environment the educational task of raising

society's pre-definitions, explanations and values to conscious awareness can be done in an atmosphere of safety leading to a positive identity formation in the pupil and the development of a healthy personality.

The moratorium will grant the pupils the time and opportunity to question their own values in relation to alternatives. Pupils at present pass through the education system without ever being forced to face the contradictions in their own value systems or question them and discuss them with their teachers or peers. A child who lacks a clear understanding of his own values becomes progressively crippled.

A child must be encouraged to confront these values. Yet schools fail to come to grips with this crucial issue. Educators tend to avoid the very idea of value inculcation, stating that the consideration of values is none of their business. The hidden curriculum shapes pupils' attitudes and values. Yet the formal curriculum and its control is considered value-free and disembodied from a moral reality. (Toffler, 1971).

A psychosocial moratorium allows the child to evolve its 'future-focused role image' within the development of the self. Singer (1970) argues that the self of the child is in part a feedback from what it is, towards what it is becoming. The target toward which the child is moving is his future-focused role image - a conception of what he or she wishes to be like at different points in the future. This future-focused role image tends to organise and give meaning to the pattern of life the child is taking. It enhances the child's adaptability through instilling an appropriate

time-bias and a sense of anticipated future. The young person develops a sense of personal identity and begins answering the question, "Who am I?". (Hjelle et al, 1976). When the future role is only hazily defined or is functionally non-existent, then the meaning that is attached to being, becomes uncertain and a dependency for need gratification from significant others and the social environment grows. Pupils must be helped away from this dependency and their growth toward a psychological and intellectual maturity enhanced. This maturity enables each pupil to react to the dimensions of their existence with a high degree of personal authenticity. (Bowers, 1974). Using the environment of safety the teacher is in a position to create learning situations that facilitate a healthy development both psychologically and intellectually and away from a negative self-image and self-alienation so often experienced by the pupils.

TEACHERS AND PUPILS IN PARTICIPATIVE PLANNING

Educators are not in a position to radically alter the curriculum overnight. The question arises of how the teacher can create meaningful learning situations for the pupils. An answer can be through participative planning. The young people of today will become the precursors of a new democracy tomorrow. Pupils must be allowed to become directly involved in their own education. Educators should work in alliance with, rather than harbour a hostility toward, the pupils and intentionally involve them, the parents and the community in questioning the status quo and the tight

organisational frame and standardisation of knowledge. The question of book knowledge having a greater validity and higher status than common sense has to be addressed. How justified are the contents of the curriculum? Are these simply a mindless holdover from the past and not based on contemporary human needs and future needed skills? Pupils need to consider the inertia and subject status aggrandisement perpetrated by experts' selectively filtering, censoring and shaping school knowledge, and those they want to participate. (Thompson, 1981).

Teachers must consider learners as individuals and that the educational process is one of becoming aware using the qualities of trust, understanding and flexibility. It cannot be accomplished with either tidiness or speed. It is also dynamic and cannot be based on the postulate of uniform development (Hawes, 1982). There are wide gaps between an intended, actual and attained curriculum.

A MORE APPROPRIATE CURRICULUM

The curriculum can be made more appropriate by providing alternatives that are varied, diverse and experimental so that pupils can imagine, analyse and consider future possibilities. The degree of escalating social fragmentation cannot be met by maintaining a highly homogeneous educational system while the rest of society races towards heterogeneity. (Toffler, 1971). The homogeneity of an ideology and political conservative persuasion stamps the school with a uniformity which endangers any pluralistic society. (Toffler, 1971). Though it is often more easy and less disturbing for teachers to concentrate on

whether a curriculum seems to be working rather than whether it is appropriate.

Children are too often bewildered by what is being taught through a 'chalk and talk' method. They sit passively and silent. Teachers provide the answers rather than listen to the questioning. They tend to keep to the syllabus rather than experiment with new ideas across curriculum. Paulo Freire (1972) suggests rather that pupils learn to follow themes across subjects. He calls this approach 'problem posing education' where teachers and pupils work together in learning to solve problems. The more traditional type of curriculum using specialised subjects he termed the 'banking concept' of education. He describes the teacher's role in the banking concept as one of organising what already occurs spontaneously by filling pupils with deposits of information which is construed as true knowledge. Pupils are treated as passive objects to be acted on rather than as subjects who are capable of acting on the world. He is equally critical of the false view of reality this dichotomy causes. Man is seen as an observer of an already complete world rather than a co-creator of it. Freire supports the view that the school curricula of most developing countries are outmoded and politically conservative. They rely too heavily on memorisation of meaningless and inappropriate facts with insufficient practical application, observation and experimentation. The banking concept of education encourages conformity to these school curricula and society.

To Freire (1972) praxis involves transforming the individual as person as well as his world. In order to change, the individual must free

his consciousness from the conditions shaping it. The pupil must become aware of his own freedom as an active and conscious participant in the construction of reality. The correct curriculum is a major source of the restriction of freedom and alienation. In order to provide an atmosphere of genuine freedom within a psychosocial moratorium, the covert curriculum will have to be raised to the level of conscious awareness where it is visible and can be manipulated. By eliminating this hidden curriculum, education will be rid of one of the most dehumanising aspects of schooling. (Bowers, 1974).

The teacher can facilitate the student's liberation through genuine and searching dialogue concerning the world in creative terms. Also, avoiding situations that dominate and control behaviour. The pupil needs to give a personal descriptive account of his own educational experience for the teacher to understand what he has learned. With teacher and learner working together, the pupil feels free to use his curiosity and creativity and the ability to consider the absurd. The pupil finds it safe to err, and novel and opposing views can be freely expressed before being critically sifted. The assumption that teachers must have more power and control for learning to take place must be destroyed.

A meaningful educational process will liberate the pupils' consciousness so that they are not easily swayed by unexamined aspects of their culture. It will develop a sense of trust in their own ability and stretch their imagination and capacity to interpret experiences and consider alternatives. The successful teacher will have developed in pupils a tolerance for complexity, tentativeness and

ambiguity about their own culture as an example of socially constructed reality. They will see their culture as an example of a variety of world views. They will also want to participate as co-producers of the definitions of their reality and move way beyond the 'culture of silence' of Freire.

THE TEACHING OF SCHOOL MATHEMATICS

It is in the teaching of school mathematics that a meaningful educational process becomes highly problematic. To many, the subject is considered a paragon of certainty. It is maintained that mathematics is less likely to be socially influenced because of its universal principles which cannot be distorted in the way subjects like history can. (Blakemore et al, 1981). But mathematics is influenced by what is taught, the way it is taught and by the aims of the covert curriculum. The highly centralised nature of the formal curriculum impedes local experimentation and reform. Much of what is contained in the mathematics syllabi consists of nonsense examples, symbols, drawings and formulae which do not relate to local ways of thinking and common sense. Syllabi drawn up by 'experts' limit freedom and constrain pupils' decisions by imposing on them a plan which predetermines what they must do. (Gerdes, 1985b)

Mathematics tends to be taught with a strong classification having clearly defined subject boundaries and a strong frame where teacher and pupil have clear roles and little power over how fast or slow they may proceed. (Bernstein, 1971). While the classification and frame of school mathematics is strong, it encourages the competitive

individualism of technicism at the expense of co-operation and communication. Few subjects have such carefully worked out questions and controlled answers. This isolated teaching creates a learned numeracy. This learned numeracy eliminates the so-called spontaneous numeracy (Gerdes, 1985a), and creates psychological barriers. The spontaneous, common sense abilities (mathematisation) are downgraded, repressed and forgotten. The clinical methods taught in schools have little value in solving mathematical problems encountered by children outside of schools. This raises serious questions about mathematics being a legitimate activity for children in schools. Yet mathematics is compulsory and heavily time-tabled. Bernstein (1971) sees the significant indicators of the relative status of school subjects as being the amount of time-tabled time allocated to the subject and its degree of compulsoriness for pupils. Added to this is the restriction of what mathematics is allowed to be studied and who may teach it.

In fact, the early stages of learning mathematics in schools offers an efficient way of instilling a sense of failure and dependency in children. Children who fail become anxious and are silenced. They withdraw and fatalistically adjust to their own domination.

(Frankenstein: Unpublished paper). This 'mathematics anxiety' leads to the subject's loss of popularity which in turn becomes an effective and selective educational filter. Successful pupils are 'suckered' into serving the elite in positions of power. Successful pupils are labelled as having an aptitude or mathematical mind. (Frankenstein).

Unsuccessful pupils are labelled failures. Anxiety is increased through parents and community subscribing to the hegemonic notion that

a mathematics qualification is a prerequisite for success.

Mathematics is seen as a value-free science, knowledge of which makes people more promotable. A view which only serves to build a romantic importance of the subject.

Rozak (1971) states that mathematics education in its present form is fundamentally dehumanising and part of the general technocratic ideology that has led to the alienation of many from the mainstream of social life. Gerdes (1985a) maintains people see mathematics as value neutral avoiding affective ambiguity. The construction of mathematical knowledge is not value-free and neutral as positivists would have it. Mathematics is essentially a social construction - a human invention rather than a natural discovery. Mathematics has developed a restricted language, impoverished to handle social issues. Problems of society are considered as technical ones by 'experts' using statistics. (Frankenstein). Thus mathematics literacy is vital in the struggle for pupils to understand how technology works and in whose interests it is being used to obscure economic and social realities. (Frankenstein). It is the teacher who must consider ways and means of developing this literacy and remove the contributors to anxiety within the constraints of the curriculum.

A MORE APPROPRIATE MATHEMATICS

In the consideration of what methods should be used in the classroom, problem-solving must give way to the problem posing as suggested by Freire (1972). Problem-solving simply isolates aspects of reality and gives pupil practice in using techniques. In problem posing the

complexities of real-life situations are revealed where at time there is no one solution, but a better understanding.

Mathematics also suffers as a subject where teachers slavishly adhere to the contents of the textbook written to the contents of a syllabus. It is all too easy. Both teacher and pupil easily accept the written word as having a finality derived from an unquestioned authority.

(Wain, 1978).

In order to make mathematics education more appropriate, teachers will also have to adapt and reformulate the content to local needs.

Active practical experience must be given using learning aids based on familiar material drawn from the immediate environment. (Gerdes, 1985b). The teacher must also search for ideas and experiences from pupils that give meaning to their lives. Themes can include, "Why are boys better than girls at maths?", etc. These 'generative themes' (Frankenstein) can lead to transformation through challenging pupils and teacher to respond through dialogue and collective action.

The teacher listens to pupils and discovers themes which can be posed as problems challenging pupils previous perceptions and taken-for-granted beliefs. The range and meaning of questions become wide and varied. Pupils and teachers have freedom and are equals in problematising their themes, reflecting and pinpointing their own understandings (Frankenstein). Both realise that wrong answers have a value and that one can reflect on errors, argue and think about them. Both teacher and pupil reflect on concept building and discover together. They become co-investigators in re-creating prior knowledge, realising that it has a human origin. (Gerdes, 1985b).

Frankenstein suggests that pupils keep a journal to write up their own learning and feelings and provide information for future lessons. The generalisations and structures created in the lessons should come from the pupils' experience and not from the formal assertions of teachers. (Gerdes, 1985b). In this way the content of the classroom begins making sense and does not arouse mathematics anxiety. According to Frankenstein, critical individual change comes about when pupils have overcome mathematical anxiety and learn mathematics. Pupils and teachers must become co-authors of a liberating action through participation and collaboration and work for this change. A feature will have to be a trust of each other in developing the relationship. Without a shared understanding as the basis,

"... the best attempts of the teacher to educate and the most ingenious pupil attempts to resist will operate only to sustain the power of schooling and avoid the radical potential of education."

(Hull, 1985)

CONCLUSION

In the end it is the teacher who must take the initiative in starting the move toward a mathematical literacy. It is the teachers who must clarify personal taken-for-granted assumptions before embarking on a tentative vision of what should be happening - despite the difficulties. It will only begin through their efforts. Teachers must begin to teach on the threshold of risk. They must remain marginal while working toward a more appropriate school mathematics. Even so, the individual is not strong enough to effect major changes alone, or maintain the momentum in designing an effective series of lessons and materials.

New ideas are not fed into a vacuum. Teachers already possess and use their traditional patterns of understanding. New ideas intermingle or become diffused with old. By using new ideas and materials, teachers also develop insights into perceiving old ideas in new ways and pose deep challenges to their conventional understanding.

The notion that new ideas on teaching mathematics can be effectively disseminated without the provision of classroom materials is an untenable one. New materials cannot be exhorted; examples of classroom practice must be detailed to prevent a garbled message. Materials need to be written and tested. (Wain, 1978). These materials can only be developed through a collaborative action of like-minded teachers.

Teachers need to bring to their teaching a wider set of resource materials. Groups of teachers can come together and work in collaborative teams to improve their teaching and produce these new learning environments for their pupils. In order to provide for new ideas, materials developed elsewhere can be used. The intention is not to transplant these, but to look for features of relevance to interpret and adapt for regional and even local conditions in making the mathematics more appropriate.

Together methods of instruction can be considered and explorations of practical situations used to help develop certain patterns and strategies of thinking in children. These include abstraction, generalisation, decoding and encoding where the child uses its own inventiveness, research and creativity in coming to understand. (Wain, 1978). Pupils and teachers can then critically appraise the

aims and implications of the new forms and discuss them to facilitate their implementation. This collaborative action will lead to a strong sense of futureness in the pupil as it considers the needs of the 'customer' of mathematics education.

Subject associations and Teacher Centres can provide the support for the small band of mathematics innovators and help in the publication of materials as well as keeping them informed about recent research and developments. These organisations can provide a platform for the sharing of ideas and yet have the teachers continue with the essential task of remaining practising classroom teachers.

School-based in-service training can provide teachers with new approaches generated on-the-job and help them in increasing their own competence and personal development and impress on them that curriculum development is their responsibility. (Wain, 1978). This collaborative strength will give teachers the means and confidence to move away from the current inequalities and stratifications mathematics tends to sustain and consider the alternatives of integration with other subjects, mixed ability teaching and optional mathematics.

Only by constantly re-considering what sort of mathematics is a necessary part of a child's education, rather than the economically significant skills required by a technocratic society, can mathematics hope to move away from the inequalities and stratification that it is perpetuating at present.

A TENTATIVE SERIES OF LESSONS ON MONEY

Step I : Explore and make explicit the interface between pupils' experience and money.

- A. What is money and how does it influence their lives?
 - (i) Pupils state views and feelings concerning money - metaphors used.
 - (ii) Pupils discuss in groups.

- B. Focus pupils' attention on areas and experience influenced by money.
 - (i) List phenomena pupils associate with money.
 - (ii) List phenomena that are natural and can't be bought.

- C. Pupils articulate reasons why money is important - taken-for-granted.
 - (i) What aspects of money have they always been aware of?
 - (ii) Discuss awareness of certain forms and not others.

Step II : Building a phenomenology about money - building a data base.

- A. Pupils keep journals of their own descriptions of their circumstances and encounters with money.
 - (i) What does money pay for
 - (a) at school?
 - (b) at home?
 - (c) in their community?
 - (d) in social activities?
 - (ii) Discuss with pupils their journal entries.

Step III : Explore the social and historical context of money.

- A. Use journals to identify and list forms of money encountered in the community and how it affects life and activities.

- B. Have pupils identify examples for further study.
 - (i) Pupils work in groups and consider the significance of what facilitates and what prohibits human experience and how people perceive money and relate to it (work, free time).
 - (ii) Pupils write up findings and report to whole class.

- C. Discuss hidden assumptions and its use in social organisation.
 - (i) Explore differences in attitudes.
 - (ii) Pupils identify cultural assumptions and discuss underlying use and striving for money.
 - (iii) Differences - how are people influenced?
 - (iv) Explore relationships between forms of social organisation.

- D. Investigate the historical development of money and its underlying assumptions.
 - (i) Overview of how money shaped the history and life styles of historical periods - pre-industrial to post-industrial.
 - (ii) Need for money changing a society's world view.
 - (iii) Money changing life styles - agrarian to urban culture.
 - (iv) Altering of view of physical environment.
 - (v) Money and the idea of progress and modernisation.

Step IV : A comparative view - Townships - cross-cultural perspectives.

- A. A community and how money is used:
 - (a) food
 - (b) health
 - (c) housing
 - (d) education

- B. Examine relationships between subsistence - plenty. How does this affect assumptions about reality?
 - (i) Myths and shaping of attitudes - education and personal achievement.

C. How does the use of money affect social customs - implications?

D. Compare differences and similarities and influence of money.

Step V : A futuristic view.

A. Pupils write own scenarios of future influence.

B. Pupils discuss implications of how scenarios will affect their lives. Clarify their ideas and values.

(based on Bowers, 1974)

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